Appendix B

Facility Energy Use and Production: Overview and Comparisons

All hospitals have heating, cooling, electricity, and to some degree, steam requirements. Typically these requirements are met by using a boiler to make steam, and the purchase of electricity. Cogeneration allows a hospital to make steam and provide some or all of its electric requirements on-site. The added step of producing electricity on-site requires additional equipment and space. The use of biomass fuels for cogeneration adds further additional equipment and space requirements. This overview compares the equipment and space requirements for three options for hospitals: standard operation, cogeneration, and biomass cogeneration.

Standard Practice

Hospitals must heat and cool buildings and provide fresh air through mechanical ventilation. Typically most hospitals will also have an emergency generator to provide back-up power in case of a power outage.

A standard method of providing heat is one or more boilers with a steam or hot water distribution system. If the boiler is oil-fired, the facility also needs a fuel oil storage tank, an exhaust stack for the boiler, controls for operation. If the boiler is large enough, an air quality permit may be required.

Air conditioning may use a central chiller system which removes heat from a building. Refrigerant-based chillers, the most common type, work like a refrigerator – drawing heat out at a low temperature and rejecting it at a higher temperature. Chillers come in a variety of shapes, forms and configurations. In all cases, something (normally water) is being chilled and heat is being dumped (typically into cooling towers). Hospital buildings typically provide interior fresh air with a mechanical ventilation system that balances fresh air intake with exhaust air outflow. The outdoor air may be heated, cooled, filtered and controlled for humidity before it is circulated.

Some facilities may use rooftop packaged HVAC systems to provide a combination of heating, cooling and ventilation, all in one unit, for a limited area of the building – and install multiple packaged systems on the same building. Packaged systems are relatively easy and inexpensive to install, but they are also difficult to maintain and frequently operate at suboptimal efficiencies. Central heating and cooling systems are easier to maintain and are more likely to be operated at their design efficiencies than packaged rooftop systems.

Most hospitals also have some form of back-up electric generation capacity in case of a power outage. These are typically oil or gas-fired reciprocating engine generator sets that provide power for critical building functions, such as selected HVAC systems and emergency lighting. Emergency electrical generation can also be provided by micro-turbines or fuel cells which operate in a similar fashion to conventional reciprocating engines.

<u>Conventional Combined Heat and Power (CHP)</u>

Conventional CHP typically is powered by a steam turbine that operates from steam generated by a medium or high pressure steam boiler.

<u>Steam CHP</u>

With steam CHP, steam is used to run a turbine before entering the heating distribution system. The turbine is then used to drive an electrical generator. The more steam the building demands, the more electricity can be produced. This form of CHP is practical if the hospital already has, or is planning, on installing a steam boiler. Key components of a steam CHP includes a medium to high-pressure steam boiler, fuel storage, exhaust stack and boiler controls, a steam turbine and electrical generator. Additional space is also needed for the turbine and generator equipment and controls.

The inter-tie of the steam CHP with the electric utility needs to be carefully designed and installed. Electricity is generated whenever there is sufficient steam load to run the turbine. The electricity generated in this type of system is an added benefit resulting from the energy needed to produce heat. Typically the electricity produced is only a portion of the facility's need. Steam CHP is a good option if the facility has excess steam capacity, room for the additional equipment, and competent staff able to manage and maintain the additional equipment. The boiler operator must understand how to operate and maintain the turbine and generator equipment – activities that should not add significantly to work loads.

Efficient management of conventional CHP systems (e.g., the greatest energy production from the least amount of fuel) will require modest additional time from competent well-trained staff; include time spent on additional maintenance and operational oversight. However, a facility with an existing steam boiler is likely to have certified boiler operators on staff that can operate the system 24 hours per day. Most if not all of the additional labor involved can usually be absorbed by existing staff.

In addition to producing heat and electricity, steam systems can also provide space cooling by incorporating an absorption chiller into the system. Absorption chillers differ from the more prevalent compression chillers since the cooling effect is driven by heat energy, rather than mechanical energy in the form of compressors. If a facility with a hot water or steam boiler already has a central chiller near the boiler room – or is planning to install one – absorption chillers can be a cost effective option. Absorption chillers require additional mechanical room space and a minimal amount of additional staff time to operate and maintain.

Biomass CHP

Biomass CHP is a step up from conventional steam-driven CHP systems. Steam produced from the biomass boiler can be used for all of the same purposes as steam from a fossil-fuel boiler including heat, domestic hot water, sterilization, laundry, heat for absorption chilling, and power production through a steam turbine and generator.

Biomass CHP uses all of the same equipment as a conventional fossil fuel CHP system including back-up fossil fuel boilers to provide heat during down times. Added to the existing fossil fuel heating system is wood chip fuel storage, wood fuel handling equipment and a properly-sized wood chip boiler with its own stack, boiler controls and pollution control equipment. This additional equipment requires considerably more mechanical room space, up to 3,000 square feet or more. The chip storage site must be carefully located to allow for tractor-trailer load deliveries of fuel.

Biomass CHP requires added space and equipment as well as additional operational and maintenance time (as much as a half-time FTE) to manage the system and to ensure the boiler is cleaned and operating properly. The payoff? If locally available, wood chip fuel is about one third the cost per Btu as fuel oil and one half the cost of natural gas. These savings can be substantial if a facility is using significant volumes of fossil fuels. Biomass is also a renewable fuel that reduces greenhouse gas emissions and can benefit the local economy.

Figure 1

**Comparison of Hospital Energy Use and Production:
Common Practice, Combined Heat and Power,
Biomass Combined Heat and Power**

Standard Practice	**CHP**	**Biomass CHP**
Boiler(s)	Boiler(s)	Biomass Boiler(s)
		Back up boiler
Stack	Stack	2 Stacks (one each for conventional and biomass boilers)
Environmental controls	Environmental controls	Environmental controls
Storage tank (oil) or gas hook-up	Storage tank (oil) or gas hook-up	Storage tank (oil) or gas hook-up
Cooling tower / condenser	Cooling tower / condenser	Cooling tower / condenser
Water treatment	Water treatment	Water treatment
Motors (fans blowers)	Motors (fans blowers)	Motors (fans blowers)
Chiller	Chiller	Chiller not necessary but desirable
Back up generator	Back up generator	Back up generator
Air compressor	Air compressor	Air compressor
Pressure reducer	Pressure reducer	Pressure reducer
	Steam turbine	Steam turbine
	Electric generator	Electric generator
	Electric interconnect	Electric interconnect
		Wood storage
		Wood handling system
		Larger building footprint
		Access for truck deliveries

Figure 2