

# THE BUSINESS CASE FOR COMBINED HEAT AND POWER

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## ABSTRACT

In an environment of increasing energy prices and market volatility, combined heat and power (CHP) offers the energy manager both the potential for cost savings and increased flexibility to better deal with and respond to changes in energy markets. CHP should be viewed as a source of thermal energy that also produces power as a byproduct. In most cases, CHP will have difficulty competing with utility-scale generation in wholesale power markets, but can be attractive offsetting purchased power while increasing power reliability and constituting an important element in a corporate energy risk management portfolio.

## INTRODUCTION

Combined heat and power (CHP) systems can represent an important element in a corporate energy management strategy. While many firms focus on the cost of the power generated by a CHP system, it is important to remember that the CHP system also produces important thermal outputs that may be of greater importance to the firm than the power. In addition, a CHP system can offer other attributes such as fuel flexibility and enhanced reliability that have values that can far exceed the direct energy costs.

This article will focus on how CHP systems should be viewed as a part of a corporate energy strategy, what the benefits to the company can be, and how a firm should go about integrating CHP into their corporate energy plan.

## CHP FOR MAXIMUM ADVANTAGE

Many corporate energy managers view CHP (also known as cogeneration) as an electric power generation technology. This electric-centric perception stems from the "PURPA-QF" legacy that resulted from the initial burst of cogeneration activity resulting from the Public Utility Regulatory Policy Act (PURPA) of 1978. PURPA created a new market for non-utility electricity power generation that was embraced by many industrial and institutional facilities, with total installed CHP capacity increasing from less than 10,000 MW in 1980 to more than 46,000 MW by 1996. The focus was on generating power to sell to the local utility at "avoided cost" [Elliott and Spurr 1999]. By the mid-1990s electricity utility restructuring along with falling wholesale prices for power had made the PURPA model less attractive in many markets [Elliott, Shipley and Brown 2003]. As a result, a more thermally focused approach to sizing CHP facilities has emerged.

In today's marketplace, it frequently makes more sense to view the function of CHP systems as being able to produce thermal energy while simultaneously producing electric power as a valuable by product. This perspective derives from the fact that facilities rely upon on-site production of thermal energy (e.g., steam, hot water, chilled water), while they can procure power from the electric utility and the CHP system. As a thermal system, the CHP system satisfies a critical facility requirement; therefore, the thermal capacity needs to be sized to meet the thermal requirements of the facility. The evolution of technologies in the past quarter century have provided flexibility in design that was not available in 1980 when the primary CHP system technology was a boiler with steam turbine. Today, power to heat output ratios can be designed to range from 0.2 to greater than 2 [Elliott and Spurr 1999] allowing the systems to be sized to closely match both thermal and electric demands. In addition, the use of duct firing of the heat recovery steam generator allows for a degree of thermal load following not available in a conventional boiler/steam turbine system.

Sizing CHP systems to the thermal load means that most facilities will continue to purchase a significant fraction of their power from an outside provider. The highest value electricity is from displaced purchases of outside power, not from sales to the grid. The retail prices of purchased electricity are several times greater than the prices that can be obtained at all but the highest peak periods in the wholesale markets. For most facilities, the transaction costs of participating in wholesale markets

make generation of power for sale unattractive. As a result, the direct benefits of CHP are from the greater efficiency and displaced purchases of outside energy rather than from the sale of electric power.

#### PURCHASED ENERGY COST SAVINGS

As noted in the previous section, CHP systems offer the potential to displace purchased electricity. In contrast to electric-power-only distributed generation, CHP systems produce two valuable energy outputs. Thus the traditional concept of “spark spread(1)” may be less directly applicable to CHP. As noted above, the primary economic output of the CHP system is the thermal energy. In almost all cases this thermal energy would have to be produced on-site from a purchased fuel. So, this fuel would need to be purchased under any circumstance whether it was used in a conventional boiler or to fuel the CHP system. In the CHP system, incremental fuel is also purchased that should be allocated to power production. In most systems, this incremental fuel is converted to electricity at an efficiency that can exceed 80%, so the incremental cost to generate electricity may be quite low. As shown in Figure 1, this combination of power and thermal output from a single system almost always leads to high system efficiency [Elliott and Spurr 1999].

In addition to the inherent efficiency of CHP systems compared with separate heat and power, many new CHP facilities will be replacing older boilers that may be less efficient than contemporary designs or are now significantly oversized for current loads. The average industrial and institutional boiler is now over 50 years old [Elliott and Spurr 1999]. On some occasions the total fuel for the CHP system may be less than the fuel required for the existing boiler.

Even greater cost savings can be realized if the facility has access to a low-cost waste fuel such as waste wood, anaerobic wastewater digester gas, land fill gas, or industrial process (e.g., refiners or blast furnace gas). While the potential for using “recycled energy” to fuel a CHP system is site specific, nationally the potential appears quite large [Casten and Collins 2003].

#### OTHER REASONS FOR CONSIDERING CHP

Energy cost savings are usually the primary focus of the economic analysis. However, for many applications the benefits from enhanced

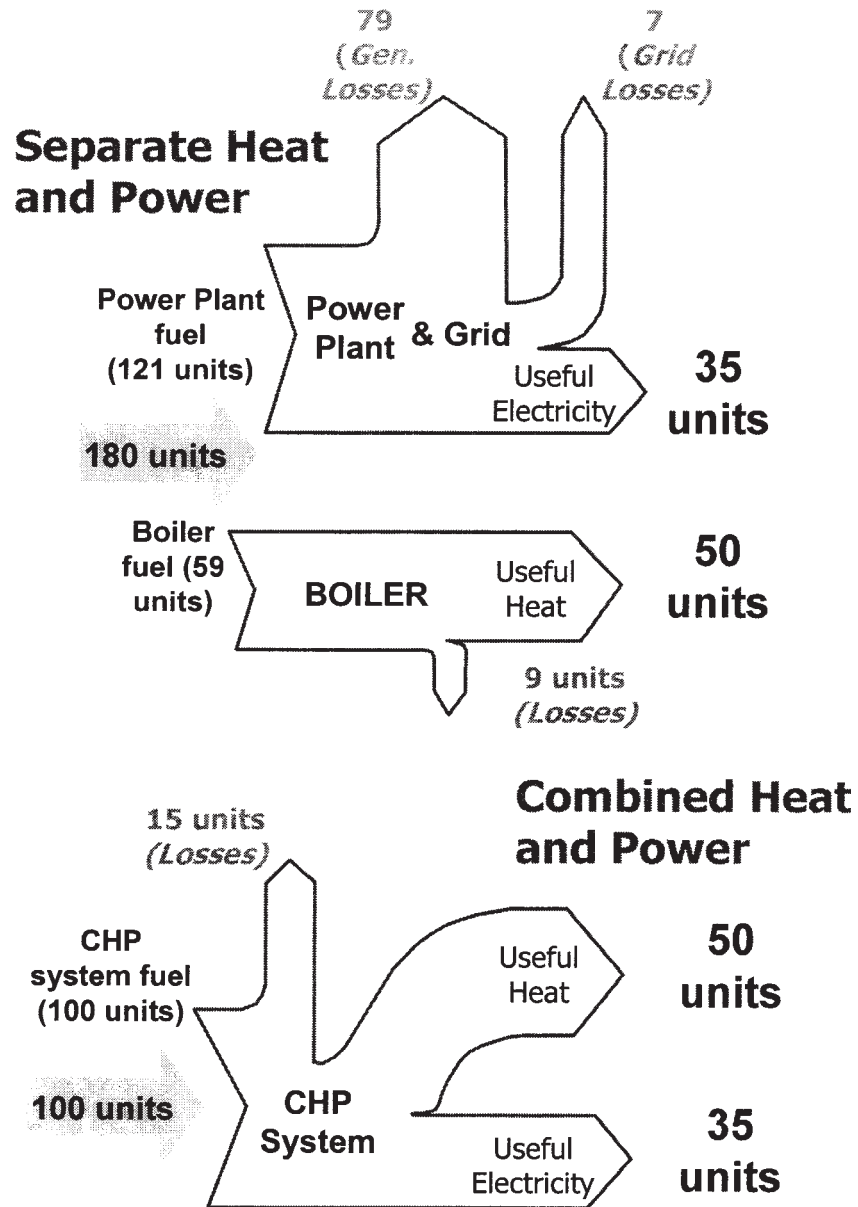


Figure 1. Comparison energy flows in CHP and separate heat and power systems.

reliability, energy flexibility and management of energy price volatility may ultimately be of greater value than the energy cost savings alone. The business case for considering CHP should be based on the total economic benefits of the system to the firm.

### **Reliability**

Having access to on-site power can significantly improve reliability of energy supplies. While in the mid-1990s reliability concerns were the primary focus of high-tech industries (Elliot and Spurr 1999, and Brown, Elliott and Shipley 2001), the events of the past three years with the rolling blackouts in California in the spring of 2001, and the August 14, 2003 blackout that hit significant portions of the Northeastern and Mid-western United States and Eastern Canada have made reliability a concern for all companies.

Having on-site generation can also stabilize facility voltage, improve power quality at the site, and provide a backup source of power in the event of a grid outage. These attributes, complemented by other power reliability equipment (e.g., uninterruptible power supplies) can reduce nuisance power interruptions and allow continued facility operation in the event of extended grid outages.

Unfortunately, as some cogenerators discovered on August 14, 2003, having a CHP facility does not mean that it can operate when the grid is down. Many of these facilities had not invested in the additional equipment needed for "islanded" operation, and when the grid went down, they were left in the dark as well. Many of these firms are now looking at upgrading their system for independent operation.

The challenge of providing increased reliability is complicated by utility interconnection rules that may not allow parallel synchronous operation of the generator [Brown and Elliott 2003]. Several creative options however exist to get around this problem. These include:

- Providing switchgear that allows the generator to be restarted isolated from the grid in the event of a grid power failure
- Using the on-site power for a dedicated critical load (or "emergency") buss, and installing switch gear to provide backup for these loads using either grid power or an emergency generator.

### **Energy Flexibility**

Energy prices volatility is again becoming a reality that facility energy and business managers will be faced with for the foreseeable

future. Both oil and natural gas prices have seen increased volatility and more than a doubling in price since the mid-1990s (see Figure 2). These fuel price increase coupled with increased demand have begun to increase electricity prices, particularly peak prices in regions with a significant share of natural gas generation [Elliott, Shipley, Nadel and Brown 2003].

A properly designed and sized CHP system can afford greater flexibility to a facility to manage its energy demand by switching fuels, shifting loads and shaving peaks depending upon economic conditions. If the facility has access to a renewable or waste energy source, this can further shield the facility from price volatility and uncertainty because these energy streams are, for the most part, isolated from energy market fluctuations.

#### **CHP's Role in a Risk Management Portfolio**

Volatility in energy prices will likely be a reality for the foreseeable future. Historically, the approach to managing energy price uncertainty has been to use financial instruments such as forwards or fixed price contracts, combined with on-site storage of fuel. As a result of recent turmoil in energy markets, these markets are currently undercapitalized [FERC 2003], so it is increasingly expensive (if not impossible) to lock in energy prices for the future. As a result, some experts like E Source, are advising clients to add efficiency and renewable energy to their risk management portfolios. "Energy efficiency and renewable energy reduce consumption, and thereby reduce future energy cost exposure," wrote Paul Komor [2004] in a recent report. Clearly CHP is an important energy efficiency strategy, and if it is fueled by a renewable energy resource, it can be even more beneficial.

With the uncertain future for energy markets [Elliott, Shipley, Nadel and Brown 2003], energy-price risk management will become an important element of the corporate energy managers' responsibility in the future, and it will be important to evaluate CHP in that context.

#### **CONCLUSIONS**

CHP is not for everyone. However, for many facilities, CHP can be an important element of their energy management portfolio. It is important to approach CHP as primarily a thermal application that produces

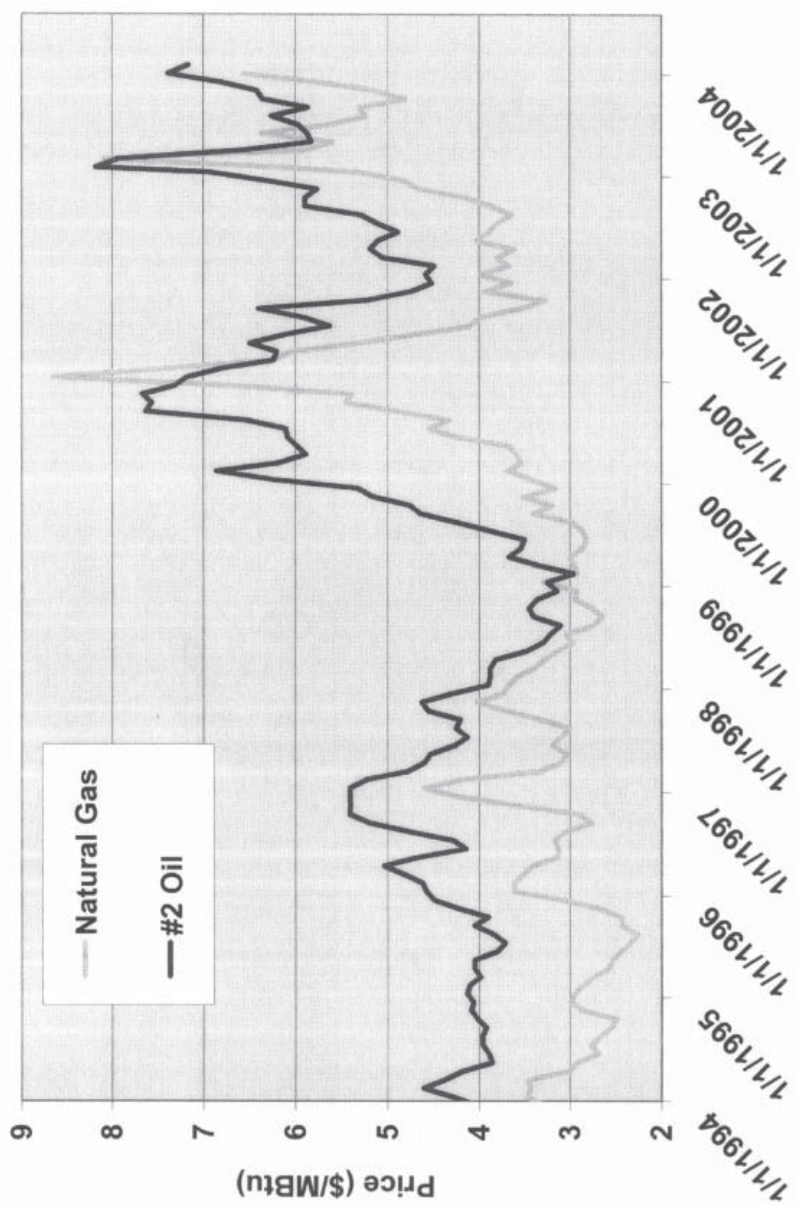


Figure 2. National average monthly purchase price of industrial natural gas and #2 fuel oil [Source: ACEEE from EIA 2004]

power as a by-product. If the system is viewed from that perspective, the power generated by the CHP system will usually be competitive with displaced grid-purchased electricity because of the systems' high fuel conversion efficiency.

Energy cost savings should not be the only financial criteria for evaluating investments in CHP. Other benefits such as enhanced reliability, energy flexibility and management of energy price volatility are frequently a more important element of the business case for CHP than simple cost savings.

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**Footnote**

(1) Spark spread is defined as the difference between the cost of purchased electricity and the cost to generate electricity from a purchased fuel on site.