Combined Heat and Power: A Successful Past Meets a Bright Future

Beth Burka, PE, CEM, CMVP
Energy Matters, Inc.

ABSTRACT

This article presents information related to the author's experience with combined heat and power (CHP) systems. Topics covered include: why and when to evaluate CHP, applications in a Midwestern city and utility policies that effect CHP applications. Studying successful, long-standing CHP applications, examining the benefits the owners received and current equipment/policies is an excellent starting point for evaluating CHP and making a good "case" for new projects. Gas transportation rates and electric curtailment programs are discussed and the concept of a tolling contract for CHP is introduced.

INTRODUCTION

Combined heat and power (CHP) is not a new technology. It has been around a long time and there are many successful case histories. This article describes several applications in St Louis, MO and the relevant gas and electric utility issues related to CHP applications. These systems were installed as far back as 1969 and as recently as around 2000.

The future is bright for CHP because we have:

- increasing end-user willingness to spend more capital for environmentally-friendly systems,
- standardized interconnection work by IEEE*,
- U.S. Department of Energy and Environmental Protection Agency support for CHP,

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*Institute of Electrical and Electronics Engineers.

- new packaged equipment, such as microturbines,
- greater end-user reliability needs,
- transmission-grid congestion and energy security issues,
- many available contracting and financing vehicles, such as design-build, performance contracting, third party outsourcing of equipment and, in some cases,
- electric utility support for distributed generation (DG).

WHY AND WHEN TO EVALUATE CHP

CHP is clearly a very efficient way to deliver energy to an end-user. It is the ultimate "do-it-yourself" energy conservation option.

Benefits

On-site power generation provides real value to a facility owner and has societal benefits as well. The equipment itself can be a valuable asset that can be managed to maximize the benefits received.

The primary benefits are:
- improved reliability and power quality
- greater energy efficiency and less pollution
- lower operating cost and price hedging
- benefits to other stakeholders.

Less pollution and greater efficiency are the primary societal benefits based on: the much higher source efficiency of natural gas delivery versus electric delivery, the relatively clean burning nature of natural gas versus coal, and the high site efficiency of CHP systems. Society also benefits in some ways from the avoided central plant capacity and transmission capacity from existing plants and distribution systems. Because of the benefits of generating power on-site, many groups of stakeholders are supporting the growth of this market.

Common estimated paybacks for CHP systems range from 6-20 years depending on many factors. Energy prices have risen and are more volatile, making it more difficult to predict what future energy prices will become and how each fuel/energy will be priced relative to the others. One strategy for dealing with this uncertainty is to keep as many options open to the facility owner as possible. Having multiple sources of energy serving the facility offers the flexibility to manage the energy needs in the best manner. CHP can offer this flexibility by increasing an owner's options.

Identifying Opportunities

Good opportunities for on-site power generation often exist where there is:

- an environmental mission or high reliability need
- a new or expanding facility
- a replacement of a central boiler plant, or emergency generators
- an undersized electric service or no electric service
- a high pressure steam loop with pressure reducing valves (PRV's) feeding a low pressure steam loop
- a coal and coal handling system that will be eliminated

For CHP, it is important that a facility have coincident electric and thermal needs or in some cases mechanical power and thermal needs. In these cases, if a new facility is being built or an existing facility is undergoing a major expansion, then a CHP system can be evaluated as an alternative to the traditional purchased utility electricity and on-site boiler plant to produce the two energy forms required. If the owner of the facility has an environmental mission or policy, it can be a positive.

Facilities with very large central steam plants may be candidates for new CHP systems if they distribute high pressure and low pressure steam loops and where pressure reducing valves are used to drop the steam pressure down. Steam turbines can be installed and the steam pressure is lowered by routing it through the turbine to produce electricity or shaft power. If the organization has decided to eliminate coal burning and the coal handling equipment, a CHP system can be considered versus a more traditional boiler-only system. If landfill gas is available, consider piping it to the end-user and installing a CHP system. This allows the use of a renewable fuel in a very efficient process that yields operating cost savings from offsetting both retail electricity and retail natural gas.

The best opportunity for CHP is in new or expanding facilities with central plants. These projects typically involve high capital costs, and the CHP system is an incremental cost increase where there is room to design in cost effective, comprehensive manner.

UTILITY ISSUES AND POLICIES

Utility policies effect CHP applications in many ways. The economics are affected by the "spark spread" between energy sources, relevant interconnection policies and natural gas pressure availability. Of course, economics are also affected by the equipment, operating and maintenance costs as well.

Energy Commodity Markets

The process of creating efficient markets for natural gas is complete and electricity is well underway. Natural gas has been deregulated and production has been separated from pipeline interstate distribution and from local distribution. The commodity is traded, there is a futures market and pricing information is published and readily available. The pipeline companies are regulated by FERC* and have tariff rates for moving the commodity.

The electric utility industry is under going a very similar regulatory shift. Production is being separated from transmission, which is being separated from the local distribution company. Independent power producers have built many new merchant power plants, FERC has mandated open access to transmission lines, regional transmission operators have been formed and FERC has proposed a standard market design for the pricing, control and operation of the transmission grid. Electricity is a more complex commodity because it can not be stored; however, it is also traded and there is a futures market. The wholesale market for electricity has led to greater congestion on the transmission system in this country and the grid is being operated in a manner for which it was not designed. Energy security issues are also being discussed.

Ownership of assets such as CHP systems will be valuable in a more volatile energy market and can be managed to lower cost or produce profit. One idea is for a CHP plant to charge a "tolling" fee to an end-user that brings an energy source, such as natural gas or landfill gas, to the CHP equipment to convert the fuel into electricity, steam or hot water and/or chilled water.

Local Natural Gas

There are a number of gas rates available to a CHP customer in

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*Federal Energy Regulatory Commission

St. Louis. In Missouri, the local distribution companies have tariff rates that include the commodity; however, large users are able to "transport" gas they purchase from brokers/marketers through the local distribution company's piping system. The owner procures natural gas from a broker and pays the local gas utility to deliver the gas to the building. This is known as a gas "transportation" rate. When buying gas from a broker, more flexible contracts can be made than when purchasing directly from the utility under a tariff rate. Contracts are typically month-ahead purchases based on published market pricing at specific locations but can also include price caps and other means of dealing with volatility.

An interruptible rate is a tariff rate for users with large connected gas loads and an alternate fuel source. The user's gas cost is lower all year if they have the ability to switch to the alternate fuel when called upon by the gas utility. The periods of interruption are typically during very cold weather but could occur for any reason. The seasonal rate is available for on-site power generators and those customers with gas cooling. From May through October, these customers purchase gas at the interruptible rate's commodity price (less than firm rate) because these users don't contribute to the utility system demand.

Another significant issue that affects CHP is the availability of higher than normal natural gas pressures.

Local Electricity

There are a number of electric policies that affect a CHP customer in St. Louis. One issue is whether supplemental or back-up service from the electric utility will be needed. If so, the utility will charge a minimum bill based on the maximum demand the utility could incur from this customer. This provision can significantly affect the economics of CHP.

The local electric utility also has voluntary curtailment riders for end-users with ability to curtail at least 500 kW of electric demand when requested by the utility on a "day-ahead" basis. The end-user is then credited on their next month's bill for the avoided energy at some calculation of market prices. Some of these end-users are credited something every month just for the option of calling upon the generators. In practice, customers with diesel emergency generators operate these generators to curtail load when requested and are paid for doing so but are not penalized for any increase in air pollution from these generators because of low operating hours.

Different rates are specified depending on the voltage of the electric service that the end-user takes from the utility. If the end-user is metered at primary voltage, then the rate charged is lower for demand and energy.

There are a number of other issues affecting CHP such as the utility's interconnection policy and the state regulations for purchasing excess power from qualifying facilities. A net metering law has been passed in Missouri for very small renewable systems only.

APPLICATIONS

There are a number of CHP installations in St. Louis. The graph below summarizes these and some of their attributes. (CCHP is combined cooling, heat and power, CHP is combined heat and power, DD is direct-drive, Sales refers to selling electricity).

Table 1. CHP IN ST. LOUIS

Facility	*Application Equipment*	*CCHP*	*CHP*	*DD*	*Sales*
Industrial Plant	Gas Turbine		X		
Auto Plant	Steam Turbine		X		
Office Building	Reciprocating Engine	X			
Data Center	Reciprocating Engine	*			X
Steam Loop	Gas or Steam Turbine		X		X
Sewage Plant	Reciprocating Engine		X		
Sewage Plant	Reciprocating Engine		X	X	

Grid-Isolated: Total Energy

A multi-story office building in St. Louis is served by an on-site total energy plant that was put into operation in 1969. This system continues to operate today with exemplary reliability and it serves the electrical, chilled water, heating and hot water needs of the building without any purchased electric service. It has six engine generator sets with heat recovery steam generators (HRSG's) that produce 15 psig steam. It has two engine-driven chillers as well as a base loaded absorption chiller.

Recently, they added a system to recover heat from the engine oil to heat the entry into the building and to become even more efficient.

Grid-Connected: On-Peak Only

A data center includes a diesel CHP plant that produces 30 psig steam and has both absorption and electric chillers. Off-peak the CHP system was shut down and all electricity was purchased from the local utility and heating needs were served by the local steam loop. The owner purchased large amounts of diesel fuel at reasonable rates (no road taxes for stationary applications).

This plant is no longer operational in CHP mode. It was operated 12 hours a day, 5 days a week, and the owner decided to stop operating in CHP mode and began participation in the electric utility's load curtailment program as described in the previous section. The owner receives a credit every month for the option of operating the generators and a market rate for energy not purchased from the utility during the requested curtailments.

Grid-Connected: Flexible

An industrial plant with a high pressure steam loop installed a 3 MW steam turbine as an alternative to pressure reducing valve where a large amount of high pressure steam is converted to low pressure through a pressure reducing valve (PRV).

The value it provides is the demand and energy savings associated with offsetting 3,000 kW of purchased electricity for a very small increase in steam usage and operating cost. They can select when it is most beneficial to use the steam turbine or switch to the PRV. They have at times operated it in conjunction with the local utilities curtailment riders and have been paid as if they were selling electricity at market prices by reducing their purchased amount.

Grid-Connected: Renewable

The local sewer company has two very interesting CHP sewage treatment plants that produce digester gas, which is used to operate reciprocating engine/generators at one plant and to direct-drive pumps and blowers at the other. The engine exhaust and jacket water heat is recovered and is used to heat the digestion process. The digester gas is supplemented with natural gas or propane and a very efficient energy process is the result.

Other Recent Projects

Other projects where CHP has been considered recently include an industrial process interested in the reliability of having on-site generators with lower operating costs and an environmentally-friendly image. Also for the same reasons, a project seeking certification per an environmental rating system considered CHP.

CONCLUSION

The past successes of CHP, the increasing reliability needs of companies as well as the increasing complexity of energy pricing structures indicate a bright future for CHP because it gives the owner an option under their control for fulfilling its energy needs. Ownership of assets such as CHP systems will be valuable, and they can be managed to lower cost or produce profit.

Large scale deployment of DG systems, of which CHP is one example, operating within the central plant/transmission grid network may prove to provide a more reliable, more flexible and lower cost electric supply.

ABOUT THE AUTHOR

Beth Burka started Energy Matters, Inc. in June 2005. Her 20 plus years of energy experience include over 14 years of experience with a gas utility including 5 years of technical marketing for on-site power generation including CHP systems. Prior to that, she worked for 5 years in new product development at an HVAC equipment manufacturer, several years in HVAC consulting, and while a student she worked for a coal company and a large equipment manufacturer. She was the first student selected by ASHRAE to participate in the Washington Internship for Students of Engineering (WISE) summer program in Washington, DC. She graduated from the University of Missouri-Rolla and Washington University. Ms. Berka may be contacted at *bburka@energymat.com*.