THESIS PROPOSAL

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This document contains the proposal of making mechanical adjustments to improve the energy consumption of the St. John Student Center located on McDonogh's campus in Owings Mills, Maryland

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10 December 2010

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Executive Summary

The St. John Student Center is being constructed on the existing campus of McDonogh School located in Owings Mills, Maryland. The Student Center is one of several new buildings being added to the campus. The Center is a 3 story, 68,000 square foot facility that houses a 3 story lobby/atrium, dining halls, commercial kitchens, a grand auditorium, a dance studio, and classrooms that range from art and photo to general seminar.

The mechanical system that was designed for the Center uses a combination of VAV and CAV technologies. The AHUs supply air to remote VAV and CAV boxes located throughout the building which provides occupancy control. The central plant located elsewhere on the campus produces both heating and chilled water. The chilled water in the plant is produced via electricity while the heating water is produced via natural gas.

The Student Center was not striving for any type of certification or rating from the Leadership in Energy and Environmental Design (LEED) which is a subsidiary of the United States Green Building Council (USGBC). A LEED analysis was performed using the version three rating scale which is the most current scale available. While this analysis was being performed only the areas pertaining to the mechanical portion of the project were looked at. These areas included Energy and Atmosphere and Indoor Environmental Quality. Once these mechanical upgrades are implemented a new LEED analysis shall be performed in order to determine the new status.

In order to reduce the load that the central plant currently receives an investigation into ground source heat pumps and total energy wheels will be conducted. Many other alternatives have been reviewed however others have been ruled out due to practicality reasons. A GSHP has many advantages and most advantageous is the fact that is uses water to transfer heat. Water can transfer heat 25 times quicker than air can. Another plus is that McDonogh is adding a new green space on the campus that will be more than sufficient to locate a geothermal well-field.

Another way to help reduce the load is by using a total energy wheel. This should be very useful due to the large amount of OA required for this student center. Upon further investigation one downside is that the architecture may have to be possibly changed.

Load calculations and energy simulations will be performed using the Carrier HAP model that was already created for the previous technical reports. Because of this it should be simple to see whether or not implementing these mechanical adjustments will benefit the Student Center.

Mechanical System Description

Overview:

The St. John Student Center is a 3 story, 68,000 square foot facility designed for McDonogh School. This Student Center has a 3 story lobby/atrium, dining halls, commercial kitchens, an auditorium and dance studio, offices, conference rooms, and classrooms that range from art and photo to general seminar. The Center is to become the hub of McDonogh campus and is one of several new buildings being constructed.

Mechanical Design Objectives:

An effective Heating, Ventilation, and Air Conditioning (HVAC) system was designed to be installed in the new Student Center in order to provide a comfortable, productive, and nontoxic environment for all the building occupants. The HVAC system was designed to meet all International Building Codes (IBC) and all International Mechanical Codes (IMC). The system was also designed to meet the minimum ventilation rates prescribed in ASHRAE Standard 62.1. Since there are classrooms located in the Center, the mechanical system designed will be very reliable to ensure a proper learning environment.

Due to the dense population of this building the occupants are at a much higher risk of obtaining an illness. This increased chance of illness means that the indoor air quality must be a high concern. Building pressurization and envelope construction quality help to ensure the quality of air found within the space by preventing unconditioned air from leaking in through the envelope and becoming a place for mold and other bacteria's to grow.

McDonogh is a school that embraces diversity of background, culture, and thought. The school was founded in 1873 as a farm school for poor boys; the school is now situated on nearly 800 pastoral acres in Owings Mills, Maryland. Special considerations were taken into account during the design of The Student Center in order to complement the surrounding buildings.

Equipment Summary:

The Student Center utilizes two different types of air systems. The majority of the building is conditioned by Variable Air Volume units, and the remainder of the Center is conditioned by a Constant Volume unit.

The HVAC system receives heating and chilled water from a new central plant. A tertiary pumping system will be utilized for distribution within the building. The system will be designed by taking load diversity into consideration. The total cooling load from the Center's HVAC system is approximately 400 tons, while the heating load is approximately 3300 MBH. Tables-01 through 04 shows summaries for the AHUs, fans, VAV boxes, and unit heaters.

Overall Evaluation of System:

The VAV and CAV systems used in the Student Center have been implemented in buildings for several decades. The VAV system has been proven to be very effictive in most applications. Due to the various activities that take place in a student center a VAV system has many advantages.

The VAV system was most likely selected due to its lower initial costs. This system also has very low maintenance costs while maintaining a high efficiency and is easy to manage.

Operating costs for the system were estimated in the HAP model to be approximately $1.04/SF (not including maintenance costs). The cost to maintain this system should be relatively low due to how common a VAV system is. The maintenance staff should not have any problems with the repair or replacement of mechanical parts.

Indoor Air Quality can be an issue with a VAV system. The problem lies at the roots of a VAV system; the air that is delivered to the spaces is a combination of ventilation and return air. If designed, installed, or balanced incorrectly supply airflow from the VAV box can modulate with no change in the outdoor air fraction. This will result in a lower then required ventilation rate. Wrong filter placement can also cause problems in this type of system. If they are not placed in the correct location or maintained, contaminants within the building can be re-circulated to all of the spaces within the building.

The mechanical system occupies some sort of space on all floors. The first floor houses plenum space only, while the other two floors contain both mechanical rooms and plenum space. The Student Center was fortunate to have a central plant located elsewhere on the campus to free up more additional space. The Center is to accommodate AHUs and pumps only. The attic managed to be architecturally pleasing while allowing additional space for AHUs. The plenum spaces have been enlarged to accommodate both supply and exhaust ductwork to be routed simultaneously.

The use of a primary secondary system has many advantages and is very reliable. To help reduce the amount of energy consumed a geothermal well field located in the new green space would be beneficial. Using a geothermal system may be investigated further during the next assignment.

The indoor air quality throughout the Center should be slightly better than that of a similar building due to the high amount of outdoor air required for the kitchens and art classrooms. As stated before due to the system mainly being a VAV system recirculation of contaminants could be a problem.

The Centers thermal comfort and environmental control are provided by the VAV boxes located within the building. Each of these VAV boxes typically serves multiple spaces similar in occupancy. Since the spaces are served by a VAV system each space should be able to achieve the desired level of comfort.

The overall mechanical system that was designed for the Student Center uses the principle aspects of a VAV system by creating a reliable and diverse system. The Center may be lacking energy recovery but this is not a concern due to the building not striving for LEED certification. Because of this making energy improvements to this system should be fairly simple. Potential areas of redesign have already risen and will be further investigated during future reports.

Proposed System Alternatives:

The current VAV and CAV system that was designed satisfies the needs of the facility owner at a reasonable system cost. Other system options which will help to reduce the initial cost, total energy cost, decrease payback period will be investigated during the next phase of research. In order to justify these changes an in depth evaluation of possible system redesign options will be conducted.

Due to the size of the building there are only a few practical areas that can be redesigned or adjusted within the entire mechanical system. Below is a list of possible changes that could be investigated.

-Investigating the utilization of Combined Heat and Power (CHP)

-Utilizing a ground source heat pump within a geothermal well field located in the new green space

-Incorporating total energy wheels

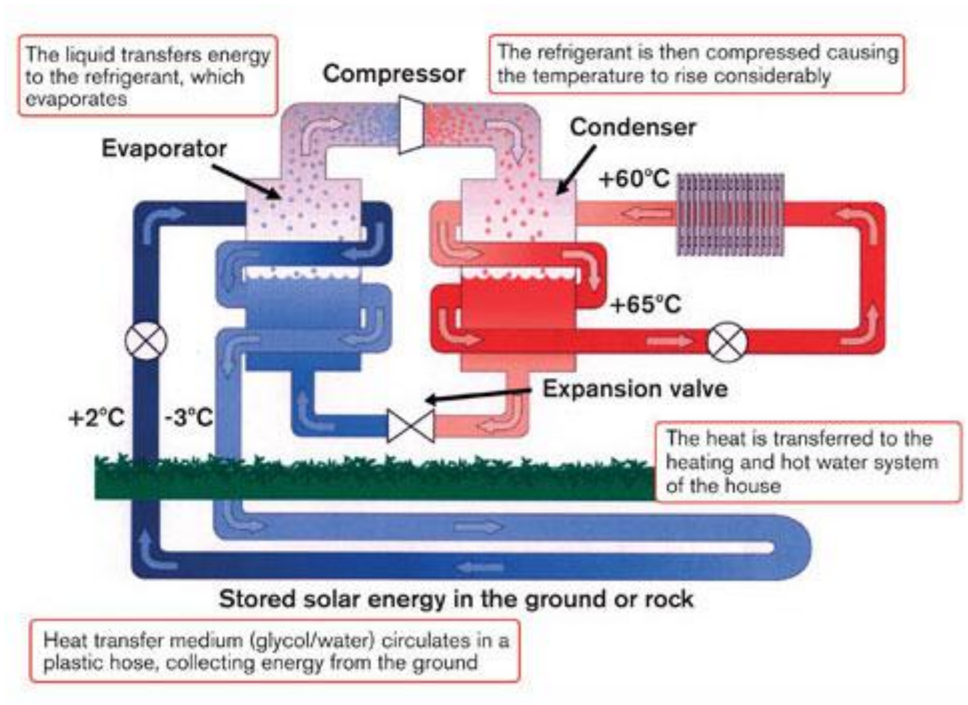
-Investigating the use of heat recovery chillers

-Investigate utilizing passive chilled beams

Two possible areas from the list above have been chosen to be further investigated. Due to these changes being made to the mechanical systems other areas have been effected. Additional studies will be performed in the end to determine the effects that these proposed changes have upon each other as well as determine the best combination that provides a decrease in energy use combined with a reasonable payback period.

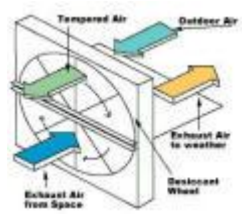
Ground Source Heat Pump:

One major advantage of using a GSHP is that it uses water as opposed to air to transport heat. Water transfers heat 25 times faster than air. Water has a much higher thermal capacity than air; this simply means that much less volume of water needs to be transported than air to have the same heat transportation effects. This in turn will create a reduction in energy consumption. Water to water heat pumps would be selected which would essentially create a chiller and boiler. There would be one set of heat pumps running in one direction to produce chilled water that serves the AHUs and another set that creates the heating water. The chilled water system would then reject heat into the ground while the heating water system would absorb heat from the ground. A downside of this proposal is that the initial cost would greatly be increased, however it is expected that the payback period will be substantial enough to offset these costs. One final note is that from an educational standpoint GSHP are fascinating and something that should definitely be considered implementing into every building.



A possible study to be conducted will talk about installing a well-field large enough to service the entire campus. A well field will be sized for the Student Center with a plan for expansion to serve the rest of the campus. Conveniently a new green space is being constructed in the center of the new buildings going up. This new green space provides the perfect location for the installation of a well-field.

Total Energy Wheels:



Total energy wheels would be an ideal installation for this student center due to the high amount of outdoor air required by code for art classrooms (0.7cm/sf exhaust). Air in these classrooms is also not allowed to be re-circulated by code. One minor problem that total energy wheels present is the increased size of AHUs. This building is to resemble and complement the architecture of existing buildings. The AHUs are located in the attic space; this space is not designed for the extra height and width that would be required for the AHU. Special consideration would need to be taken into account for the architecture and the structural support systems. One suggestion has been to use a dual plate heat exchanger energy recovery unit that operates at variable volume.

One major downside for using a total energy wheel is yet again up-front costs. This will cause the initial cost of the buildings mechanical system to increase greatly. However, once again it is expected to have a very lucrative payback due to the high volume of OA required.

Breadth Topics:

Construction management

As noted above both of these mechanical adjustments will affect the initial cost of the building. These technologies, primarily the GSHP, will also cause an increase in the amount of time to finish the construction of the building. The GSHP would also add more phases of the construction due to the fact that holes would need to be surveyed to ensure a proper site and then holes would then be drilled. This will be an interesting change in the schedule and something that will make for a great breadth study.

Architecture Breadth

As stated above the increase in size to the AHUs due to the total energy wheels will impact the architecture of the building. This student center is one of several new buildings being added to the already gorgeous campus of McDonogh School. One of the main requirements was to ensure that the new buildings "blend" with the existing buildings. The attic houses the units that would need to have total energy wheels installed. These units were not designed to be large enough to accommodate these wheels, because of this addition the attic would need to be tailored to fit these units inside. This will make for an interesting study to determine whether or not the attics can be enlarged or if they would need to be redesigned completely.

Tools and Methods:

I plan to conduct research on these mechanical adjustments to determine whether or not they are beneficial to the overall building. The tools used to conduct this research will range from, but is not limited to, Carrier's HAP, Microsoft Excel, and other advanced computer tools. These programs can show just how beneficial or unbeneficial these adjustments would be. Conclusions will be made during the testing period and will be outlined in future reports. The Student Center will also be re-evaluated and at least LEED certification is expected.

Carriers HAP can be used to create single zone models that can then show indoor conditions that are expected within the space. HAP has been used already in earlier reports, and the annual energy consumption has already been determined. Implementing these two mechanical adjustments can then be put into the already created HAP model and then total energy savings can be determined.

Microsoft Excel, is a very basic yet powerful tool that allows for great user control. This program would be used to solve complex equations and also produce study related tables and images. Since this program is so user friendly it should prove to add a substantial amount of quality to future reports.

Other programs will be used to adjust the construction budget considering both time and money. Microsoft Project is one tool that will prove to be most useful for the re-allocation of man power, time and money due to the mechanical adjustments being made. Revit architecture or Google SketchUp will be very useful when replicating any changes in the architecture due to the enlarged AHUs.

Preliminary Research:

"Ground Source Heat Pump." Dec. (2010): WEB.

Hubbard, R. 2009. "Water-to-Water Heat Pumps." ASHRAE Journal 51(1):28-35

MacMillan, Jim. "Ground Source Heat Pumps In Schools." *ASHRAE Journal*. Sep. (2007): 34-38. Print.

"Map To HVAC Solutions." *Energy Recovery: Wheel Versus Plates*. 02 (2006): WEB.

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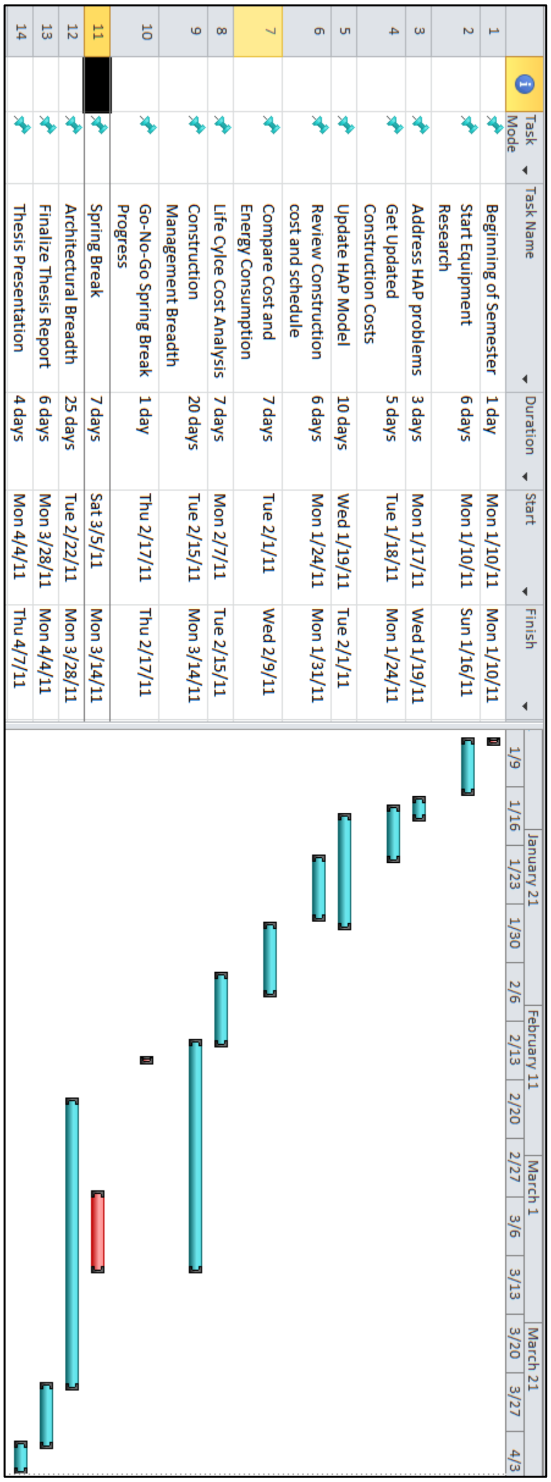
Draft Work Plan:



	Task Mode	Task Name	Duration	Start	Finish
1		Beginning of Semester	1 day	Mon 1/10/11	Mon 1/10/11
2		Start Equipment Research	6 days	Mon 1/10/11	Sun 1/16/11
3		Address HAP problems	3 days	Mon 1/17/11	Wed 1/19/11
4		Get Updated Construction Costs	5 days	Tue 1/18/11	Mon 1/24/11
5		Update HAP Model	10 days	Wed 1/19/11	Tue 2/1/11
6		Review Construction cost and schedule	6 days	Mon 1/24/11	Mon 1/31/11
7		Compare Cost and Energy Consumption	7 days	Tue 2/1/11	Wed 2/9/11
8		Life Cylce Cost Analysis	7 days	Mon 2/7/11	Tue 2/15/11
9		Management Breadth Construction	20 days	Tue 2/15/11	Mon 3/14/11
10		Go-No-Go Spring Break Progress	1 day	Thu 2/17/11	Thu 2/17/11
11		Spring Break	7 days	Sat 3/5/11	Mon 3/14/11
12		Architectural Breadth	25 days	Tue 2/22/11	Mon 3/28/11
13		Finalize Thesis Report	6 days	Mon 3/28/11	Mon 4/4/11
14		Thesis Presentation	4 days	Mon 4/4/11	Thu 4/7/11

References:

Administation, E.I. (n.d.). *Energy Star*. Retrieved October 23, 2010, from: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/e02.pdf.

James Posey Associates, Inc.

Justin Bem

Previous Senior Thesis Reports 2009-2010

Torcellini, M.D. (June 2007). Source Energy Emission Factors for Energy Use in Buildings. Golden, Colorado: National Renewable Energy Laboratory (NREL).

US Energy Information Administration. EIA. Retrieved October 23,2010, from: http://www.eia.doe.gov/dnav/404error.asp?qFlag=y.