WHITE PAPER

# COMBINED HEAT AND POWER:

## REAPING THE BENEFITS OF CHANGED MARKET CONDITIONS

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Conventional wisdom has long held that the most cost-effective and reliable source of energy is the utility grid — arguably humanity's largest and most complex machine.

Although many hospitals and other critical facilities would prefer to control their destinies by generating their own power, reliable on-site power generation systems have always been too complex or too costly to justify. But thanks to advances in technology, weaknesses in the utility grid and a dynamic utility market, Burns & McDonnell has helped an increasing number of clients reap the benefits of combined heat and power (CHP)[1] systems.

Burns & McDonnell recently partnered with two healthcare providers to design and build new facilities with on-site CHP modules that provide self-sufficient primary power: the Dell Children's Medical Center of Central Texas, a 475,000-square-foot, 176-bed, $200 million facility in Austin that opened in 2007; and Shands HealthCare, a 200-bed cancer hospital in Gainesville, Fla., scheduled to open in late 2009. Each is powered by a CHP system with a natural gas-fired combustion turbine that generates electricity on-site.

Burns & McDonnell is one of only seven companies — and the only engineering and construction firm — selected by the U.S. Department of Energy to develop on-site energy CHP systems.

There are at least five major reasons that healthcare facilities benefit from CHP systems.

[1] CHP is sometimes referred to as cooling, heating and power because the waste heat from the combustion turbine can also be used to provide essentially free cooling by using a steam turbine chiller or steam absorption chiller.



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The Gainesville Regional Utilities (GRU) South Energy Center will provide off-the-grid, high-quality power to the Shands Cancer Center, a 200-bed facility.

## LIFE CYCLE COST

Traditionally, hospitals rely on the utility grid for electricity. However, in recent years, CHP technology and design approaches have advanced, as have industry attitudes, making CHP systems affordable and justifiable in many locations.

For example, the relatively small 5-megawatt (MW) combustion turbines, which are designed for use in hospital-sized CHP applications, only recently have become available to the market. These turbines are optimized to provide power for approximately 500,000-square-foot facilities that are in continual operation, such as modern urban hospitals.

While the initial construction of a CHP plant with a combustion turbine typically costs approximately 20 percent more than a traditional central utility plant, CHPs can save facilities 25 percent to 40 percent on their annual utility costs. The savings is determined by many factors, including the differential utility cost between electricity and natural gas, the comparison of the electric and thermal loads of the facility, and the scheduled operation of the facility.

CHP TECHNOLOGY AND DESIGN APPROACHES HAVE ADVANCED, MAKING CHP SYSTEMS MORE AFFORDABLE AND JUSTIFIABLE.

The savings is generated because the waste heat from the combustion turbine is used very efficiently

to provide essentially free steam for building heating and hospital processes such as kitchen heating equipment, sterilizers, pool heating and humidification. The free steam also can be used to generate chilled water through a steam turbine or steam absorption chiller. For instance, a nominal 5 MW turbine can provide enough waste heat to provide up to 59,000 pounds per hour of steam or up to 1,200 tons of chilled water without additional energy input. That produces significant savings over the life of the facility.

## RELIABILITY AND REDUNDANCY

Yet despite the significant savings, the best value of a CHP plant may not be its attractive life cycle cost but rather the reliability and redundancy it offers. This is best illustrated by remembering some high-profile events that occurred between 2001 and 2005.

During that time, America suffered three of its worst domestic disasters: the terrorist attacks on Sept. 11, 2001; the massive Northeast Blackout on Aug. 14, 2003; and Hurricane Katrina in Louisiana and Mississippi in August 2005. Those events demonstrated the importance of electric and thermal energy flows to essential facilities in times of extended crisis. People naturally assume hospitals will be safe havens during events of this scale.

Hospitals traditionally use diesel engine generators to provide the code-required emergency and essential back-up power requirements. However, periodically operated generators running on stored fuel oil are less than reliable for extended (or even short-term) operations. Research has demonstrated that a CHP system with grid backup is more reliable than the traditional grid-plus-backup approach, in which emergency diesel generators statistically fail 67 percent of the time during power outages exceeding 24 hours.[2] As a result, once an electrical grid goes down for an extended period, traditional facilities are often left without power to provide for patients' physical and psychological well-being.

In addition, most healthcare facilities have emergency power available for only the minimum code-required emergency and essential power systems during a utility grid outage. Yet modern digital hospitals need more than minimal emergency power during extended


The CHP system at Dell Children's Medical Center made it one of the first grid-independent hospitals in the nation.

[2] Source: Primen Perspective's "Rx for Health Care Power Failures: Improving Patient Care While Growing Energy Service Provider Revenue," DE-PP-24, 11/2003.



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electrical outages if they are to provide adequate care. They must have access to nearly 100 percent of their normal power in the event of an extended utility grid failure. Further, the cooling systems in a traditional hospital typically are not connected to the emergency generators. Imagine trying to operate a hospital without air conditioning for an extended period in a hot, humid climate.

The combustion turbine is the heart of a CHP plant.

In contrast, CHP systems typically are designed to generate and deliver 100 percent of the hospital's power whether the CHPs are connected to the local utility grids or operating in island mode, in which they are fully independent of the electrical grid.

This approach transforms the local electrical grid from a primary source of energy to a backup source, creating a facility with two highly reliable and wholly redundant power sources. For the Texas and Florida projects, Burns & McDonnell designed the hospitals to have connectivity from two different utility substations. Therefore, as long as a facility's CHP or either substation is operational, all hospital power and equipment, as well as every wall outlet, continue to run during both normal and emergency conditions. This far exceeds the current code requirements but meets the expectations of the community, as well as the needs of 21st century medical diagnostics and treatment.

## STABLE POWER

In addition to reliable power, digital equipment in modern hospitals requires stable power — power relatively free of voltage sags, surges and spikes.

The ugly truth is that power from the utility grid is often too inconsistent and uneven, or dirty, for sensitive digital equipment, especially in urban areas with aging and unreliable electrical distribution systems. Many things cause grid power flow to sag and surge, such as damage to transformers or utility substations, ice storms that knock down power lines, and natural interruptions such as lightning strikes.

## CHP PLANTS USE ABOUT 250 PERCENT LESS FOSSIL FUEL RESOURCES THAN A TRADITIONAL CENTRAL UTILITY PLANT.

In order to overcome these power instabilities, most hospitals install power conditioners and uninterruptible power supply units (UPSs). These typically serve equipment highly sensitive to voltage fluctuations or involved in a treatment that cannot be interrupted.

In contrast, power from CHP is very consistent and stable. The short distance from a CHP to its customer greatly reduces the likelihood of interference to the power flow. In addition, a CHP can help maintain consistent voltage levels to a facility even as the demand fluctuates throughout a typical day.

### GREEN POWER

Power from a CHP is also more environmentally friendly than power from the electrical grid.

In the United States, the primary fuel conversion to useful energy efficiency is a relatively low and unimpressive 29 percent. That is, for every BTU (a unit of heat energy) of fuel consumed, only about 29 percent generates electricity that is usable at a customer's meter. The rest of the BTU is lost either as waste heat to the atmosphere due to the inefficiencies of electrical generation or to electrical resistance over transmission and distribution systems.

In contrast, since CHP systems generate electricity on site, power is immediately used by customers with minimal transmission and distribution losses.

Since the waste heat generated by combustion turbines is effectively used to produce steam or chilled water, CHP systems achieve energy efficiency rates of 70 percent to 85 percent. That means CHP plants use approximately 250 percent less fossil fuel resources than a traditional on-site central utility

The GRU South Energy Center and other CHP systems provide improved energy efficiency compared to a traditional central generation plant by using waste heat to produce steam or chilled water.



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The GRU South Energy Center achieves reductions in nitrogen oxide, carbon dioxide and sulfur dioxide emissions.

plant with natural gas packaged boilers and electric centrifugal chillers fed from the local utility system. Thanks to the advanced technology and high efficiency of modern combustion turbines, CHPs also generate lower emissions than a traditional electrical power plant. For example, the Shands HealthCare CHP system produces 95 percent less nitrogen oxides, nearly 100 percent less sulfur dioxide and 58 percent less carbon dioxide when compared to a central utility plant powered by fossil fuel and the utility grid.

This carbon dioxide reduction is equal to the annual carbon stored by 5,446 acres of pine and fir forests or the carbon emissions of 4,365 passenger vehicles per year, as calculated by the U.S. Environmental Protection Agency (EPA) CHP Emission Calculator. Further evidence of the CHP's environmentally friendly operation is that in 2009 the Dell Children's Medical Center became the first U.S. hospital to be awarded Leadership in Energy and Environmental Design (LEED®) Platinum Certification by the U.S. Green Building Council. The CHP plant contributed eight out of a possible 10 Energy & Atmosphere Credit points toward that certification.

## POTENTIAL COST SHARING

It is easy to see why the U.S. government is encouraging more on-site power generation. The

International Energy Agency's 2008 World Energy Outlook says world energy demand will grow by two-thirds over the next 30 years, with fossil fuels meeting 90 percent of the increase.

The current model of centralized energy production is only about 29 percent efficient at converting fossil fuels to usable energy. No other major industry is less efficient at converting raw materials to usable product. This is mainly because the utility industry has not had the incentive to improve efficiency over the past 50 years since the cost of producing power has been passed on to users. Governmental agencies such as the Department of Energy and the EPA are tightening restrictions on emissions, which will continue to increase electricity costs.

LOCAL UTILITIES HAVE DEMONSTRATED A NEW WILLINGNESS TO PARTNER FINANCIALLY ON CHP FACILITIES.

In order to encourage more efficient and environmentally friendly power generation, these governmental agencies have recently demonstrated their support for CHP generation by providing federal grant assistance toward construction costs.

Burns & McDonnell brought more than $4 million in federal assistance to the Texas and Florida projects. Local utilities also have demonstrated a new willingness to partner financially on CHP facilities. Even though the CHP projects in Texas and Florida provide service to just one client each, both local utility companies partnered with those healthcare providers to purchase and operate the CHP systems. These facilities help those utility companies fulfill their mission of providing power to their customers, and any excess power goes back to the utility grid.

Each of these relationships reduced the CHP installation costs for the Texas and Florida hospitals, making their annual utility savings even more significant.

Although the concept of CHP has been around for decades, the future will see CHP systems become a common option for healthcare and other facilities that require reliable, stable and cost-effective power. Burns & McDonnell has demonstrated its competency with this technology, as well as its ability to partner with its clients to design and build these more reliable and energy-efficient facilities.

The first step in considering a CHP for a new or replacement healthcare facility is a feasibility study. This relatively low-cost exploratory step identifies the expected power demands and energy options of a proposed hospital and provides an evaluation of local utility services.



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