Thesis Proposal

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Multipurpose Activity Center
West Long Branch, NJ

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Executive Summary

This report contains the proposed changes and redesign of the Multipurpose Athletic Center (MAC) at Monmouth University's located in West Long Branch, N.J. The MAC building is 160,000 square foot building that is going to be redesigned for a semester long thesis project. The ideas for the redesign were thought of during the first three extensive reports focusing on different aspects of the building. The overall glaring issue that could not be avoided is the fact that the building can not be built because the surrounding power lines do not have the capacity to support the addition of the building. Therefore, the idea of producing power locally presented itself as a logical solution. After further investigation it was determined that combined heat and power would be a good application for this site.

The combined heat and power will be linked to an absorption chiller along with an active desiccant wheel system. The system will use the exhaust heat from the micro turbines in the chillers and desiccant wheels. The chillers will be linked to an ice storage system to help level the load on the chillers and make the system more efficient.

This report also covers the justification of the proposed work. In addition, the report discusses the integration and coordination challenges that are expected in the future semester. Also, an initial discussion of the methods and tools that will be used is included. Additionally, a schedule of the spring semester is attached to give a preliminary idea of when each proposed topic will be researched.

Building Background

The Multipurpose Activity Center or MAC building is located on Monmouth University campus in West Long Branch, New Jersey. The MAC building is has multiple purposes and functions. The building will support the basketball, volleyball, concerts, summer camps, convocation ceremonies, as well as other various activities. The building was designed to serve the students, faculty, and the surrounding community.

The overall size of the MAC building is 160,000 square feet. This consists of three floors with the center of the building taken up by the gymnasium. The building contains many athletic offices and suites. The building has multiple diverse spaces including the gymnasium, fitness center, athletic office spaces, and suites. These spaces provide unique requirements for the designed mechanical system.

The following is a basic summary of the mechanical system and its operation. The mechanical system will be altered from the designed conditions to a new redesigned system for the purpose of Pennsylvania State University Architectural Engineering thesis project.

System Overview

The MAC building is served by eleven air handling units that condition the spaces within the building. The mechanical rooms consist of two chillers that provide the cooling to the units and three boilers that provide the heat and reheat to the building. There is a fairly even split between the air handling units being variable air volume and constant air volume. Additionally, some of the units provide 100% outdoor air while others provide mixed air.

The MAC building provides a unique set of schedules. For a majority of the time the building is not going to be run near full load. The building consists of a gymnasium that will not be at the designed load of people except during limited times during the year such as basketball games, volleyball games, convocation ceremonies, and concerts. Also, there are offices that consist of the different coaches and staff that will be occupied during the year. Therefore, the building does not have a set schedule of operation where the building is always going to be in full use.

Air Side System

The air handling units are either variable air volume or constant volume units serving different spaces. The system consists of six constant air volume units with five of them located inside and the sixth is a rooftop unit. The remaining five units are variable air volume units are all located within the building. Four of the constant air volume units are 100% outdoor air. The 11 air handling units are designed to supply air ranging from 3170 cfm to 45000 cfm, with the total supply air of 175,830 cfm. The design outdoor air percentage ranges from 21% to 100%. With so much air being exhausted from the spaces heat recovery looks like an option that can be explored.

Water Side of System

Chilled Water Side

There are two centrifugal chillers with a 450 ton capacity that run in parallel. The evaporators are rated to supply 900 gallons per minute (gpm). The chillers supply cold water, 44F, to a primary/secondary loop that serves the air handling units. The water returns from the air handlers at a temperature of 56F. The condensers are rated at 1350 gpm each. The condenser water is cooled using two induced draft cooling towers with a 1350 gpm capacity. Each cooling tower has a variable frequency drive that can produce airflow of 133450 cubic feet per minute (cfm). The fans vary the speed from off to fully on to regulate the leaving water temperature at the specified 85F.

Hot Water Side

There are three 200 horsepower hot water boilers in parallel that serve the building. The boilers are dual fuel that can run off either natural gas or no. 2 fuel oil. The boilers are 80% efficient and produce 6800 MBH each with 680 gpm. The hot water produced leaves the boilers and is distributed to the building. The boilers are designed to be a primary/secondary loop supplying the building with water ate either 180F or 140F. The secondary loop has two different state points with one system serving the building at 180F and the other system serving the building at 140F. Each of these systems has two variable frequency pumps to serve their respective coils. The majority of the system is served by 180F hot water.

Electrical System

The building is served by Jersey Central Power & Light which provides 2500 KVA. The primary voltage is supplied to the system at 470/277V 3-phase and is then stepped down to through a transformer to 208/120V 3-phase. The building also has an emergency generator sized at 275 kW, 470/277V, and 3-phase. Monmouth University campus is built in a residential area; therefore, the power lines do not have the capacity to supply the addition of the MAC building. This provides a unique situation to explore.

Considered Alternatives

The MAC building offered many opportunities to change the existing design and explore an alternative different than the solution the original design team chose. The building is not typical in the sense that it does not just have office spaces or fitness spaces. The building has multiple spaces including a gymnasium, offices, locker rooms, conference rooms, and suites. The diversity in the type of spaces gives the designers an opportunity to consider different systems. The schedules of the building offer the designers a unique challenge within the design. The gymnasium and the offices are at peak load at different times during a day. Considering the unique building spaces and schedules there were some design alternatives that were considered and later rejected after further investigation.

An initial idea for the building was to replace the existing mechanical system with a dedicated outdoor air system (DOAS) along with a parallel ceiling radiant panel system. The DOAS system would have taken advantage of using an enthalpy wheel and sensible wheel to lower the energy costs in the cooling coil and reheat coil of the system. The system would have allowed for a smaller duct system throughout the building. Furthermore, the air handling units could be smaller, since the air supplied to the space is on a ventilation requirement basis. Smaller air handling units would help with the already restricted mechanical spaces. DOAS would have been a good proposal for the office and conference spaces within the building; however, the building has such a variety of spaces that DOAS did not seem to fit the criteria within all the spaces. For instance, the locker rooms have showers and therefore the latent load within the room would be high which would be conducive to condensation on the panels. Furthermore, the radiant ceiling panels would need to be integrated into the design with the architects' approval. Overall, this option did not seem like a viable option for the MAC building.

A second idea for the building was to add indirect evaporative cooling to the supply side of the air stream. The idea behind this was to lower the load on the cooling coil by initially cooling the supplied air. Initially this was thought to be economically beneficial by lowering the load on the cooling coil but since with the high wet bulb temperature the supply air temperature would not be reduced enough to justify its first cost. Furthermore, this topic was not in depth enough to rationalize spending an entire semester researching the topic.

The mechanical load on the chillers was considered to be cut by using geothermal heat pumps to provide the cooling in the summer and also provide part of the heating required during the winter months. The initial idea was to use a vertical ground coupled heat pump cycle. According to ASHRAE Applications handbook, the approximate groundwater temperature is 56F. This option was disregarded for a few reasons. To receive the 900 tons of cooling the building needs, the number of holes that would be needed was a cause for concern. Also, the geology study of the area to determine the water table and temperature was not originally thought to be available. Ultimately the location of the vertical bore holes on the limited surrounding space of the campus deterred this idea from developing into a proposal.

The last option was to consider altering the design of the building in order to make the building LEED credited on some level. Technical Assignment 2 goes into further detail on the current design of the building and how many points it would be awarded with the current design. This would give the opportunity to explore numerous options to obtain points. The LEED guideline gives five categories where a building can be analyzed and designed to become a more sustainable building. Initial thought gave the idea of having a rainwater catching system along with low flush fixtures to help the building become more water efficient. The mechanical system would be analyzed to become more efficient. Overall, there is a lot that can be learned from trying to make the MAC building a LEED certifiable building but the scope of the project would be more focused on the building as a whole instead of the mechanical system. Therefore, analyzing the changes that would need to be made to make the building LEED was determined to be to radical of a changed warranted for this project.

These alternatives are all viable options to explore for the MAC building, although none of the options can solve the power problems that currently exist with the building. Some of the above options will lower the energy requirements for the building but it is unlikely to be lower the power requirements enough for the existing power lines to be able to support the MAC building.

Proposed Redesign

The major function of the redesign for the Multipurpose Activity Centers' mechanical system is to redesign the system to be able to be built with the existing power conditions that the University is experiencing. The building will be analyzed and redesigned during the 2005 spring semester and then presented to a board in April of 2005.

Scope

To support the overall goal of allowing the MAC building to be built with the existing power restraint a separate electrical system will be used. The major mechanical alteration to the building will be the addition of combined heat and power (CHP) also known as cogeneration.

CHP will be optimized to provide the amount of electricity the building will need during the peak operating hours. Micro turbines that are powered by natural gas will be used to provide the power. The exhaust heat will then be used to power an absorption chiller that will further supply the building. Furthermore, the exhaust will be used to provide the building with the heat needed for hot water and reheat.

Along with the CHP, the system will use operate with a chilled water thermal storage system. The idea for implementing a chilled water storage system is to level the load on the absorption chillers. This addition will make the CHP system more efficient since the waste heat is always being used to run the chillers. Without thermal energy storage, the chillers would not be run at a consistent load and therefore the efficiency of the CHP system would lower.

A further application of the exhaust heat will be analyzed to determine the feasibility of its use. Since the exhaust heat from the absorption chillers is still relatively high, the addition of an active desiccant wheel in the air handling units will give the units the ability to lower the humidity before the air is introduced to the cooling coil. Along with an active desiccant wheel an enthalpy wheel will be analyzed to determine if it will have added benefits. Ultimately there will be a decision whether to add an active desiccant wheel and enthalpy wheel, an active desiccant wheel, an enthalpy wheel, or not add either into the air handling units.

In conclusion, the mechanical system redesign will try to optimize the system. This will be achieved by supplying the building with the appropriate amount of electricity, while also having the exhaust heat be used to supply the absorption chillers. The consistent load of the chillers due to the thermal storage offers an advantage to the overall efficiency. Also, there is an air side saving that can be accounted for by figuring in the cooling coil savings that is obtained by lowering the latent cooling need by using the rejected heat to regenerate the desiccant wheel. Overall, the redesigned mechanical system will replace the existing designed boilers, chillers, and electrical needs from the utility.

Justification

The proposed redesigned is expected to allow the building to be built. The major focus and justification for the system that is being proposed is that the building will no longer need to wait until the utility supplies the power lines needed to support the addition on the building. The building can provide its own power and any extra power that is supplied can be sold back to the campus at the rate the power utility is charging the university. Furthermore, the overall buildings energy consumption should lower with the addition of an active desiccant system. In addition, the system proposed is complex and will offer a great deal of educational value that can be used on later projects.

Integration and Coordination

The biggest issue with the integration is the addition of the redesigned mechanical equipment. The interior mechanical space will lose the existing boilers and the chillers will be replaced by absorption chillers. The major affected area will be outdoors with the addition of micro turbines and thermal storage tanks. This can prove to be more complicated than originally thought since the building is in the middle of campus and there are architectural impacts that will need to be taken into consideration.

A further integration issue will be involved with the desiccant wheel. The air handling units are already snuggly fit into the space provided and the addition of a desiccant wheel and/or enthalpy wheel may make the equipment to large for the given space. If a desiccant wheel is chosen the issue will be to coordinate the supply of the exhausted air from the chillers to the wheels. In the end, there are going to be many issues involving integration and coordination that will have to be dealt with as they present themselves.

Breadth Areas

The addition of a micro turbine to supply the needed power will provide an opportunity to redesign the existing electrical interface to the building. The change to electrical system will be looked into greater detail. The ultimate goal of the system is to be able to offer the campus the excess power the micro turbines are producing at the same rate the electric utility company is charging. This will give the MAC building the ability to run on a more consistent schedule and not have to vary the amount of power that is produced.

Furthermore, the chillers being changed from a typical centrifugal chiller to an absorption chiller will reduce the electrical load.

A further study will look into the replacement of the existing lighting in the gymnasium. The study will look into replacing the bulbs that consume up to 1000 watts each into high efficiency sport lighting. This can further reduce then electrical load the building will be consuming. Overall, the electrical redesign needs to be looked at since the site is going to be generating its own power.

Project Methods

To analyze the systems that are being proposed will require the use of different analysis tools. The major focus in the proposal is the integration and addition of the new mechanical systems. The beginning part of the semester will be focused on learning the ways to implement the proposed ideas and how to analyze the system. Carriers Hourly Analysis Program (HAP) will be used to find the loads needed for the air handling units. Furthermore, HAP will be used to look into the electrical side and determine the size of the micro turbines that are being added. Along with these calculations an absorption chiller will be sized from the load that is found from HAP. The addition of an enthalpy wheel or desiccant wheel will give the opportunity to do some hand calculations. These calculations will be done using excel to help model the air side load on the cooling coils.

The electrical breadth topic will be analyzed using the National Electric Code (NEC). This will be an asset in determining the lines and codes needed to connect the micro turbines to the MAC building along with the rest of the campus. Furthermore, a manufacturer's guide will be explored to determine the ability of changing the existing sport lighting to high efficiency lighting. The tools to this analysis are undetermined but will be figured out in the coming semester.

Above is a preliminary list of the tools that will be needed to perform the goals of the proposal. As the semester progresses, there will be more tools implemented to further the buildings analysis.

Preliminary Research Bibliography

ASHRAE/IESNA Standard 90.1-2001. ASHRAE Incorporated, Atlanta, GA. 2001

ASHRAE Handbook of Applications, 2003.

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ASHRAE Handbook of Systems and Equipment, 2000.

Carrier. Hourly Analysis Program. v.4.20a. 2004.

Energy Cost Comparison New Jersey. http://www.locationnj.com/Energy_Rates.asp

Grossman, Gershon, D.Sc. and Joseph E. Rasson, Ph.D. Absorption Systems for Combined Heat and Power: The Problem of Part-Load Operation. ASHRAE 2003

Popovic, Predrag, Ph.D., Aristotle Marantan, Reinhard Radermacher, Ph.D., and Patricia Garland. Integration of Microturbine with Single_Effect Exhaust-Driven Absorption Chiller and Solid Wheel Desiccant System.

LEED Rating System: version 2.1, U.S. Green Building Council, 2002

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RS Means, Mechanical Cost Data. Version 2004.

Spring Semester Proposed Schedule

Listed below is a preliminary schedule of the research and building analysis that will be performed during the spring semester. The dates schedule is subject to change at anytime.

January 2005

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
9	10 Research on CHP	11	12 Faculty Consultation	13	14	15
16	17 Research on CHP	18	19 Faculty Consultation	20	21	22
23	24 Research on Absorption Chillers	25	26 Faculty Consultation	27	28	29
30	31 Research on Desiccant and Enthalpy Wheels					

February 2005

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2 Faculty Consultation	3	4	5
6	7 Research on Ice Storage	8	9 Faculty Consultation	10	11	12
13	14 Load Analysis of Building Using HAP	15	16 Faculty Consultation	17	18	19
20	21 Integrating Proposed Systems and Running Analysis	22	23 Faculty Consultation	24	25	26
27	28 Integrating Proposed Systems and Running Analysis					

March 2005

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2 Faculty Consultation	3	4	5
6	7 Spring Break	8	9	10	11	12
13	14 Integrating Proposed Systems and Running Analysis	15	16 Faculty Consultation	17	18	19
20	21 Buffer Week for Any Unresolved Issues	22	23 Faculty Consultation	24	25	26
27	28 Thesis Report Write-Up	29	30 Faculty Consultation	31		

April 2005

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4 Practice Thesis Presentation	5	6 Faculty Consultation	7	8	9
10	11 Presentation Week	12	13	14 ALL DONE!	15	16