Thesis Proposal

Geisinger Hospital for Advanced Medicine
Danville, Pennsylvania

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Executive Summary

The Geisinger Hospital for Advanced Medicine is being constructed in Danville, PA on the existing Geisinger campus. The hospital includes eight above ground floors, a lower level, and a ninth floor mechanical penthouse. The building will include exam rooms, operating rooms, offices, and patient rooms. Some of the building is also dedicated to shell spaces for future needs of the hospital.

The current designed mechanical system includes VAV boxes, a new boiler plants, and an addition to the existing chiller plant. Air handling units will be located in the ninth floor penthouse and in the fourth floor mechanical room.

This proposal investigates ways to improve the mechanical system and decrease the energy use of the building. The proposal includes installing a combined heat and power plant (CHP) and a dedicated outdoor air system (DOAS). A CHP plant will decrease the amount of energy used by the building, decrease electricity needed from the local utility, and reduce the emissions caused by the building. A DOAS should also decrease the energy use of the building and improve the indoor air quality of the building by increasing ventilation and decrease the ability of contaminants from traveling through the building. Incorporated into the DOAS will also be energy recovery devices to further reduce the energy used by the building.

This proposal also includes two breadths, which look at how other systems will be affected by the redesign of the mechanical system. The first is the electrical system which will be greatly affected by the installation of a CHP plant and will need to be redesigned accordingly. The second is the architecture; changes will need to be made to the boiler plant to accommodate the additional CHP equipment and since the DOAS will decrease the sizing of the air handling units, more space will open up on the fourth floor and the ninth floor penthouse will need to be redesigned.

The proposal includes the tasks required to accomplish a thorough investigation of both proposed alternatives. Preliminary sources are provided and a suggested spring semester schedule is included.

Building Design Overview

Geisinger Hospital for Advanced Medicine is a 300,600 square foot building being constructed at Geisinger Main Campus in Danville, PA. The hospital will be nine stories with a lower basement level and a ninth floor penthouse. The building construction has begun and the expected completion is Spring 2010. The estimated construction cost total $108 million.

The building design includes several shell spaces and floor designated for future use as the hospital's needs grow; these shell spaces total about half the square footage of the complete building. No future spaces will be analyzed in this report as little information is known about future intended uses.

The lower level is a partial shell floor but includes the dining room, toilet rooms, and staff areas. The first floor is also a partial shell floor but also includes the non-invasive cardiology areas. The second floor contains four operating rooms and space for an additional four. The third floor is a complete shell floor. The fourth floor contains a large mechanical room and the cardiology clinic. The fifth floor houses the cardiothoracic and vascular clinics, and lab clinics. The sixth floor is also a complete shell floor. The seventh and eighth floors are relatively the same and contain patient rooms.

Mechanical Systems Overview

The mechanical design includes eight air handling units, five to be installed now and three for future use. Other major mechanical work includes a new chiller building and an addition to the existing boiler house.

Air handling units AHU-4-1 and future AHU-4-2 will supply air for the operating rooms. The operating rooms require their own air handling units because the rooms need to be cooled to a lower temperature of 60°F and humidity levels must be more stringently controlled. AHU-4-1 will be installed now and sized to supply a current cfm of 12,000 of mixed outdoor air and return air and a future cfm of 18,000. AHU-4-2 is the future air handling unit and will be installed when the remaining four operating rooms are designed and constructed. Both of these air handling units will be located in the fourth floor mechanical room and both are designed for variable air volume. The mechanical system for the operating rooms also includes a energy recovery unit, which along with a cooling and heating coil pretempers the outside air and provides dehumidification.

Air handling unit AHU-4-3 will be installed now for the surgical pharmacy. AHU-4-3 supplies 2,700 cfm of return air to its spaces only cooling the air, reheat coils will take care of any heating loads. The air handling is located in the fourth floor mechanical room and is a constant volume unit. These areas will receive outdoor air ventilation through transfer air from surrounding spaces supplied by the south air handling units.

Air handling unit HV-4-4 is a future air handling unit for the kitchen hood make-up. This air handling unit will also be located in the fourth floor mechanical room and will be variable air volume.

The remaining areas of the building will be supplied by four air handling units, which includes one future unit. AHU-M-S1 and AHU-M-S2 will supply the south side of the building, both sized for a current cfm of 50,000 and a future cfm of 80,000. AHU-M-N2 and future AHU-M-N1 will supply the north side of the building. AHU-M-N2 will be sized for a current cfm of 80,000 and a future cfm of 77,000. The two south air handling units will be manifolded together and the two north air handling units will also be manifolded together. This provides one supply and return duct riser for the south side of the building and one supply and return duct riser for the north side of the building.

The hospital will use VAV boxes for most of the spaces and variable frequency drives will enable the air handling units to respond to the space loads. In spaces where positive pressure is required, according to AIA guidelines, return air boxes will be used. All supply air will be distributed through ceiling-mounted air devices.

Supplemental heating and cooling for several spaces is provided through fan coil units and radiant heating panels. Several spaces, mainly elevator machine rooms and electrical rooms will be provided with fan coil units to supply cooling and heating. Radiant heating panels will be installed at the perimeter glazing of levels three through eight.

Considered Alternatives

The Geisinger Hospital for Advanced Medicine is designed as a fairly typical hospital; air distribution is accomplished through variable air volume boxes with hot water reheat, boilers provide hot water for heating, a chiller plant supplied chilled water for cooling, and air handling units are located in the roof penthouse. Since a hospital can be fairly energy intensive due to 24 hour operation, increased ventilation needs, and the need to limit the spread of contaminants, additional energy saving alternatives were considered.

An alternative considered would be the use of renewable energy sources. Solar panels could be installed on the roof to provide electricity and reduce the amount of energy purchased from the utility. Solar panels have an expensive first cost and a long payback period. The solar panels would also need a large roof area, which is limited due to the proposed green roof. Although solar panels would cut the energy costs of the building, more cost effective alternatives are available. Another source of renewable resource is geothermal power. Using geothermal power for heating and cooling would cut the amount of energy needed by the hospital. In order to supply enough geothermal power to the hospital a very large amount of underground pipes would need to be installed, this would be difficult due to the existing buildings already on the Geisinger campus. Although geothermal heat pumps would be a great way to cut the energy use of the building, installing it does not seem practicable without distribution to the existing hospital buildings.

Proposed Mechanical Depth

The proposed redesign for the Geisinger Hospital for Advanced Medicine includes installing a combined heat and power (CHP) plant for the hospital. The purpose of this plant would be to provide power and thermal energy for the hospital. A CHP plant would reduce the amount of energy used by the building since exhaust from the electricity generation is converted to useful heat for the building. A CHP plant would reduce energy costs of the building, improve energy efficiency, and reduce emissions caused by the building.

One reason that the hospital would be a good candidate for a CHP plant is the relatively flat electrical and thermal loads of the building. Since a hospital is in operation 24 hours a day the loads do not suddenly drop off at night like other commercial buildings. Flat load profiles increase the effectiveness of a CHP plant. Another reason the hospital should install a CHP plant is to reduce the emissions caused by the building. A hospital's number one concern should be the health and safety of people. Reducing emissions will help improve outdoor air quality which improves the health of people.

The type of CHP being considered is a gas turbine, since natural gas is already available at the site. The turbine would produces electricity for the building, either for the base load or peak load, and then the exhaust would be used to make hot water and steam for the hospital. Depending on the actual thermal needs determined the boilers would either be eliminated or resized. The CHP plant could be located where the new boiler plant is to be installed. Considerations will have to be made for the other buildings on the campus and their use of the existing infrastructure.

Another redesign being considered is a dedicated outdoor air system (DOAS) for the hospital. Although the hospital already meets all ASHRAE Standard 62.1 requirements, a DOAS system could improve the air quality in the building. A DOAS could improve the air quality of the building while also lowering energy costs, less fan energy would be used, and less air would need to be heated or cooling. Each space would be able to be supplied with exactly the ventilation required and contaminants would not travel throughout the building as easily. The duct sizes would be decreased though piping to radiant heating panels and chilled beams would need to be added. Additional energy recovery devices would be installed to improve energy efficiency. The air handlings would all need to be reselected and the decreased size would allow for more occupiable spaces.

By combining a CHP plant and a DOAS system the energy use of the building could be greatly improved. Air quality of the hospital would be improved and decreased emissions would improve the outdoor air quality.

Proposed Breadths

Electrical

The installation of a CHP plant would require some redesign of the electrical systems. Instead of all the electricity being supplied by the utility, most of it will be coming from the CHP plant. However a hook-up to the utility will still need to remain for when loads exceed the CHP plant's capacity and in case of any equipment maintenance needed. The amount of power needed for normal operation must be determined along with emergency power that would be needed from the utility.

Architectural

The installation of the CHP plant will require a redesign of the boiler plant housing, the building will probably have to be resized to make room for the new equipment. Also the installation of a DOAS may open up more space in the hospital on the fourth floor, due to the decreased sizes of the air handling units in the fourth floor mechanical room. The main focus of this breadth will be to adjust the site plan and incorporate changes that will need to be made to the boiler house, elevations and floor plans of the boiler house may also be made. Open space on the fourth floor will be redesignated in floor plans and impacts to elevations will be considered.

Tools and Methods of Research

A CHP plant and a DOAS system have both been proposed as alternatives for the Geisinger Hospital for Advanced Medicine. These systems are both intended to reduce the amount of energy used by the building. Both systems must be researched to determine the effectiveness of both systems and determine if one or both should be implemented.

Accurate energy and thermal loads will need to be calculated to determine the sizing of the propsed CHP system. Carrier's Hourly Analysis Program (HAP) will be used to estimate these loads, and a second program will be used for verification, potentially eQuest. The information input into these programs will be obtained from the design documents and information used in technical assignment two. The CHP plant will then be sized and priced. Both energy savings and reduced emissions will be calculated to determine the feasibility of implementing this system at the hospital.

Ventilation schedules from technical assignment one will be used to size the dedicated outdoor air system. The ventilation schedules will be recalculated using AIA hospital guidelines to determine the ventilation air needed to meet hospital standards. Load calculations from HAP will help determine the sizes of radiant heating panels and chilled beams. The system will then be sized and priced. Both energy savings and indoor air quality will be looked at to determine the feasibility of this system.

Once both systems have been researched and the best solution determined, the electrical and architectural breadths will be performed. The electrical system will need to be redesigned to accommodate both a CHP plant and DOAS system. Both systems will also affect the architecture of the design, either by increasing the size of the housing for the boiler plant, where the CHP plant is likely to be located, or by adding additional space to the building once air handling units have be resized.

Preliminary Research

Fischer, Steve. "Assessing Value of CHP Systems". ASHRAE Journal, Vol. 46, No. 6. June 2004.

This article provides equations to calculate the usefulness of a CHP system. It will be a good source to help with evaluating different systems to choose the most effective one.

Jeong, Jae-Weon. "Designing a Dedicated Outdoor Air System with Ceiling Radiant Cooling Panels"' ASHRAE Journal, Vol. 48, No. 10. October 2006.

This article goes step-by-step through the process of designing a dedicated outdoor air system. It will be useful to see one way of designing a DOAS system and will help me get started on my design.

Larragna, Michael. "DOAS and Humidity Control". ASHRAE Journal, Vol. 50, No. 5. May 2008.

This article examines how to control humidity in a space with a DOAS. Since many rooms in the hospital demand specific humidity levels it will be useful in determing the best way to meet these requirements.

Zogg, Robert. "Using CHP Systems in Commercial Buildings". ASHRAE Journal, Vol. 47, No. 9. September 2005.

This article lists some of the benefits of using CHP in buildings. It examines energy saving potential and typical uses of CHP systems. It will serve as a good start to researching the design of CHP systems.

Spring Semester Work Plan

Week		Task
12-Jan	18-Jan	Begin Thermal and Electrical Load Calcs
19-Jan	25-Jan	Verify Load Calcs in Second Program
26-Jan	1-Feb	Research CHP Systems, Finish Up Load Calcs in Both Programs
2-Feb	8-Feb	Choose CHP system, Reseach DOAS, Finish Up Ventilation Schedules
9-Feb	15-Feb	Sizing of DOAS system
16-Feb	22-Feb	Review Calculations, Finish Up Anything Needed
23-Feb	1-Mar	Begin Putting all Information into Report
2-Mar	8-Mar	Begin Electrical and Architectural Breadths
9-Mar	15-Mar	Spring Break
16-Mar	22-Mar	Finish Up Breadths, Further Work on Report
23-Mar	29-Mar	Any Further Calcs or Research Needed for Report
30-Mar	5-Apr	Wrap Everything Up
6-Apr	12-Apr	Final Report Due- April 8
13-Apr	19-Apr	Presentations
20-Apr	26-Apr	-
27-Apr	3-May	-
4-May	10-May	Final Exams

References

ASHRAE Handbook: 2004 HVAC Systems and Equipment. American Society of Heating, Refrigeration, and Air Conditioning Engineers. Atlanta, Georgia. 2004

ASHRAE Handbook: 2005 Fundamentals. American Society of Heating, Refrigeration, and Air Conditioning Engineers. Atlanta, Georgia. 2005

ASHRAE Handbook: 2007 HVAC Applications. American Society of Heating, Refrigeration, and Air Conditioning Engineers. Atlanta, Georgia. 2007

EwingCole. 2008, <u>Mechanical Construction Documents.</u> EwingCole, Philadelphia, PA. 2008.

Fischer, Steve. "Assessing Value of CHP Systems". ASHRAE Journal, Vol. 46, No. 6. June 2004.

Jeong, Jae-Weon. "Designing a Dedicated Outdoor Air System with Ceiling Radiant Cooling Panels"' ASHRAE Journal, Vol. 48, No. 10. October 2006.

Larragna, Michael. "DOAS and Humidity Control". ASHRAE Journal, Vol. 50, No. 5. May 2008.

Zogg, Robert. "Using CHP Systems in Commercial Buildings". ASHRAE Journal, Vol. 47, No. 9. September 2005.