U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Hospitals Discover Advantages to Using CHP Systems

Combined heat and power systems—also known as cogeneration systems—use a heat engine or power station to simultaneously generate both electricity and heat. They convert waste heat from electrical generation into energy that can be used for heating and cooling. More than 200 hospitals nationwide operate CHP systems.[1]

The number of hospitals using CHP systems has grown steadily[2] in recent years. Hospitals using cogeneration are taking advantage of favorable utility rate structures and hedging against rising electricity prices. Because cogeneration uses waste heat to produce thermal energy for heating and cooling, hospitals that use CHP systems are more energy efficient. Reduced emissions lessen their impact on the environment as well. This fact sheet has been developed by the U.S. Department of Energy's Hospital Energy Alliance to assist hospitals in planning, designing, and constructing energy-efficient, cost-effective combined heat and power systems.

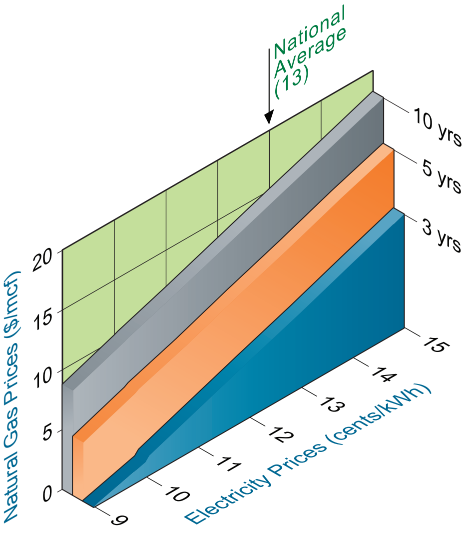
Financial Advantages

CHP often can offer financial advantages over power purchased from a local utility or produced by other energy systems. Those advantages follow.

Hospitals are ideal candidates for combined heat and power (CHP) systems. Because hospitals function 365 days a year, 24/7, they require round-the-clock energy. Combined systems enable hospitals to reduce energy costs, improve environmental performance, and increase energy reliability. Resources saved are often redirected to improve patient care.

- *Lower, more predictable energy bills*: Total system energy efficiency is improved when power is produced onsite through a CHP system. Annual operations and maintenance savings can average more than $400,000[3] for a 2 MW gas turbine system. By enabling hospitals to supply their own power, CHP systems also provide a hedge against the rising cost of electricity.
- *Increased revenue potential*: In some states, CHP can create an additional revenue stream by allowing hospitals to sell surplus electricity back to their utilities. A hospital's ability to do this depends on the net metering and rate policies of its utility. Typically, "selling back" during off-peak hours is not profitable for a hospital, but, given the right circumstances, it can be a revenue generator during peak hours.

CHP systems often can be installed for less cost upfront than renewable energy options—such as photovoltaic systems—of a similar scale. When matched to suitable loads, some CHP systems can provide a simple payback in the five- to 10-year range, depending on system size and energy costs.[4]



Shown here are natural gas and electricity prices needed to achieve three-, five-, and 10-year simple paybacks for a 2 MW CHP system. At an electricity price of 13 cents/kWh, a five-year simple payback can be achieved when natural gas prices are less than $11.25/mcf.

This analysis assumes a construction cost of $2,000 per kilowatt. See http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html for average retail electricity price data by region and state.

1. Midwest CHP Application Center and Oak Ridge National Laboratory. http://www.chpcentermw.org/06-01_application.html.
2. Report on National Center for Energy Management and Building Technologies Task 15, 2005.
3. 2 MW CHP operating at 10k Btu/kWh for 8,322 hrs/yr with 5 MMBtu/hr recoverable, capital cost of $2,000/kW, O&M cost of $0.011/kWh, and given U.S. average gas prices of $9.78/MMBtu and electricity prices of 10.12 cents/kWh. (See graph at right.)
4. Given average system of 2 MW with $1,500–$2,000/kW installed cost, and national U.S. energy prices. (See graph at right.)

Commercial Building Initiative

More Reliable Emergency Power

Hospitals must perform critical, life-saving functions even when a widespread disaster interrupts their supply of natural gas and electricity from the utility grid. CHP systems can be designed to maintain critical life-support systems, operate independently of the grid during emergencies, and be capable of black start (the ability to come online without relying on external energy sources). Because they are already up and running, CHP systems can offer a more seamless, reliable power alternative than traditional emergency generators. During the New York City blackout of 2003, half of the 58 metropolitan hospitals had failures in their backup power generators.[5] CHP systems, however, are not automatically configured for backup capability; hospitals must ensure that the systems have automatic transfer capability and that output can be matched with demand.

Environmental Benefits

CHP systems have a higher whole-system efficiency than systems that split heating and power generation because cogeneration captures waste heat from electricity generation and uses it to generate steam for heating and cooling. With less fuel consumed, greenhouse gases (such as carbon dioxide) and air pollutants (like nitrogen oxides and sulfur dioxides) are reduced; for a 5 MW CHP plant, emissions generally are reduced by more than 25,000 tons per year (see chart at right).

By using cleaner feedstocks, such as some forms of biogas and biomass, CHP systems can in some cases produce fewer emissions than those utilizing traditional fuels. These environmental benefits should be quantified and factored into the total cost of the CHP system. For an example of how to perform this type of analysis, see Practice Greenhealth's energy impact calculator at http://practicegreenhealth.org/tools-resources/energy-impact-calculator.

5. From Energy and Environmental Analysis, Inc., for the U.S. Department of Energy Oak Ridge National Laboratory, June 2004.

Case Study

NewYork-Presbyterian Hospital

New York, New York • Completed in 2009

Details

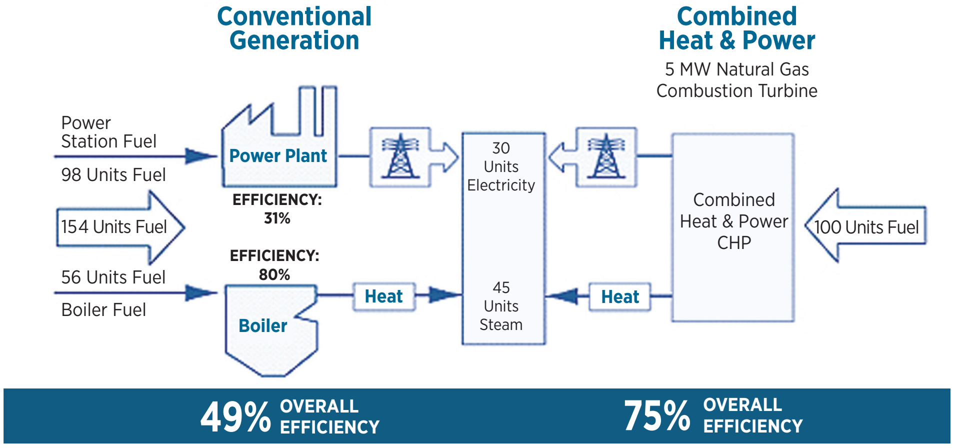
- The CHP plant has a gas turbine drive, a 7,500 kW electric generator, and a heat recovery boiler with duct firing.
- The onsite system operates in a synchronous parallel configuration with the utility grid; supplemental electric energy is provided by Consolidated Edison under normal operating conditions.
- Installation was simplified because the system was designed to fit into the existing boiler plant location.
- The hospital takes advantage of Consolidated Edison's rate structure that promotes use of clean cogeneration.

NewYork-Presbyterian Hospital/Weill Cornell Medical Center determined that major operational and cost benefits would result from installing a CHP system in its existing boiler plant. The hospital took advantage of state and utility incentives to construct a cost-effective and environmentally friendly system.

Expected Results

- Will save the hospital approximately $5 million per year.
- Will generate 100 percent of the hospital's base electrical load and two-thirds of its peak electrical load.
- Will reduce the hospital's purchased power by 80 percent.
- Will increase firm steam capacity by 23 percent.
- Will reduce CO_2 produced by 67,000 tons annually.
- Will provide a 100 percent redundant power source for inpatient areas.

CHP Systems Decrease Harmful Emissions



Source: EPA Conventional Generation vs. CHP Report, http://www.epa.gov/chp/basic/environmental.html.

Important Factors to Consider

CHP systems are not for every hospital. Their cost-effectiveness needs to be evaluated on a case-by-case basis. In determining a CHP system's viability, there are several important considerations:

- *Incentives and rate structures*: Many utilities are implementing "friendly tariffs" that facilitate CHP. Some utilities charge hospitals a standby rate, so that the utility can provide the infrastructure to support all of a hospital system's load in the event that the cogeneration plant should fail. Interconnection agreements, siting issues, and permits all should be discussed with the partnering utility. Local and national incentives—including direct financial grants, tax incentives, and low-interest loans—should be determined. See the U.S. Department of Energy's Database of State Incentives for Renewables and Efficiency: www.dsireusa.org/library/includes/techno.cfm?EE=1&RE=1.
- *Black start capability*: Hospital CHP systems should be configured for black start, or the ability to come online without relying on the electric grid. This involves extra equipment, such as a battery pack, but enables hospitals to operate effectively during times of crisis.
- *Prime mover type*: Designers must choose equipment that best fits the hospital's thermal and electrical loads and power quality requirements.

Hospitals must consider incentives and rate structures, black start capability, and prime mover types.

Case Study

Dell Children's Medical Center of Central Texas

Austin, Texas • Completed in 2007

Details

- A 4.3 MW gas-fired turbine was installed in a new 35,000-square-foot utility plant.
- Construction cost was $18 million.
- Two independent electrical feeders provide a backup for the onsite generation.
- An emergency generator (for black start capability) provides another backup for life-safety systems.

Results

- The system generates all of the hospital's electricity.
- The plant is 75 percent more efficient than coal-fired power plants.
- Waste heat from the gas turbine is used to produce steam and chilled water used directly by the hospital.
- Enhanced quality of power ensures smooth, continuous operation of clinical equipment.
- Excess electricity is exported to the utility grid.
- The hospital experienced gross savings of $6.8 million in construction costs and reinvested $5.8 million in additional energy conservation measures.
- The project earned 10 points in LEED EA1 efficiency credit.
- The CHP system and reduced energy use enable the hospital to exceed ASHRAE 90.1 standards by more than 60 percent—as opposed to approximately 17 percent without CHP.

Dell Children's Medical Center of Central Texas is a 509,000-square-foot, 176-bed hospital built in 2007. Dell Children's is the first hospital in the world to be awarded LEED Platinum certification. The hospital's parent company collaborated with municipal utility Austin Energy to build a district energy plant on the hospital site. The cogeneration system at the heart of the plant enables Dell Children's to be one of the first hospitals in Texas to use an onsite energy system as its primary source of electricity, with the grid as its backup.

Which Prime Mover is Right for You?

Because circumstances vary, hospitals need to determine which prime mover type suits them best:

- Gas turbines: Gas turbines are commonly used in hospitals and other large facilities because of their light weight, quick startup, and size. Simple cycle or combined cycle turbines can be used to generate a base electricity load.
- Microturbines: Microturbines are smaller than industrial-sized gas turbines. They are particularly useful for CHP projects that require scalability, allowing for modular buildout of the system.
- Reciprocating engines: Reciprocating, or internal combustion, engines create power from spark-ignited or compressed-ignited engines. They typically use natural gas, diesel oil, or biofuels. These engines are good for small-scale CHP systems, and with their fast start times, they can be useful as backup energy systems.
- Fuel cells: Fuel cells are relatively new to commercial CHP use. Carbon dioxide emissions are low during operation, but life-cycle emissions vary with fuel type.

Comparison of Prime Movers[6]

CHP Prime Mover	Capacity Range (kW)	Electric Generation Efficiency		Installed Cost ($/kW)	O&M Costs ($/kWh)
		% (of LHV)	Heat Rate (Btu/kWh)		
Reciprocating Engines	100–500	24–28	12,000–14,000	1,400–1,800	0.012–0.015
	500–2,000	28–38	9,000–12,000	1,000–1,400	0.010–0.012
Gas Turbines	1,000–10,000	24–28	12,000–14,000	1,000–1,500	0.007–0.008
	10,000–50,000	31–36	9,500–11,000	800–1,000	0.005–0.008
Microturbines	100–400	25–30	11,400–13,700	1,000–2,000	0.010–0.015

Fuel cells are another viable prime mover type. Capacity ranges, efficiencies, and costs vary among types of fuel cells, which include phosphoric acid (PAFC), solid oxide (SOFC), molten carbonate (MCFC), and proton exchange membrane (PEMFC). For more information about the use of fuel cells in CHP applications, visit http://www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/index.html.

6. Midwest CHP Application Center and U.S. Department of Energy. *Combined Heat and Power (CHP) Resource Guide for Hospital Applications, 2007.* Appendix A1.1 – PRIME MOVERS.

Hospital Energy Alliance

HEA is a forum in which healthcare leaders work together with DOE, its national laboratories, and national building organizations to accelerate market adoption of advanced energy strategies and technologies.

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Commercial Building Initiative

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