Coppin State University Physical Education Complex – Thesis Proposal

Updated Mechanical Project Proposal

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Location: Baltimore, MD

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Executive Summary

Currently the Coppin State University Physical Education Complex operates using fourteen variable air volume (VAV) air handling units. There are very large chillers, boilers and a cooling tower to operate and serve all the unique spaces within the complex. An energy model was created and compared to the design engineer's model in previous technical reports. Since the complex is so large, it consumes a lot of energy, in turn emitting large amounts of carbon.

In order to decrease the amount of energy consumption some alternatives were investigated, such as ground-source heat pumps, enthalpy wheels, heat recovery chiller and architectural solar panels. At the conclusion of research the options that were chosen for further investigation were ground-source heat pumps and a heat recovery chiller.

A geothermal heat pump system will be added to the current system and will be dedicated to zones A and B of the complex. These zones are the only spaces in the complex that are operational year round. If ground-source heat pumps are added, it will allow the entire central plant to be shut down during the summer months saving a large portion of energy.

Adding a heat recovery chiller will also help reduce the overall energy consumption of the building. This chiller will allow the boiler to be shut down when the hot water needs are not high. By adding this recovery chiller, the boiler may be able to be downsized as well as save money for the overall natural gas and fuel oil costs for the complex.

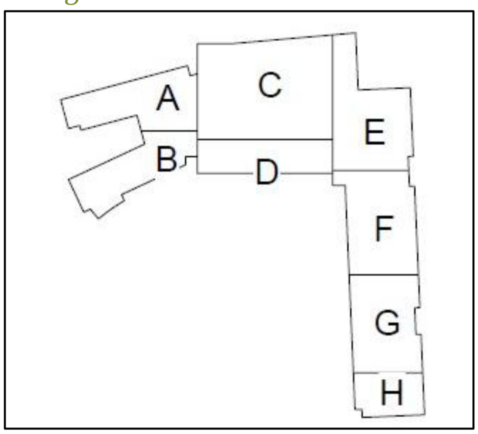
While adding these two systems to the complex their effect on the overall building will be investigated though the construction management and electrical breadths. The effect of adding large equipment to the overall load of the building may cause changes in the electrical systems already installed. Installing ground-source heat pumps will greatly affect the construction schedule, man power and cost so all of these will also be analyzed.

Building and Mechanical System Description

The new Physical Education Complex at Coppin State University was designed to support the health and human performance academic programs, the indoor and outdoor athletic teams and the West Baltimore community outreach mission of the University. The Complex features laboratories, classrooms, faculty and staff offices, dance studio, auxiliary gym, racquetball courts, fitness center, 4,100 seat arena and an eight lane NCAA regulation pool. It also houses a future satellite central utility plant with the associated maintenance and support service shops. Outdoor improvements include an outdoor track, soccer field, softball field, tennis courts, and a new campus entrance.

Due to the intricacy and varying spaces in the complex it is broken up into eight zones labeled A through H as seen in Figure 1 below. The complex is served by a total of fourteen air handling units (AHUs), some interior others exterior. For large spaces, such as the arena and auxiliary gym, a single zone VAV system was used. There are also two energy recovery units that serve the locker rooms located throughout the complex. The future central utility plant houses two 500 ton chillers, three dual fuel 250HP boilers and space for future expansion. The cooling tower is located close to the central utility plant, on the roof of zone A.

Figure 1 - Architectural Zoning



AHU-1 is controlled to maintain a unit discharge of 55°F, which provides sufficient cooling and dehumidification for all zones during design conditions. It serves zone A of level one which consists of shops served by constant air volume terminal units with reheat coils. Air handling units 2, 3 and 4 serve zone B on levels 1, 2 and 3, respectively; these zones are comprised of central services and facility maintenance offices. Zones A and B are the only zones that are operational year round due to the facilities and maintenance offices and shops located in these zones. These three units utilize variable air volume (VAV) terminal units with hot water reheat coils. The arena, in zone C, is considered a single zone and is served by AHU-5 and AHU-6. Zone D includes the concourse on the second level with offices above, on the third level. This zone is served by AHU-7 on the second level and AHU-8 on the third level which both use VAV terminal units as well. The auxiliary gym is served by AHU-9 and AHU-10 in zones F and G, which also use a single zone VAV system. The classrooms and dance studio in zones G and H are served by AHU-11 with VAV air terminal units. AHU-12 and AHU-13 serve the multipurpose room and fitness area, respectively, which are also single zone VAV systems. The last unit, AHU-14, is a single zone heating only unit which serves the vehicle maintenance area in zone B. Other systems in the building include two energy recovery units which serve the locker rooms due to their high exhaust requirements and a pool dehumidification system for the indoor pool in zone E.

Mechanical Redesign Overview

The redesign of the Coppin State University Physical Education Complex will concentrate on the reduction of energy use and cost for the complex. An energy analysis was performed for the building and it was discovered that the complex uses over 10,000,000kWh in a year costing the university about $800,000 a year. In order to reduce the energy use of the complex multiple alternatives were considered including ground-source heat pumps, enthalpy wheels, heat recovery chiller and architectural solar panels.

Alternatives Considered

Ground-Source Heat Pumps

Zones A and B, as described above, are the only zones that are operational year round. These zones can easily be taken off the central utility plant and have their own mechanical equipment. Separating these zones will allow the central utility plant to be shut down during the summer months, helping to reduce the amount of energy drastically.

To help further reduce the load on the complex, zones A and B can be placed on a ground-source geothermal system. The adjacent track and soccer field has sufficient green space to easily implement the required pumps underneath the field.

Enthalpy Wheels

Currently the locker rooms throughout the complex utilize heat plate recover units to recover heat lost due to the high ventilation rates required. Replacing these units with enthalpy heat recovery wheels would help reduce the energy used and increase the heat recovered. An enthalpy wheel could also be utilized in the pool area to help de-humidify the air before entering the space.

Heat Recover Chiller

To help reduce the cost and amount of energy used by the complex, a heat recovery chiller could be installed in the central utility plant. The heat recovery chiller will be able to use the exhausted heat from the chiller and utilize it this heat to produce hot water. This setup will allow the boilers to be shut down during the summer months or when the hot water needs are at a minimum.

Architectural Solar Panels

The complex has a high percentage of glass on all sides of the building. Implementing architectural solar panels on a majority of these windows will help reduce the overall energy needed from the grid. Allowing the complex to produce its own electricity will not only help the overall energy consumption but will also help the building gain additional LEED points for renewable energy.

Proposed Redesign

To help decrease the amount of energy used by the complex a heat recovery chiller and a ground-source heat pump system for zones A and B will be redesigned into the complex. Both of these additions will concentrate on energy reduction in the central utility plant.

Adding a dedicated heat recovery chiller will allow the boiler to be shut down when the hot water needs are not high. Heat-recovery chillers can produce up to 130°F which is sufficient enough for the building's hot water needs. Allowing the boiler to be shutdown will help reduce total energy costs as well as reduce carbon footprints because no fossil fuel will be utilized by the building directly. With the addition of this heat recovery chiller the overall size of the boiler may also be able to be downsized. There is sufficient space located in the central utility plant for the addition of this dedicated heat recovery chiller.

Geothermal heat pumps have many advantages over the conventional mechanical systems. When using a geothermal system for cooling the pumps dump the excess heat found in the air into the ground through the loops in the ground. Zones A and B are the only sections of the building that operate year round so implementing a ground-source heat pump system will allow the central plant to be shut down during the summer months, being much more efficient than running an entire plant. The system installed in the complex will be a cooling only system since it will only operate in the summer months. The space required for this system could easily be found within the complex and the surrounding land. The two zones being redesigned are adjacent to the current central utility plant so any additional equipment needed could be installed in the plant. The complex also has more than 10 acres surrounding it for installation of the heat pumps.

Breadth Topics

Electrical

When adding large equipment such as heat pumps and heat recovery chillers the first place to look is the electrical capacity of the building. An interesting study would be to see if the building's electricity already has enough capacity to add this equipment. Safety factors may have been accounted for during the design process to where the building could already handle these additions. If not, newer panel boards, control centers or transformers may need to be designed and added.

Construction Management

These two redesign components will drastically effect the overall construction of the complex. The construction budget and schedule will be modified and reconfigured to see if the energy savings due to these additions are overall worth it for the owner. If the heat pumps are installed directly adjacent to the building the construction will drastically be altered due to the delicacy of the bore holes. A Life Cycle Cost Analysis will be performed as well as comparing initial costs when adding these redesign components.

Tools and Methods

To ensure accurate understanding of the following research explained, I plan on doing extensive research on the equipment that will be installed. Programs such as Microsoft Excel, Carrier's HAP, and other innovative computer tools will be used throughout the entire investigation.

HAP will be used to compare the energy savings and reduced carbon emissions when adding the new equipment. The model previously made will be compared to a newer model that will include both concepts as well as looking at each individually. Once the energy savings is calculated an overall cost analysis will be performed as well as a life cycle cost analysis to see what the payback period will be for the owner.

Other programs will be used to adjust the construction budget, schedule and man power to understand the actual impact of adding these systems. The surrounding site will also need to be investigated for installation of the ground-source heat pumps. The addition of these pumps may also interrupt the location of equipment and trailers on the site, so the layout of the site may need to be reorganized. If any scheduling needs to be altered programs such as Microsoft Project will be used to clearly illustrate the changes.

Equipment and construction costs will need to be gathered in order to determine the actual cost of adding the selected equipment. If the actual cost of equipment is available through a manufacturer other references such as R.S. Means will be utilized for pricing.

Preliminary Research

Burt, James. "Reducing Energy Costs With Condensing Boilers & Heat Recovery Chillers." *ASHRAE Journal* Mar. (2007): 46-55. Web. 6 Dec 2010.

MacMillan, Jim. "Ground Source Hear Pumps in Schools." *ASHRAE Journal* Sep. (2007): 34-42. Web. 6 Dec 2010.

Mescher, Kirk. "Simplified GCHP System." *ASHRAE Journal* Oct. (2009): 24-40. Web. 7 Dec 2010.

Sherren, Mike. Personal Interview. Nov 30, 2010.

"Two Good Old Ideas Combine to Form One New Great Idea." *Trane Engineers Newsletter* 20.1 1-6. Web. 5 Dec 2010.

Tentative Work Schedule

Task Name	Duration	Start	Finish
Semester Start	1 day	Mon 1/10/11	Mon 1/10/11
Begin Mechanical Equipment Research	6 days	Mon 1/10/11	Mon 1/17/11
Make New HAP Alternatives	11 days	Mon 1/17/11	Sat 1/29/11
Analyze Previous Cost and Construction Schedule	6 days	Sun 1/30/11	Fri 2/4/11
Begin Electrical Research/Sizing	9 days	Wed 2/2/11	Sat 2/12/11
Compare Cost and Energy Consumption	10 days	Tue 2/1/11	Mon 2/14/11
Life Cycle Cost	5 days	Fri 2/11/11	Thu 2/17/11
Go - No Go Spring Progress	1 day	Thu 2/17/11	Thu 2/17/11
Construction Management Breadth	13 days	Thu 2/17/11	Sat 3/5/11
Spring Break	7 days	Sat 3/5/11	Sun 3/13/11
Electrical Breadth	10 days	Sun 3/13/11	Thu 3/24/11
Finalize Thesis Report	11 days	Thu 3/24/11	Thu 4/7/11
Create and Practice Presentation	4 days	Mon 4/4/11	Thu 4/7/11
Final Summary Reports and Presentation Due	1 day	Thu 4/7/11	Thu 4/7/11
Faculty Jury	4 days	Mon 4/11/11	Thu 4/14/11
ABET Analysis/ CPEP Update	5 days	Mon 4/18/11	Fri 4/22/11
Senior Banquet	1 day	Fri 4/29/11	Fri 4/29/11