CHP (Cooling, Heating, and Power) AT THE MISSISSIPPI BAPTIST MEDICAL CENTER

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INTRODUCTION

Mississippi Baptist Medical Center (MBMC) is a 624-bed urban hospital employing 3,000 including 497 medical personnel. The facility has large electricity and steam requirements, a centralized physical plant, and small daily variations in energy usage. Thus, conditions are favorable for cogeneration. In 1991, MBMC decided to install a CHP system with the hopes of meeting a large portion of the facility's electricity and steam requirements. The system consists of a natural gas turbine generator set, diverter valve, waste heat recovery boiler, economizer, and two double effect steam absorption chillers and was designed to provide MBMC with 80% of its total electrical needs, 95% of its steam demand, and 75% of its cooling needs.

SYSTEM DESCRIPTION

A flowchart and schematic illustrating the CHP system are presented in Figures 1 and 2, respectively.

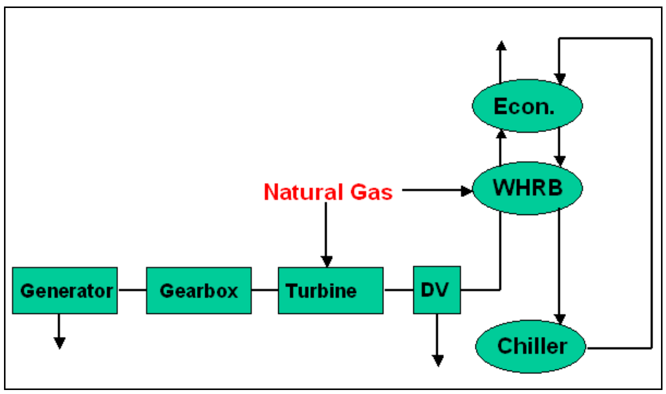

Figure 1 System Flowchart

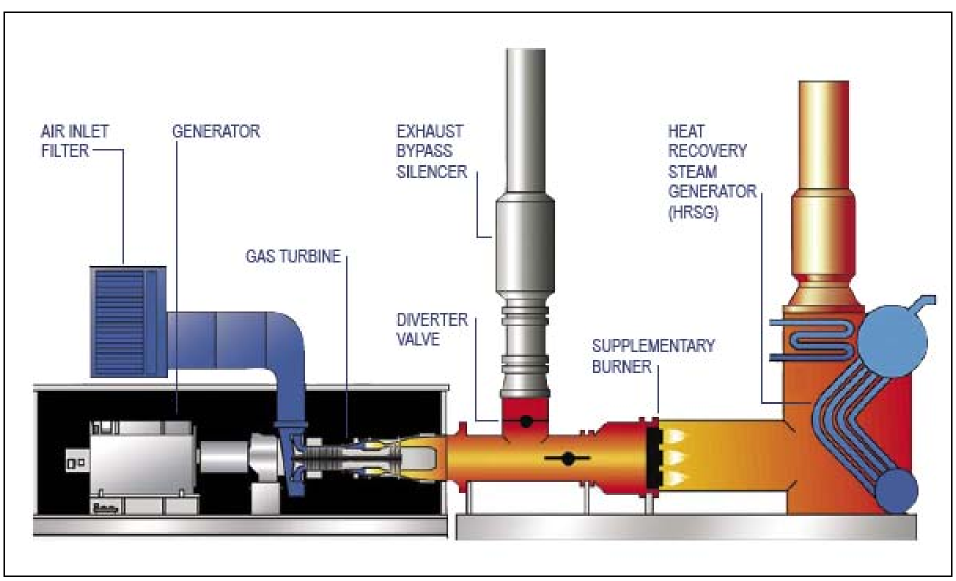

Figure 2 System Schematic

Gas Turbine Generator Set

The gas turbine generator set is Solar's Centaur H Model, which is a factory packaged gas turbine-driven generator set. The basic system specifications are presented in Table 1.

Table 1 Turbine Generator Set Specifications

Power (kW)	4,600
Heat Rate (kJ/kW-hr)	12,270
Exhaust Flow (kg/hr)	68,680
Exhaust Temp. (°C)	510
Steam Production (tonnes/hr)	10.9-49.1

Basically, the air enters the compressor where it is compressed to about 5 times atmospheric pressure. In the combustion chamber, high-pressure fuel, 125 psi natural gas in this particular system, is mixed with the compressed air. The high temperature and pressure combustion products are used to power the generator and the compressor. An illustration of the process is given in Figure 3.

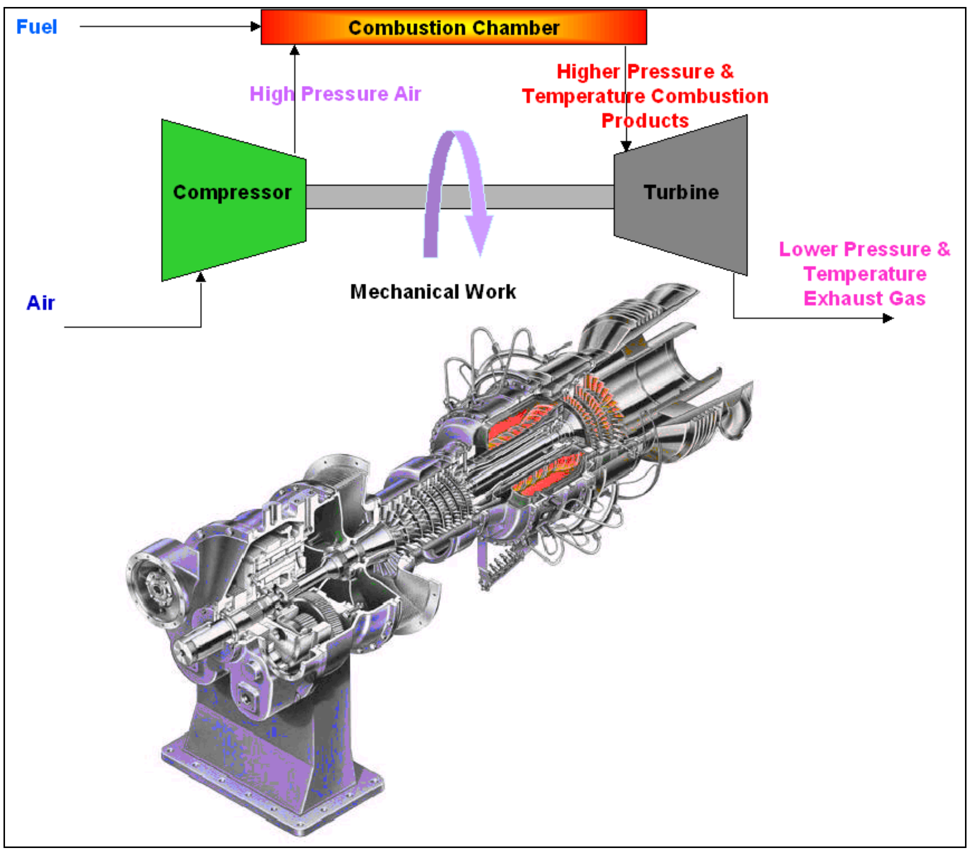

Figure 3 Gas Turbine Generator Set

Diverter Valve

The diverter valve, depicted in Figure 2, is used to regulate the amount of exhaust used in the waste heat recovery boiler. Only the amount of exhaust needed to meet the steam requirement is used. The excess is diverted through the exhaust bypass stack into the atmosphere.

Waste Heat Recovery Boiler

The waste heat recovery boiler uses the exhaust from the gas turbine to generate steam. The steam can be used in a variety of applications including heating, cooling, and equipment sterilization. The typical waste heat recovery boiler used in a CHP plant is shown in Figure 4.

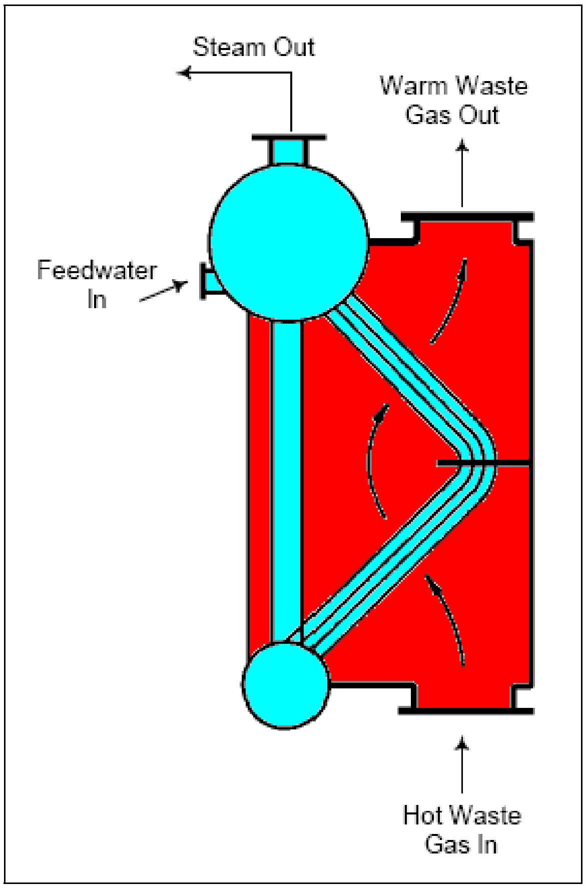

Figure 4 Waste Heat Recovery Boiler

The boiler in the MBMC plant is an ABCO waste heat recovery boiler rated at 300 lb/hr producing steam at 125 psi. If the heat from the exhaust gas is insufficient to meet the steam requirements, a 5.8 MMBTU duct burner is used to produce to supplement the waste heat.

Economizer

The waste heat boiler is equipped with an economizer. The purpose of the economizer is to increase the overall boiler efficiency by heating the feed water with the boiler's waste heat. The economizer is essentially a forced-flow heat exchanger as shown in Figure 5.

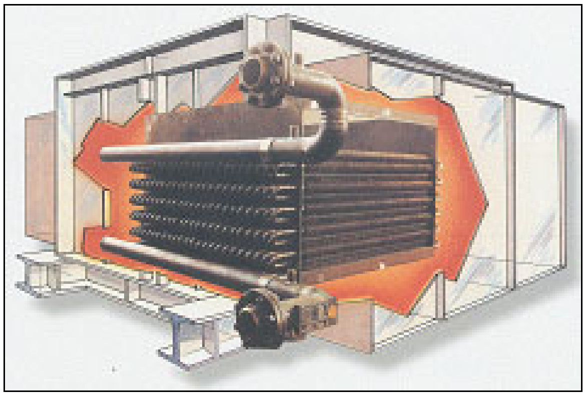

Figure 5 Economizer

Steam Absorption Chiller

Two double-effect steam absorption chillers are used to cool the majority of the MBMC. The remaining cooling load is met using vapor compression. The double effect absorption cycle (Figure 6) uses a combination of water (refrigerant) and lithium bromide (absorbent), which are separated and recombined in the following manner:

1. Low-pressure refrigerant vapor is absorbed into the refrigerant.
2. A large amount of heat is released (used to fire the low-pressure generator)
3. The solution is pumped to a high-pressure generator.
4. Heat is added using the steam produced by the waste heat boiler.
5. The refrigerant is desorbed from the absorbent as a result of the heating.
6. The vapors from the generators are combined and flow to the condenser.
7. The resulting high-pressure liquid is throttled through an expansion valve.
8. The low-pressure is evaporated and provides the cooling.
9. The remaining liquid absorbent is recombined with the low-pressure refrigerant vapors exiting the evaporator.

Absorption chillers are preferable in CHP systems due to the availability of waste heat. This essentially free heat source replaces the higher-cost electricity used in a conventional chiller.

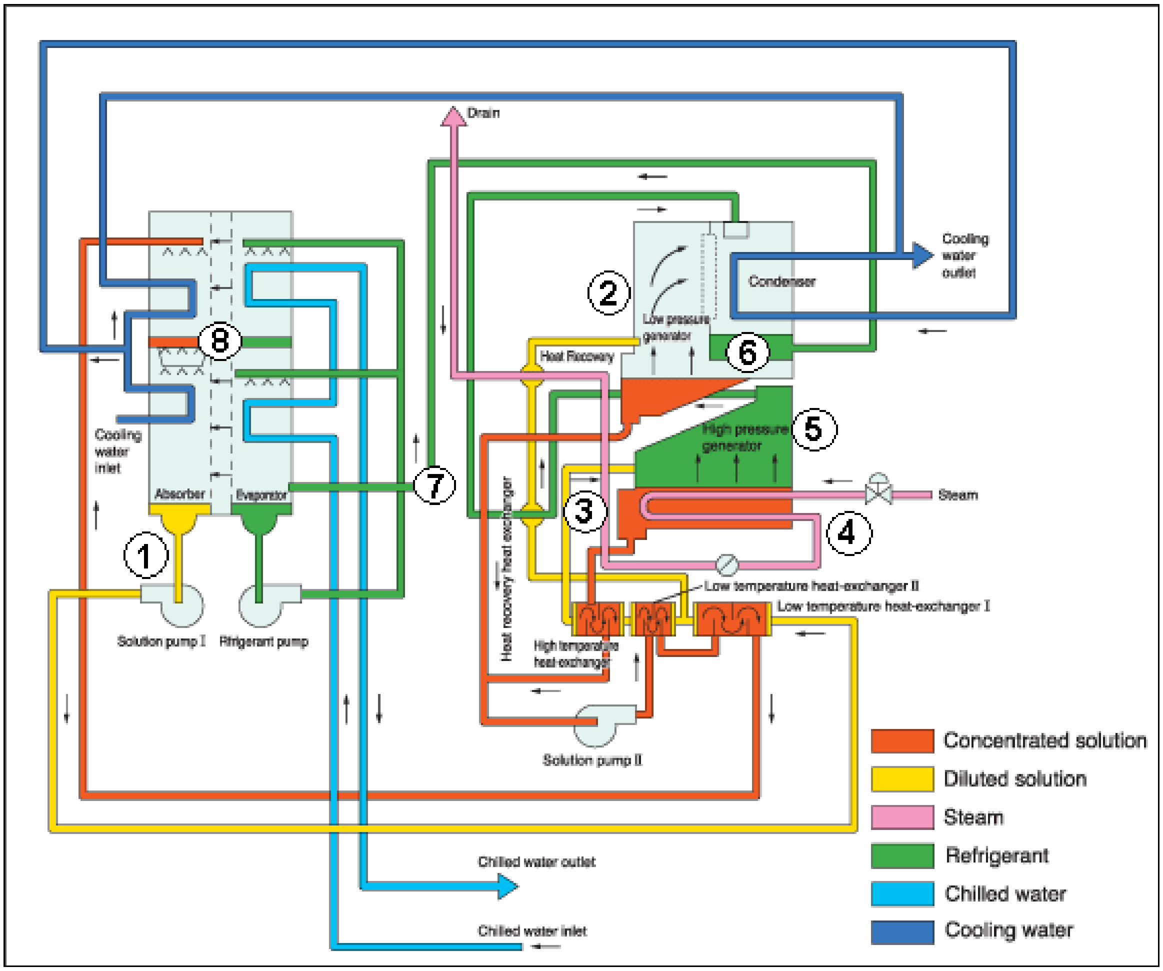

Figure 6 Double Effect Absorption Cycle

ECONOMIC IMPACT

An on-site CHP system is much more efficient than purchasing off-site utilities (Figure 7). Typical CHP overall efficiencies are close to 80% while conventional generation efficiencies fall well below that, in the range of 30-50%. An approximate savings calculation can be performed assuming the proper usage information is available. Before the system was installed in 1991, the gas turbine cogeneration system was expected produce savings of as much as $800,000 in electric bills each year. With the initial system cost being $4.2 million, the simple payback was estimated to be 6.3 years.

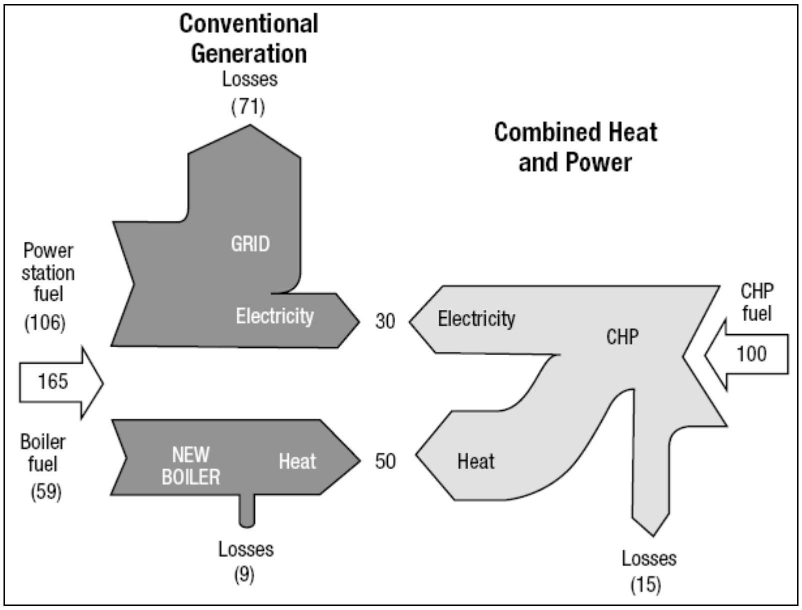

Figure 7 Conventional Generation vs. CHP

Early Years

An earlier study was done concentrating on the years of 1994-1996. The study, done by Dr. B. K. Hodge and Dave Schmidt, showed that the estimated annual cost savings was slightly lower than anticipated at approximately $701,000. The system, however, was on track to meet the 6.3-year simple payback period.

Recent Years

The recent savings estimates associated with the CHP system at MBMC were calculated by subtracting the turbine natural gas usage devoted to generating electricity and the annual maintenance costs from the electrical cost avoidance. The electrical cost avoidance is simply the amount of electricity generated times the current rate per kWh. Approximately 30% of the turbine natural gas input is devoted towards generating electricity and an additional 20% is devoted to process losses. The remaining 50% is used to fire the waste heat boiler. Thus, the turbine natural gas devoted towards generating electricity (including process losses) is calculated by multiplying 50% of the total turbine natural gas usage times the current rate per MMBTU. The maintenance cost is $174,000 annually and is all-inclusive. The cost savings information is presented in Table 2.

Calendar Year	Electrical cost Avoidance ($)	Additional natural Gas cost ($)	Maintenance Cost ($)	Total cost Savings ($)
2001	1,415,774	708,549	174,000	533,225
2002	1,587,074	776,950	174,000	636,123
2003	1,823,494	743,852	174,000	905,643
2004	2,022,926	972,401	174,000	876,524

The average savings over the years of 2001-2004 was approximately $737,879 annually. During the recent years, especially 2003 and 2004, MBMC was able to negotiate a contract locking in a very low natural gas rate. The savings are also a result of their ability to connect to and disconnect from the power grid without penalty.

HURRICANE KATRINA

In the early morning of August 29, 2005 the most destructive hurricane in United States history made landfall on the Mississippi Gulf coast. The impact of the hurricane was felt most by the states of Louisiana, Mississippi, and Alabama. The hurricane resulted in the destruction of 302,000 homes, $125B in damages, 2.7M power outages, and 1193 deaths. The hurricane, however, shed light upon the advantages to having an on-site CHP system. The independence provided by the CHP system allowed MBMC to continue operation relatively unaffected. As soon as power reliability became a factor MBMC performed a load shed, switched off of the power grid, and continued operation in turbine-only mode. MBMC was the only hospital in the Jackson metro area to remain nearly 100% operational. After approximately 50 hours, the power reliability issue was addressed and MBMC connected to the power grid and returned to normal operation.

CONCLUSIONS

The CHP system at MBMC was successful in its early years and has continued to be successful even after almost 15 years in operation. The success of the system became very apparent in the aftermath of hurricane Katrina and is a result of several factors. The MBMC power house staff consistently monitors the system and maintains its components in order to maximize the average online efficiency. The MBMC staff was also able to negotiate utilities contracts, which include very low gas rates and no penalty for switching on and off the power grid. If the staff's dedication remains unchanged, the success of the system will certainly continue.