COMBINED HEAT AND POWER

ESC Energy Solutions Center

CHP's Spark Spread Over Competition = Economic No-Brainer

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Engine-Driven CHP Offers Savings, Disaster Protection

Environmentally friendly, combined heat and power significantly increases overall energy efficiency.

BY DREW ROBB

Short lead time. Fast startup. Sound economics. Reliable operations. Low emissions. Those are just some of the benefits of combined heat and power (CHP), and why the technology is growing in popularity among manufacturers as well as owners, managers, and operators of commercial buildings and public institutions.

Many hospitals, for example, are advocates of CHP technology. CHP applications for facilities in the range of 100 kW to 5 MW generally use natural gas, engine-fired CHP. In this configuration, the waste heat can be recovered from hot engine exhaust, the cooling fluid

PHOTO COURTESY OF SISSON STUDIOS

A 2,245 pound-per-hour heat recovery steam generator is part of a CHP system that generates electricity and steam as well as chilled and hot water for Upper Chesapeake Medical Center in Bel Air, Maryland.

and/or the lubrication system. By doing so, this greatly increases overall efficiency and lowers the cost of energy.

Those are the kinds of advantages that attracted officials at Upper Chesapeake Medical Center (UCMC) in Bel Air, Maryland, to CHP.

"Our main drivers for adopting CHP were being able to operate during a storm or prolonged electrical outage, the environmental friendliness of our engine-driven system, and projections showing savings of more than $9 million over 20 years in energy costs," said Don Allik, hospital facilities director at UCMC.

Part of the University of Maryland Medical System, UCMC is a 200-bed, state-of-the-art general medical, surgical hospital and medical complex. The facility encompasses a hospital, two medical office buildings, parking garage, the Klein Ambulatory Care Center of Harford County, administrative offices, a cancer center, and medical services for residents of Northeastern Maryland.

PHOTO COURTESY OF SISSON STUDIOS

A 2 MW natural gas generator is part of the engine-driven CHP system at UCMC.

KEEPING THE LIGHTS ON

With the needs of so many people to accommodate, the facility could not afford to have one minute of downtime; patient safety is paramount. Yet, the 1.5 MW diesel generator it used for backup power acted as a single point of failure. The danger of this became apparent during Hurricane Sandy when many hospitals in the region lost power.

NYU Langone Medical Center, for example, suffered outages during the storm as issues at an electrical substation caused a power failure and backup generators malfunctioned. This resulted in critical care services being shut down and the evacuation of 300 patients. Since then, NYU Langone has installed an 8 MW Taurus 70 Solar® gas turbine CHP system. Other facilities already employing CHP at the time of the storm were able to ride it out. Greenwich Hospital in Connecticut, for example, relied on two 1.25 MW gas, engine-based CHPs to continue services despite power being out in the surrounding area for several days.

After the events of Hurricane Sandy, UCMC reviewed its disaster preparedness capabilities. Officials realized that if an outage occurred, its diesel generator would only be able to provide power to the critical care area and a few other buildings. The cancer center and several other parts of the facility would not be covered.

While this drove the demand for CHP, further factors had to be considered such as the need for additional cooling capacity and backup power, as well as limited space availability for CHP system components.

PRESIDENTIAL AID

The U.S. Department of Homeland Security proposed a rule requiring hospitals to have alternate sources of energy to maintain temperatures in order to protect patient health and safety, as well as for the safe and sanitary storage of provisions. President Barack Obama also signed an executive order setting a national goal of deploying 40 GW of new industrial CHP in the United States by the end of 2020. As a result, Maryland offered an incentive of up to $2 million per project, which helped UCMC in its ambition to safeguard its facilities during an emergency. This enabled the center to partner with Clark Construction's Energy and Structured Finance group to erect the facility, thereby transferring the ownership from the hospital to Clark. Clark owns the system assets and sells electricity to the hospital in addition to providing thermal capacity for both heating and cooling.

The main elements of the plant are a 2 MW reciprocating engine from Caterpillar, a 350 ton Broad USA absorption chiller, a 500 ton heat rejection cooling tower, a 2,245 pound-per-hour heat recovery steam generator, and associated control systems. By using compact, efficient components, the CHP system generates electricity and steam as well as chilled and hot water.

"Our CHP system greatly improves our overall reliability, and [that] means we not only can serve our own patients during an outage, but we can act as a vital community resource during emergencies," Allik said. "Its emissions levels represent the equivalent of taking 2,200 cars permanently off our roads."

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For more information about combined heat and power (CHP), go to:

CHP Consortium: *www.understandingchp.com*

Solar Turbines: *www.solarturbines.com/chp*

Rentech Boiler Systems Inc.: *www.rentechboilers.com*

Fire Up the Turbines

Microturbines generate a stable power source.

BY TONYA MCMURRAY

More than 3,600 combined heat and power (CHP) systems are installed across North America, saving money, improving energy efficiency and reducing greenhouse gas emissions. And, many of those systems are run with small, compact, lightweight and low-emission microturbines.

Widely used, microturbines represent an energy management solution that uses natural gas to produce electricity and, with a heat exchanger, captures the heat generated so that it may be used for thermal needs. Ranging in size from 30 kW to 400 kW, microturbines run at high speeds, allowing for high efficiency with minimal noise and vibration. Multiple microturbine units can be connected together to meet larger electric demands.

These small turbine engines are derived from turbocharger technologies, such as those found in large trucks and the turbines found in jet aircraft. While the most commonly used fuel is natural gas, microturbines can also run on a variety of gaseous elements.

Heated air and fuel are combined in the microturbine's combustor, igniting the mixture and feeding it to the turbine. This ignited air-fuel mixture spins the turbine to operate the generator, producing electricity for use onsite.

Captured thermal energy can be used for the production of hot water for local use, space heating, absorption cooling, desiccant dehumidification, and to supply other thermal needs.

PHOTO COURTESY CAPSTONE TURBINE CORP.

Capstone Turbine Corp. manufactures microturbines that typically pay for themselves within three to five years, according to Jim Crouse, executive vice president of sales and marketing.

COMPACT POWER

Microturbines were put into commercial use beginning in 2000. In the 15 years since, they have proven to be powerful drivers for CHP systems, especially in large installations with significant heat needs. Customers can expect to see up to 80 percent combined heat and power efficiency with a CHP application and up to 90 percent efficiency when an absorption chiller is added to the system to provide space cooling using the heat recaptured from the microturbine. With those efficiencies, Capstone microturbines typically pay for themselves within three to five years, said Jim Crouse, executive vice president of sales and marketing with Capstone Turbine Corp.

According to the U.S. Energy Information Administration (EIA), natural gas-powered CHP equipment offers the lowest carbon emissions.

The systems' electrical efficiencies increase as the size of the microturbine increases. Multiple units can be connected

PHOTO COURTESY OF CAPSTONE TURBINE CORP.

The Ritz-Carlton San Francisco has reduced its energy consumption by 20 percent, saving an estimated $120,000 in energy costs in each of the first 10 years since installing a microturbine-based combined cooling, heating and power system.

together to handle larger loads and increase reliability. Because the units are small and lightweight, they can be installed in almost any facility. The turbines can often be lifted in freight elevators to the top floors of multi-story buildings.

The compact, modular design of microturbines makes them flexible and adaptable, said John Zuk, vice president of marketing and sales for Philadelphia Gas Works.

"Sometimes a customer will put in one or two units, and then will realize the benefits and want to expand, so they'll add a couple of more units," he said. "Because they're modular, you can expand the system simply and easily."

The systems are also quiet with minimal vibration, Zuk said. He added that some hotels have rooftop installations and are able to install the system directly over guest rooms because there is no sound or vibration to disturb hotel guests.

CAPPING THE RITZ

The Ritz-Carlton San Francisco was the first in the world to install the Capstone microturbine-based UTC Power Company's PureComfort combined cooling, heating and power (CCHP) system to conserve energy and protect the environment. The system's quiet, low-vibration microturbines were ideal for the hotel, which wanted to ensure the unit didn't interfere with its relaxing ambiance.

During the 10 years the system has been in operation, the Ritz-Carlton has reduced its energy consumption by 20 percent, saving an estimated $120,000 in energy costs each year. With incentives from California's Self Generation Incentive Program and the U.S. Department of Energy, the hotel saw a payback on its investment within four years.

Besides hotels, microturbines can be found in educational institutions, medical facilities, data centers, landfills, and a variety of commercial operations. Microturbines are ideally suited for industrial or commercial CHP applications requiring large amounts of both electricity and heat.

Facilities that are able to use the captured heat on an ongoing basis are the best candidates for microturbine technology, Zuk said.

"Everyone can use electricity," he said. "The question is, can you use the waste heat 24/7 for cooling or heating? Hotels, for example, can use the waste heat for hot water, for guest room heating, for the kitchen and laundry, and, sometimes, even for pools and hot tubs. Some customers use the waste heat for heating during the winter and for cooling during the summer, so they're using it 365 days a year. That's when the application makes sense. Otherwise, you go from system efficiencies of 80 percent down to 30 percent when you're not using the heat."

HEATING UP

"Microturbines produce more heat and steam than other technologies," said Bob Fegan, principal technical consultant for DTE Energy. "For any application that needs steam or any application that needs a large volume of very hot air, such as kilns and drying operations, microturbines have the advantage."

Fegan worked with the VA Medical Center in Ann Arbor, Michigan, on one of the first installations of the Capstone C1000 microturbine with a steam heat

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PHOTO COURTESY OF CAPSTONE TURBINE CORP.

The Ritz-Carlton San Francisco was the first in the world to install the Capstone microturbine-based UTC Power Company's PureComfort combined cooling, heating and power system to conserve energy and protect the environment.

(continued from page 5)

recovery system. The Capstone microturbine boasts 33 percent electrical efficiency and an overall CHP efficiency of up to 90 percent. Total CHP efficiency is the sum of the net electricity generated plus hot water or steam produced for building thermal needs divided by the total fuel input to the system.

"The system is installed in the boiler house next to conventional boilers and is used just like a standard boiler, producing steam that goes directly into the facility's steam header," Fegan said. "Electricity produced from the turbine is fed into the main distribution system and used just like electricity from the grid."

Other facilities use the excess heat generated by the microturbine for both heat and cooling throughout their buildings. In 2013, the Pennsylvania State Employees Credit Union (PSECU) decided to invest in a natural gas CCHP system to reduce overall operational costs and become more environmentally friendly.

PSECU needed power generation as well as space heating and cooling for its 239,000-square-foot LEED Gold-certified facility and data center. The CCHP system relies on a Capstone C800 Power Package, four 1,000,000 BTU heat exchangers and a 250 ton, flue gas-fired absorption chiller. The system is able to work independently from the local utility grid to maximize efficiency. The system produces 800 kW of electricity as well as hot and chilled water for the facility.

Since the system was completed in October 2013, it has reduced carbon emissions by 1,468 tons per year, the equivalent of removing 243 cars from the road.

A GOOD INVESTMENT

Microturbines produce stable and reliable power. Capstone microturbines have only one moving part, which allows for longer service intervals, minimal vibrations and lower operating costs. Maintenance for microturbines is pretty straightforward with no oils that need replacing. Zuk noted that many manufacturers offer maintenance contracts to ease ongoing maintenance needs even further.

The reliability, combined with low maintenance cost, makes microturbines a good investment, Fegan said. Like all CHP and CCHP systems, microturbines reduce the risk of electric grid disruptions and enhance energy reliability by allowing for continued operation during electrical power outages.

Microturbines typically have extremely low emissions. In fact, most microturbines are able to meet even the most stringent emission requirements with built-in technology so that the system won't require post combustion emission control techniques.

When correctly engineered, the small microturbine helps facilities achieve optimal performance in the production of electricity and thermal loads.

"Microturbines are best utilized by customers looking to break free from the burden of high utility bills," Crouse said. "By running 24/7, almost any commercial or industrial business can fully utilize the electrical and thermal outputs, maximizing the economic benefit. The low life-cycle cost of the microturbines, paired with the ease of achieving high overall efficiency and reliability, makes for a smart investment in clean energy production." **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium:
www.understandingchp.com

Energy Information Administration:
www.eia.gov

Capstone Turbine Corp.:
www.capstoneturbine.com

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WASTE HEAT FOR CHILLING

Baltimore Gas and Electric (BGE), Maryland's largest natural gas and electric utility and part of Exelon Corp., is the utility provider for the UCMC project. Jim Libertini, product manager for the BGE Smart Energy Savers Program, said the UCMC CHP unit is designed to run 24/7 and operates in conjunction with BGE's electric grid.

The waste heat from the gas engine, he explained, supports a 350 ton absorption chiller purchased as part of the project. This unit takes steam or very hot water and uses it to generate chilled water through a chemical action process.

"The waste heat generated from operating the CHP unit is collected and delivered to the chiller," Libertini said. "Utilizing this waste heat vastly increases the efficiency of generating electricity."

For Libertini, the overall benefits of CHP are:

- Resiliency and ability to control one's own destiny in the event of a catastrophic emergency;
- Ability to use the waste heat to offset thermal or heating needs, making the system highly efficient;
- Ability to use a potential backup generator full time, allowing beneficial use out of the investment as opposed to a part-time diesel generator;
- Ability to better control energy costs;
- If using natural gas to power the unit, no onsite fuel storage concerns; and
- Reduces carbon footprint.

Libertini advises those considering CHP not to be tempted to oversize the unit. The best approach, he said, is to understand your thermal needs and size the unit to closely match those specific thermal requirements. This will take input from engineers and contractors who have plenty of experience with this technology. But once in place, CHP provides peace of mind that hospital facilities will have the wherewithal to keep running in the face of a disaster or power outage.

"The new CHP unit enables UCMC to expand that umbrella of protection to operate additional heating and cooling systems as well as other necessary equipment in order to keep their facility up and running during an emergency," said Libertini. "In addition, UCMC has also been able to significantly reduce their energy costs." **CHP**

Small Size, Large Benefits

MicroCHP offers clean, reliable and cost-effective energy solutions.

BY TONYA MCMURRAY

With an aging electric grid and increasing electricity prices, a technology popular internationally may hold the answer for North American companies. MicroCHP (combined heat and power) systems that generate less than 50 kW of electricity, are a proven technology for reliable, cost-effective and clean energy.

Like larger CHP systems, microCHPs capture excess heat from the production of electricity, providing onsite electricity generation, heat and hot water. While larger CHP systems typically operate in campus-type environments, microCHPs are designed for smaller buildings and homes.

Developed in the 1990s, microCHP technology has grown rapidly. Adoption in Europe and Asia has been very strong due, in part, to much higher energy prices in those areas than the cost of energy in North America, said Yoshimine Sekihisa, manager of the life and energy department at Aisin World Corp. of America.

State and local governments offering clean energy incentives often ignore the value of microCHP, favoring wind and solar power instead. Those incentives can be important as upfront installation costs for microCHP can be higher than their larger counterpart systems; however, long-term energy savings make CHP a good investment.

An analysis by the Natural Gas Technologies Centre (NGTC) found that while microCHP systems may cost more than their counterpart solar or wind systems, they reduce energy costs by as much as 35 percent, using a much smaller space. The study also found that microCHP systems fueled by natural gas reduced carbon dioxide emissions up to 3.5 times more than solar or wind systems, depending on the location. (See comparisons from the NGTC study below).

Sekihisa noted that the northeastern United States, with its cold climate, is an ideal market for microCHP systems since heating costs are often a significant expense. Therefore, the colder weather provides a greater heat-sink for microCHP, enabling it to operate longer and more optimally.

Abundant domestic supplies of natural gas are another benefit for North America, he said. Low natural gas prices make microCHP more attractive because the payback on the initial investment is quicker, making this technology more attractive than buying electricity from the power grid. **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium:
www.understandingchp.com

Aisin World Corp. of America:
www.aisinworld.com

Natural Gas Technologies Centre:
www.ctgn.qc.ca/en/homepage-en

12,000 Sq Ft - 10 KW DE System	Solar - PV	Wind	CHP
Installed Cost ($/kW)	$5,300	$6,000	$7,280
Annual Savings (/kW installed)	$156	$216	$592
Space Required (Sq Ft/kW installed)	76	785	1.4
CO2 Saved (/kW installed)	1,871	2,588	6,502
Ave. hours /year at max power	1,550	2,175	8,311

75,000 Sq Ft - 65 KW DE System	Solar - PV	Wind	CHP
Installed Cost ($/kW)	$4,600	$3,300	$2,250
Annual Savings (/kW installed)	$157	$161	$583
Space Required (Sq Ft/kW installed)	76	121	0.28
CO2 Saved (/kW installed)	1,878	1,933	6,369
Ave. hours /year at max power	1,550	1,595	8,322

SOURCE: NATURAL GAS TECHNOLOGIES CENTRE

Gas Turbine-Based CHP Ensures Greatest Efficiency

This technology is ideal for larger facilities as well as commercial and industrial sites.

BY DREW ROBB

The most efficient form of power generation is a natural gas-fired, turbine-based combined heat and power (CHP) system. That's why it is becoming increasingly popular among personnel who manage larger buildings, factories, manufacturing plants, hospitals and educational institutions.

"Gas turbine-based CHP gives us far more control of our power production, and at a cheaper rate than the local electric utility due to the relatively low price of natural gas," said Phil Plentzas, director of business operations in the facilities development and management department of Arizona State University (ASU). "It also enables us to provide lower cost steam to heat the campus."

The Sun Devil Energy CHP plant is operated by NRG on behalf of ASU. A 7 MW gas turbine by Solar Turbines was installed in 2006 originally to increase the reliability of power for campus-critical lab loads. The plant was tied into the campus' central steam system to increase waste heat utilization and economics. A 2 MW steam turbine brings this combined cycle facility up to a total of 9 MW of potential electrical output.

Here's how the CHP facility works: The plant has five chillers (each 2,000 tons) that are used as part of the campus' chilled water distribution system. The electricity provided by the gas turbine runs those chillers and helps to reduce the peak electrical load on campus. The waste heat from the gas turbine is captured and converted into steam, which is used for heating and for more power production.

"For most of the summer months, steam runs the second turbine, as additional steam is not needed for heating the campus," Plentzas said. "When the need passes to reduce the peak electrical load on campus, steam provides heat. A duct burner is used to increase the output of steam, which makes it more efficient than the boilers in our central steam plant."

GAS TURBINE CHP BASICS

There are many different ways to implement CHP in an organization. Gas engines, also known as reciprocating engines, much like the engine in a car, can be sized for small and mid-sized sites and may be the best economic and efficiency choice for such facilities. But beyond a particular size, the gas turbine (also known as a combustion turbine or a natural gas-fired turbine) generally presents a more favorable cost/benefit proposition.

How does it work? Gas turbines are very similar to jet engines. The word "turbine" comes from the Latin "turbo," which means a spinning top, eddy or whirlwind. A turbine, then, is a type of machine that produces power via a spinning wheel or rotor.

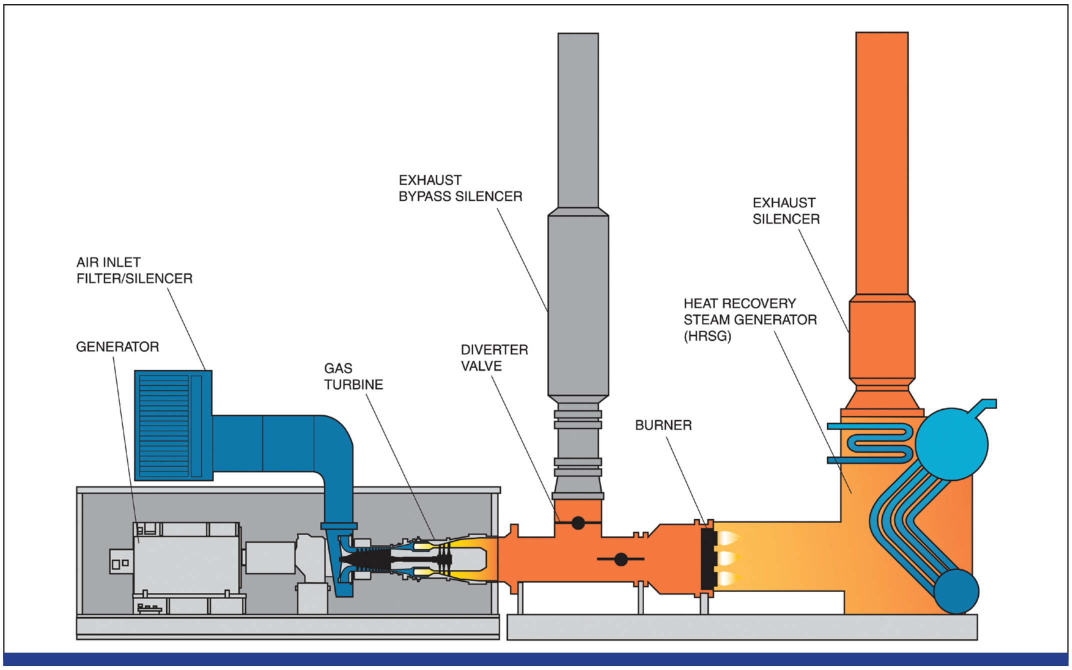
In a gas turbine, compressed air is mixed with natural gas, which is ignited and burned at extremely high temperatures to generate electricity.

Gas turbines achieve very high levels of efficiency when used in conjunction with a heat recovery steam generator (HRSG). In this case, the gas turbine is used in combination with a steam turbine in what is called a combined-cycle power plant. The heat from the gas turbine exhaust is captured in the

PHOTO COURTESY OF ARIZONA STATE UNIVERSITY

Arizona State University uses a gas turbine-based CHP plant to increase the reliability of power for campus-critical lab loads.

SCHEMATIC COURTESY OF SOLAR TURBINES



In a gas turbine, compressed air is mixed with natural gas, which is ignited and burned at extremely high temperatures to generate electricity. Gas turbines achieve very high levels of efficiency when used in conjunction with a heat recovery steam generator (HRSG).

HRSG so it can create steam to drive a steam turbine and generate even more electricity. Alternatively, the waste heat produces steam that can be harnessed and used for industrial processes, for heating or for cooling.

Gas turbine-based CHP then, is ideal for applications where steam is needed for continuous operations and processes, where high temperature heat is required, and in facilities needing at least 1 MW or more of power.

Florida Public Utilities (FPU), for example, is installing a 22 MW Titan 250 natural gas turbine by Solar Turbines for CHP as part of the new Eight Flags Energy Center that will be in commercial operation by 2016. Waste heat will provide process-related steam and hot water to a Rayonier Performance Fibers site on Amelia Island in Florida. The steam will be used to maintain operational flexibility across the plant's cellulose specialties production processes. Eight Flags Energy will provide electricity to the FPU grid, as well as steam and hot water to Rayonier Performance Fibers and aid in a reduction of electrical cost to FPU.

About 50 percent of Amelia Island's electric requirements will be generated on the island, reducing line losses and risks due to the island only having a single transmission line. The facility will become a firm, on-island generating source that will provide increased reliability even when impacted by an electric outage emergency. This will lower costs and provide more reliable service to FPU customers.

"The cost of the plant and the pricing arrangement for excess power we have made with FPU made it attractive to go with natural-gas fired CHP versus other incremental sources and fuels," said C.A. McDonald, general manager of Eight Flags Energy Center.

The exhaust from the turbine will be run through the HRSG to capture thermal energy for Rayonier's use in its cellulose production process. Boiler feed water from Rayonier will be converted into steam, which will be returned to Rayonier for use in the production process. In addition, de-mineralized water provided by Rayonier will be channeled through a hot water economizer in the HRSG to increase the temperature by approximately 70°F. This hot water will be returned to Rayonier for its production processes.

"The two main drivers of this project were the high wholesale power costs we have with FPU and the desire by Chesapeake Utilities to invest in an economically viable energy project," said Mark Cutshaw, director, business development and generation, FPU. "The CHP facility will produce electricity at a much lower cost than the current wholesale power cost."

He said the initial engineering and feasibility analysis included both natural gas-fired turbines and reciprocating engines from a variety of manufacturers. Detailed information — such as hourly electrical demand from FPU, hourly thermal load projections from Rayonier Performance Fibers, and local temperatures — was gathered. Models were then developed to determine which equipment provided the most efficient and cost-effective design based on local requirements.

"The Solar Turbines natural gas-fired Titan 250 equipped with a Rentech HRSG proved to be the most advantageous and efficient design," Cutshaw said. **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium: *www.understandingchp.com*

Caterpillar Inc.: *www.cat.com*

Broad USA Inc.: *www.broadusa.com*

Solar Turbines: *www.solarturbines.com/chp*

CHP's Spark Spread Over Competition =Economic No-Brainer

Combined heat and power is, by far, the most efficient way to produce power.

BY DREW ROBB

Energy efficiency is on everyone's mind. If you walk into an appliance store, every refrigerator has an ENERGY STAR® rating with detailed information on annual energy consumption and energy cost savings.

Similarly, every new car is graded in terms of mileage per gallon – and that makes a big difference to the price at the pump. On a grander scale, government policy is transforming the nation's energy mix. Coal-based power generation is gradually being phased out and replaced by renewable energy and clean natural gas-fired generation. Natural gas permits more practical options of harvesting and utilizing the waste heat than coal power production. While efficiency is good for the environment, it also lowers the overall cost of obtaining natural gas – for both producers and consumers.

How much more efficient is natural gas? According to the U.S. Energy Information Administration (EIA), electricity produced from coal is only 32 percent efficient. The reason for this is that energy is lost generating the power, transmitting that energy along high voltage lines and then distributing it to homes and businesses. By the time it reaches the consumer, more than two thirds of the energy is lost.

Natural gas-fired combined heat and power (CHP), on the other hand, can be close to 80 percent efficient. This is achieved through the capture and use of the heat that is generated during power production that otherwise would be wasted.

Additionally, the most efficient way to produce power is CHP. Also known as cogeneration, CHP entails the simultaneous production of electricity along with utilization of waste heat from the electric generator to produce steam or hot water, respectively, for a variety of purposes. This waste heat can be used to produce additional power generation in the case of a combined cycle power plant, heating a facility, hot water needs, cooling purposes, humidity control, or industrial processes.

What does this mean in economic terms? According to the EIA's Short Term Energy Outlook for Commercial Retail Energy Prices, assuming a cost of 11 cents per kilowatt hour (kWH), grid-based electricity works out to an estimated $32.36 per mmBTU in 2016. On the other hand, according to the agency, natural gas will average around $7.91 per mmBTU. In

PHOTO COURTESY OF SOLAR TURBINES

OSU used a 5.5 MW gas turbine and 1 MW steam turbine. The exhaust heat from the gas turbine is utilized for further power production and to produce steam for various uses within the facility.

other words, next year the estimated cost of natural gas will be four times cheaper than electricity from the grid.

EXCEEDING EXPECTATIONS

The sound economic case for CHP is borne out in the many companies that have adopted the technology. In the case of large CHP systems, the savings can be significant.

Take the case of Oregon State University (OSU). Its original steam plant was constructed in 1923 and expanded in 1948. Upgrading such an old facility would have cost $30 million. This turned out to be little more than it would cost to build an entirely new energy system. The university chose the latter option. But this decision had consequences, such as having to comply with Oregon's State Energy Efficiency Design. This demanding standard requires all new government buildings to exceed existing code efficiency requirements by at least 20 percent. But that wasn't enough for OSU. It decided to take it a stage further and raised project goals to meet Leadership in Energy and Environmental Design (LEED) Platinum requirements, something that had never been achieved by any power plant before.

"In an environmentally friendly state like Oregon, reducing emissions and eliminating energy waste are highly valued," said Amy Schulties, major accounts manager at OSU's natural gas utility provider NW Natural. "This CHP installation can also provide an educational benefit by serving as a living laboratory for OSU engineering students studying energy systems and building design."

The need for the highest possible levels of efficiency led OSU to implement a 5.5 MW Taurus 60 gas turbine from Solar Turbines in 2011. It works in conjunction with a 1 MW Elliott steam turbine, and a Rentech heat recovery steam generator (HRSG) to harness the exhaust heat from the gas turbine and transform it into further power production and steam.

"This is a highly efficient, almost no-loss energy and steam production system," said Les Walton, OSU's supervisor of energy operations. "While the old plant's efficiency level was around 82 percent, the new plant's efficiency is up to 92 percent."

The new OSU Energy Center provides all the necessary steam for the entire OSU campus, and half of the electrical needs of the campus. The plant can produce up to 6.5 MW of electricity, but typically runs at around 5.8 MW, and is capable of producing 250,000 pounds of steam per hour. The steam travels through a buried two-mile pipe to the main campus, where it is fed into the buildings. The steam is used for heating, cooling and humidification of these buildings. Hot water is used to sterilize soil in the greenhouses and support experiments that are temperature and humidity controlled.

"Our original expectations were to save up to $800,000 per year in energy costs by using CHP," Walton said. "But last year we saved around $2.6 million."

THE BIG PAYBACK

Another organization experiencing similar results is the Philadelphia College

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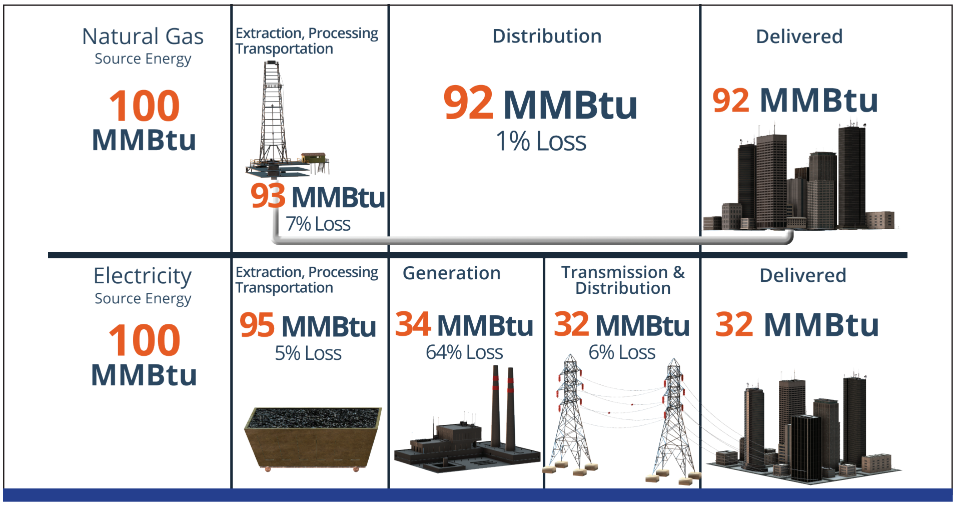
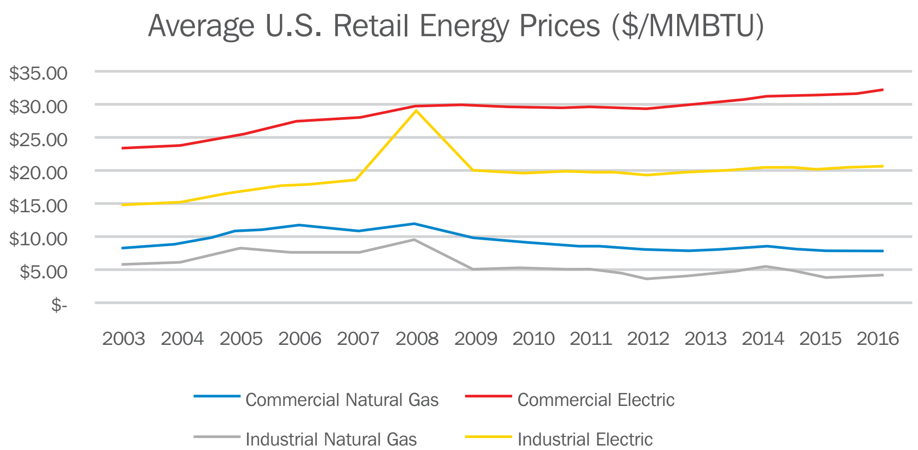


According to the U.S. Energy Information Administration, electricity produced from coal is only 32 percent efficient because energy is lost generating the power, transmitting that energy along high voltage lines and then distributing it to homes and businesses. Natural gas-fired combined heat and power (CHP), on the other hand, can be close to 80 percent efficient. This is achieved through the capture and use of the heat that is generated during power production that would otherwise be wasted.



SOURCE: ENERGY INFORMATION ADMINISTRATION, FOR 2003 THROUGH 2014. 2015 & 2016 FROM EIA SHORT TERM ENERGY OUTLOOK

PHOTO COURTESY OF SOLAR TURBINES

By instituting CHP, OSU saved $2.6 million in energy costs last year, surpassing an estimated $800,000.

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of Osteopathic Medicine (PCOM). When PCOM began looking for an energy solution to supplement power in its Rowland Hall Building, it explored technology that would reduce its carbon footprint. The college initially focused on solar and wind power; however, those technologies were not feasible.

"The payback would not have been favorable," said Frank Windle, chief facilities officer at PCOM.

After additional research, PCOM opted for a CHP plant using natural gas-fired microturbines.

"Microturbines provided an energy-efficient alternative that offered low emissions," Windle said.

The facility installed two 65 kW Capstone microturbines to power the building. Recaptured waste heat is used for hot water and heating. In addition to increased energy efficiency, Windle said the microturbines have few moving parts, and will operate 8,000 or more hours before needing any maintenance.

"PCOM has seen a significant reduction in energy demand since startup of the microturbines," said Windle. "If these results continue to yield favorably, we plan to expand the use of microturbines to other campus facilities."

The financial reward for installing CHP at PCOM could be significant.

"The savings from microturbine-based CHP could be up to 50 percent of overall electrical costs," said Sherif Youssef, director of major accounts at Philadelphia Gas Works, which supplies natural gas to PCOM. "Most CHP projects will have a payback period between four and six years."

CHP THRIVING IN ALL INDUSTRIES

But it is not only educational institutions that are turning to CHP. Paper mills, petrochemical plants, manufacturers, hotels, holiday resorts and other businesses have discovered that CHP is the best way to reduce energy costs, lower emissions and provide steam or hot water to serve their needs.

Eden Resorts, for example, a 301-room resort in Lancaster County, Pennsylvania, installed a 400 kW 2G Energy Inc. gas engine in 2014 to generate power for use within the facility, while also supplying steam and hot water. In this particular case, the company preferred a natural gas engine to a gas turbine.

"Each given technology has its pros and cons," said Dean Anton, a spokesperson for Eden Resorts. "For us, the gas engine is simple to understand, and easy from a service and maintenance standpoint."

The resort capitalizes on the waste heat from its gas engines. Energy from an engine or turbine is typically lost as the heat simply dissipates into the surrounding air or fluids such as water or oil. But a gas engine can make use of three different heat exchangers to take advantage of the waste heat – one in the exhaust heat, one in the lubrication system, and one in the cooling system. These heat exchangers aboard the CHP serve different areas of the resort – one for pool heating, one for the domestic hot water, and one for space heating. Each heat exchanger is configured to provide the defined temperature for the given output. The pre-existing, internal piping for each of those hot water sources then picks up the heat from the heat exchanger.

"CHP was principally an economical decision as the gas engine provided the best cost per output," Anton said.

SOUND ECONOMICS

As officials for these and many other facilities have discovered, CHP provides a reliable, dependable and economical way to generate power onsite while providing steam or hot water from waste heat. Capturing this waste heat not only increases overall efficiency, it offers a way to further boost power output, as well as heating, cooling, water heating, humidity control, and steam or water resources for a variety of industrial processes.

Further, CHP can be deployed at sites with relatively modest needs such as a small commercial facility to extremely large power needs of industrial customers. Those doing so can lower their energy costs and gain control of their electricity supply. Facilities located in vulnerable areas of the electric grid, for instance, are no longer dependent on the grid to continue critical business operations. Alternatively, CHP can provide backup generation in the event of a power cut or natural disaster.

In the vast majority of cases, CHP will prove to be far more efficient and cost effective than any other source of power. Indeed, making continuous use of both electricity and thermal energy can save up to 35 percent on overall energy costs. In the case of OSU, that added up to almost $3 million per year. But even smaller facilities, like PCOM and Eden Resorts, can realize considerable savings by making the transition to CHP. **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium: *www.understandingchp.com*

Energy Information Administration: *www.eia.gov*

Elliott Group: *www.elliott-turbo.com/Turbines*

Rentech Boiler Systems Inc.: *www.rentechboilers.com*

Capstone Turbine Corp.: *www.capstoneturbine.com*

2G Energy Inc.: *www.2g-energy.com*

Solar Turbines: *www.solarturbines.com/chp*

Turning Up the Heat

CHP creates free heat for more efficient energy use throughout a facility.

BY TONYA MCMURRAY

California's Playa Vista community of residential, retail, office and recreational space is designed with sustainability in mind. In fact, its emphasis on environmentally friendly technologies earned it the U.S. Environmental Protection Agency's ENERGY STAR® certification prior to construction.

Playa Vista's 25,000-square-foot community recreation facility, The Resort, contributes to its goal of zero energy with a mixed fuel approach using a 63 kW photovoltaic solar system and a natural gas combined heat and power (CHP) system with a 75 kW gas-fueled internal combustion engine.

The CHP system supplements the solar energy generation by providing electricity at night and on cloudy days. The heat generated by the CHP engine is captured and processed through a shell and tube heat exchanger to heat the resort's junior Olympic-size pool as well as the lounging and children's wading pools. The system reduces greenhouse gas emissions normally associated with the production of electricity and hot water.

The CHP system further reduces the total import power requirement, helping the resort get closer to a net zero energy goal, said Derek Fraychineaud, vice president, residential construction with Brookfield Residential, the project developer.

Playa Vista's managers expect its system to increase overall efficiency up to 80 percent and reduce greenhouse gas emissions by up to 50 percent. They expect to see annual energy savings of $10,000, said Joe Shiau of the Southern California Gas Emerging Technologies Program.

CHP'S EARLY PAYOFF

While Playa Vista relies on a mixed energy solution, many other facilities find that CHP alone provides the most cost-effective solution for creation of electricity and heat.

It was the promise of energy efficiency that led the Seaford School District to install a CHP system in a major facilities expansion. Encompassing 82 square miles in lower Delaware, the district serves about 3,500 students.

Seaford School District uses waste heat from its 100 kW Tecogen InVerde CHP system year-round to run an absorption-based cooling system during warmer weather and providing heat during cooler weather, said Roy Whitaker, chief of buildings and grounds for the district.

Although the system is not yet fully operational, the district has seen a 10 percent energy cost reduction, said Brian Zigmond, project manager at architectural and engineering firm Studio JAED.

"We expect that to rise pretty substantially, as the data taken thus far has included a portion of time when construction was still going on," he said. "We have yet to commission the system, as we're just bringing the last of the mechanical renovations online now. Overall, we expect a payback of around seven years on the total system." **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium: *www.understandingchp.com*

Tecogen® Inc.: *www.tecogen.com*

PHOTO COURTESY OF TECOGEN INC.

Seaford School District uses waste heat from its 100 kW Tecogen InVerde CHP system year-round to run an absorption-based cooling system during warmer weather and providing heat during cooler weather.

Weathering the Storm

CHP systems keep the power on during major outages.

BY TONYA MCMURRAY

Major weather events often leave thousands without power, forcing evacuations or creating risk for already vulnerable populations. But, as many East Coast facilities learned during 2012's Superstorm Sandy, combined heat and power (CHP) systems can provide a readily available backup system. CHP systems generate onsite electric power and heat from a single fuel source.

With a diameter of 1,100 miles, Superstorm Sandy caused major damage in the mid-Atlantic and northeastern United States when it hit land on October 29. At the peak of the storm, more than 8 million electrical utility customers were without power for several days, even weeks.

But facilities with CHP systems installed fared much better than those who relied on the electric power grid. While the grid was incapacitated, facilities with their own CHP-generated power supply were able to operate independent of the grid.

MISSION-CRITICAL OPERATIONS

Maintaining power during the storm was critical for the Long Island Home (LIH), which operates a 197-bed mental health and addiction treatment center and a 320-bed nursing and rehabilitation center in Albany, New York. LIH upgraded its CHP system in 2007 and converted from diesel fuel to natural gas to meet air quality standards. With its upgrade, LIH also made sure it would be able to be independent of the grid during any major outage, said John Rathbun, lead technical support consultant for National Grid.

LIH's CHP system meets all of the facility's electricity needs and energy needs. Rathbun notes that is somewhat unusual, as most CHP systems are sized according to the amount of heat needed, which often results in facilities still using the electric grid for some portion of their power needs.

Companies pay a little more to have a CHP system that can operate independent of the grid, but for many mission-critical operations – such as health care facilities – the investment is worth it, Rathbun said. Many of those facilities are already legally required to have emergency backup power to ensure lights and heat work, but the emergency systems may not power things like kitchen facilities or computers, which can be important during outages lasting more than a day or so.

That extra investment proved worthwhile for LIH, which isolated its facilities from the electric grid approximately 12 hours prior to Superstorm Sandy. For 15 days during and after the storm, LIH operated four 250 kW CPH engines, supplying all necessary power for its facilities.

While LIH could have reconnected to the grid sooner, the Long Island Power Authority (LIPA) requested it remain off the grid while the utility worked to stabilize power, Rathbun said. With LIH off the grid, the LIPA was able to focus on power restoration to area homes and businesses.

In nearby Connecticut, Danbury Hospital, a 371-bed comprehensive medical center, was able to operate without any loss of power throughout the storm and its aftermath. And in Clinton, New Jersey, the Hunterdon Developmental Center used its CHP system to provide power and heat to both a health services complex with living facilities and a correctional facility during the several days the surrounding area was without power.

All of those organizations used CHP systems powered by natural gas, a clean and readily available fuel source.

PHOTO COURTESY OF SOLAR TURBINES

Maintaining power is key to medical facilities like New York City's Montefiore Medical Center. During the worst electrical blackout in U.S. history in 2003, Montefiore Medical Center was the only hospital in New York City that continued to operate with full power, including air conditioning during the height of a heat wave. The medical center's CHP system is able to produce just over 9 megawatts of power while also producing steam that is used to warm buildings during the winter and cool the facility during the summer.

"The good thing was that natural gas was available throughout the storm in most locations," said Chris Lyons, manager, power generation for Solar Turbines. "What was in short supply was diesel fuel since many needed this to serve their backup generators."

EXTENDING AID

Many organizations provided shelter to their own employees and their families, offering a place to get a hot meal, take a hot shower or charge a cell phone to allow for communication with extended family members.

Because companies with CHP systems were up and running, many were able to offer support to the broader community during the storm. Sikorsky Aircraft Corp. in Stratford, Connecticut, used its helicopters to send needed supplies to others in the Northeast. LIH was able to refrigerate medication and charge electrical medical equipment for the community and provide care to patients evacuated from low lying facilities.

The Pepco Midtown Thermal Energy Plant in Atlantic City, New Jersey, is only a few blocks from the Atlantic Ocean and was in the center of the storm's path. But with its 6 MW Taurus 60 Solar® gas turbine CHP system, Pepco was able to continue providing power to many area hotels, which, in turn, were able to house their own employees as well as local residents and travelers during and after the storm.

New York University's CHP system not only provided uninterrupted electricity, heat and cooling to its central campus, but also allowed NYU to work with city officials to set up a command center at the university. The school also provided housing to area residents forced to evacuate their homes.

Superstorm Sandy is just one example where CHP systems have proven their effectiveness as a backup power supply. During the major Northeast blackout in August 2003, hot temperatures created an added threat for many mission-critical institutions. Facilities such as LIH, Bucknell University and the Montefiore Hospital in the Bronx were able to operate throughout the blackout because of CHP installations.

Rathbun adds that during the 2003 blackout, approximately 70 percent of standby generators failed. The failure of standby generators is often a risk during large-scale or long-term power outages because standby generators typically sit unused until they are needed during an outage.

"Some bigger facilities test their generators, but they turn them on for 15 minutes or so, and they don't usually test them at load. They turn them on to make sure they work, but they aren't at load running off the generator," Rathbun said. "Because your CHP system is in operation all the time, you know it's going to work. And if there is a problem, you're going to know it and be able to fix it before the lights go out."

Lyons said many CHP systems are also installed in hurricane-prone areas such as Louisiana. "In these areas, if a complex like a hospital is without power and has flooding, they can have severe damage issues such as mold," he said. "Having a CHP system that can operate allows power to pump out water and then climate control the building to avoid these type of after effects."

SUSTAINED POWER

Keeping power on for residential buildings became a priority for the city of Toronto after a 2013 ice storm left many without power for nearly two weeks. By law, Toronto buildings must have life-safety emergency generators capable of evacuating building occupants during outages. The city, however, is currently considering creating a "sustained occupancy" requirement for multi-family buildings to enable their tenants to better withstand long-term and wide-scale power outages, said James Kennedy, president and CEO of Magnolia Generation Inc., which provides combined heat and emergency power (CHeP) systems for condominiums, apartment buildings, and assisted living facilities.

"If you have thousands of people in a building during a large scale power outage, you need to be able to keep people in the building safely and comfortably. Sustained occupancy power allows people to stay in their buildings during a power outage, even if it lasts several days," Kennedy said.

PHOTO COURTESY OF MAGNOLIA GENERATION

A new CHP system for a Toronto condo will serve as an emergency backup generator during power outages while providing electricity, heat and hot water on an ongoing basis. The system, scheduled to be completed by November, is one of several similar projects underway in the city.

CHeP, he said, can provide a building's ongoing energy, heat, and hot water needs while also continuing to serve as an emergency generator during power outages.

"It provides a critical advantage for the safety and comfort of building tenants during long-term and wide-scale power outages that would otherwise force evacuation," Kennedy said. **CHP**

For more information about combined heat and power (CHP), go to:

CHP Consortium: *www.understandingchp.com*

Solar Turbines Inc.: *https://mysolar.cat.com*

Magnolia Generation Inc.: *www.magnoliagenerationinc.ca*

Solar Turbines: *www.solarturbines.com/chp*