Thesis Proposal

Photo by Fred Martin

Clemson University Advanced Material Research Laboratory
Anderson, SC

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Mechanical Option

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Executive Summary

Clemson University ARML in Anderson, SC is an 111,270 square foot research facility owned by Clemson University.

The building's supplied air is given by 19 air handling units which feed into one plenum and severs the entire building. The units are made up of fifteen AHU units ranging from 1,000 to 11,300 cfm with VAV boxes that supply the lobby and office spaces. The remaining four units are MAH units ranging from 6,800 to 20,650 cfm. There are two 3,348 MBH gas fired boilers and one 4,094 MBH electric boiler. There are three 266.6 ton chillers and two 375 ton cooling towers.

The chief goal is to alter the existing HVAC system to conserve energy and decrease yearly utility costs. Secondary goals include decreasing the power density and optimizing the lighting in the building where densities are much greater than needed. In return, the other goal is to resize the electrical system components throughout the building which were affected.

In order to obtain the energy reduction desired, chilled beams will be one of the many options used in this study. The low fan speed used to deliver air to the outlet diffusers has a low energy requirement. They also operate at relatively high chilled water flow temperatures, meaning the chillers have to do less work than for a fan coil system.

Energy recovery is also a main design issue, and to ensure this, I will be using an energy recovery wheel with a purge section to re-heat my intake air to reduce cost on manual re-heat.

Since it is important to minimize the amount of energy required and maximizing the energy usage, an analysis will be conducted on the lighting in areas of concern.

Lighting can be one of the largest loads on a building. A well designed lighting system and conserve energy along with providing adequate lighting.

Integrating the chilled beams will have a noticeable reduction in energy consumption. Optimizing the lighting in the areas of concern will also show impact on the electrical load. Since both redesigns will show reduction of energy consumption, the electrical system will need to be re-evaluated with the new loads in mind. A small CM analysis will be preformed since ductwork, fan, and equipment will be downsized, along with the initial cost of the system.

Background

Design Objectives and Requirements

Clemson University AMRL is a two-story mixed use building located in Anderson, SC. This 111, 270 sq ft. building houses office space, laboratories, conference rooms, and clean rooms. There are 15 AHU's and 4 MAH's that condition this building. The mechanical system uses an on site boiling and chilling plant to condition air for the AHU's and VAV distribution system. AHU numbers 8, 10, and 11 uses VAV boxes to supply the space. Most of the mechanical equipment is located on the second floor, where there is a small space allocated for this on the first floor. Clemson University ARML, due to its many laboratories, requires a lot of mechanical equipment. In design, they used mostly an entire floor to house the mechanical equipment. With this, the total area of the mechanical space on the second floor is 31,841 sq. ft. After calculating the areas other than the mechanical floor space, such as the draw tower and first floor mechanical room, there is a total of 35, 626 sq. ft. of lost rentable space. Out of 117,000 sq. ft, 30.4 % of this area is given to the mechanical equipment.

The AMRL is served by 19 units, ranging from 1,000 cfm to 20,650 cfm. The amount of minimum outside air to the AHU's varying between 300 to 20,650 cfm. As noted before, the rooms serviced by AHU 8, 10, and 11 uses VAV boxes to control the climate which people occupy.

Clemson AMRL uses two 3,348 MBH gas fired boilers and one 4,094 MBH electric boiler. There are three 750 gpm/266.6 ton chillers and two 1,125 gpm/375 ton cooling towers. The air supplied to the building is from the fifteen AHU's range from 1,000-11,300 cfm and four MAH units ranging from 6,800 to 20,650 cfm.

Mechanical System

-Air Handling Units/ Make-Up Air Handling Units

Fifteen air handling units with three of them having VAV's and 4 MAH units serve Clemson AMRL. They provide conditioned air to offices, laboratories, conference areas, and clean rooms. Table 5 shows the operating conditions for the AHU's. The Make-Up Air Handling Units are also shown in table 5. They were needed to condition the additional space since the air exhausted through the fume hoods would need replaced.

-Cooling Towers

There are two 375 ton, 1,125 gpm cooling towers located on site. The cooling towers provide condenser water for the 15 AHU's.

-Chillers

There are three 266.6 ton, 750 gpm chillers located at the AMRL.

-Boilers

There are two 3,348 MBH gas fired boilers and one 4,094 MBH electric boiler located at Clemson's AMRL.

-Energy Recovery Coil

Clemson's AMRL uses three energy recovery coils. They provide cooling for the condenser water loop from the cooling towers and heat for the hot water loop from the boilers.

-Variable Air Volume Boxes

The conditioned air from AHU 8, 10, and 11 is ducted to several variable air volume (VAV) boxes, which are located in the ceiling plenum. They are selected in ranges of cfm. There are also different gpm amounts for the hot water reheat coils to each of the VAV boxes.

-Basic System Operation

Clemson's AMRL consists of both air-side and water-side mechanical equipment and systems. The air-side consists of AHU's, MAH's, and VAV boxes. An example of the air-side schematic is shown in figure 1. The water-side operation consists of a hot water system and a condenser water system. The hot water system is shown in figure 2 and the condenser water system is shown in figure 3 below.

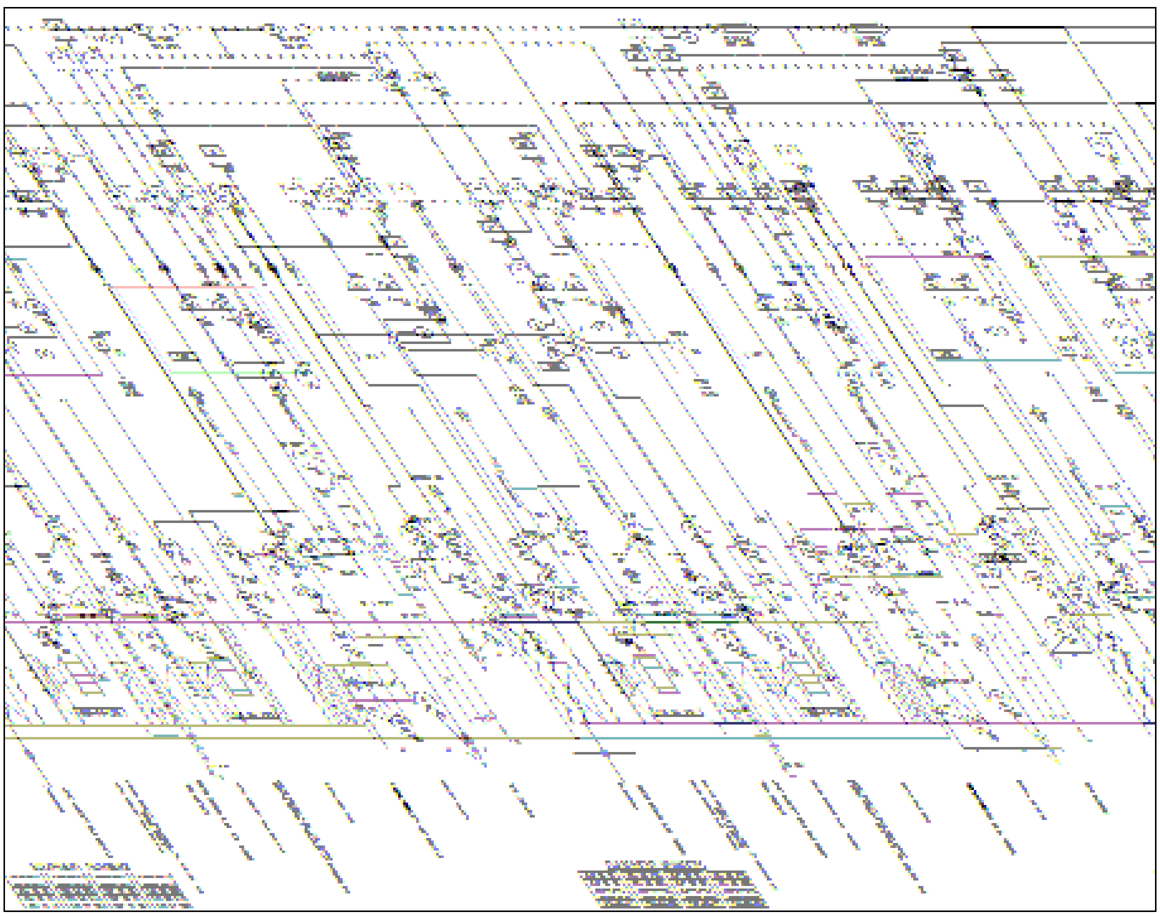

Figure 1—Air-side schematic for a sample of 4 AHU's

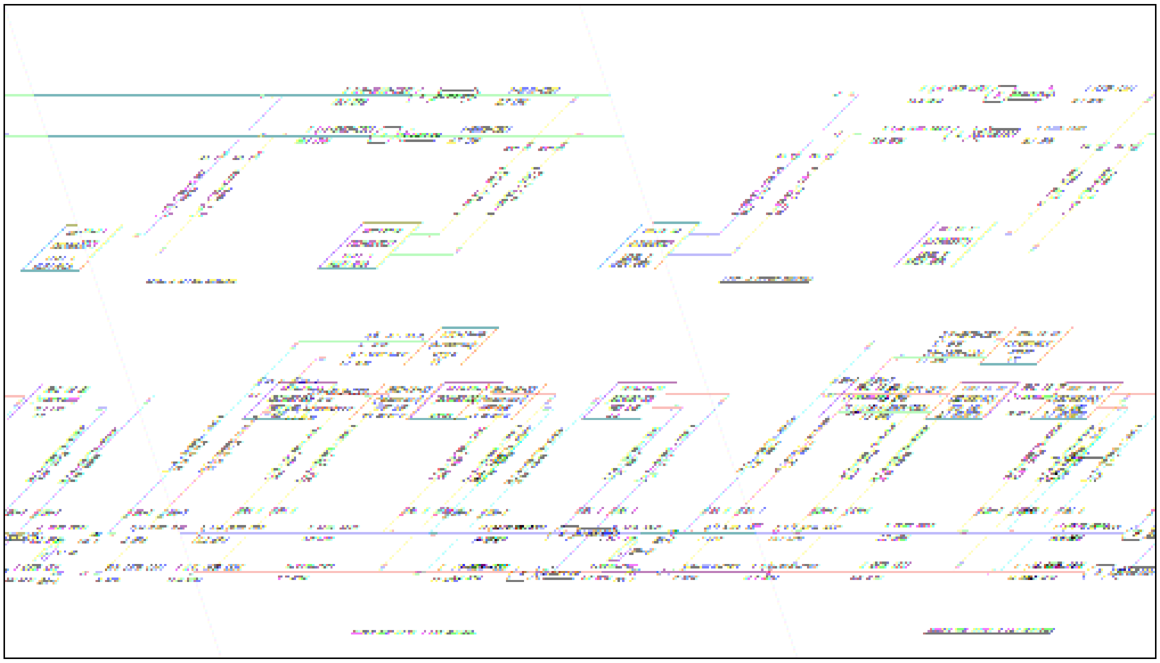

Figure 2—Sample of Hot Water Schematic

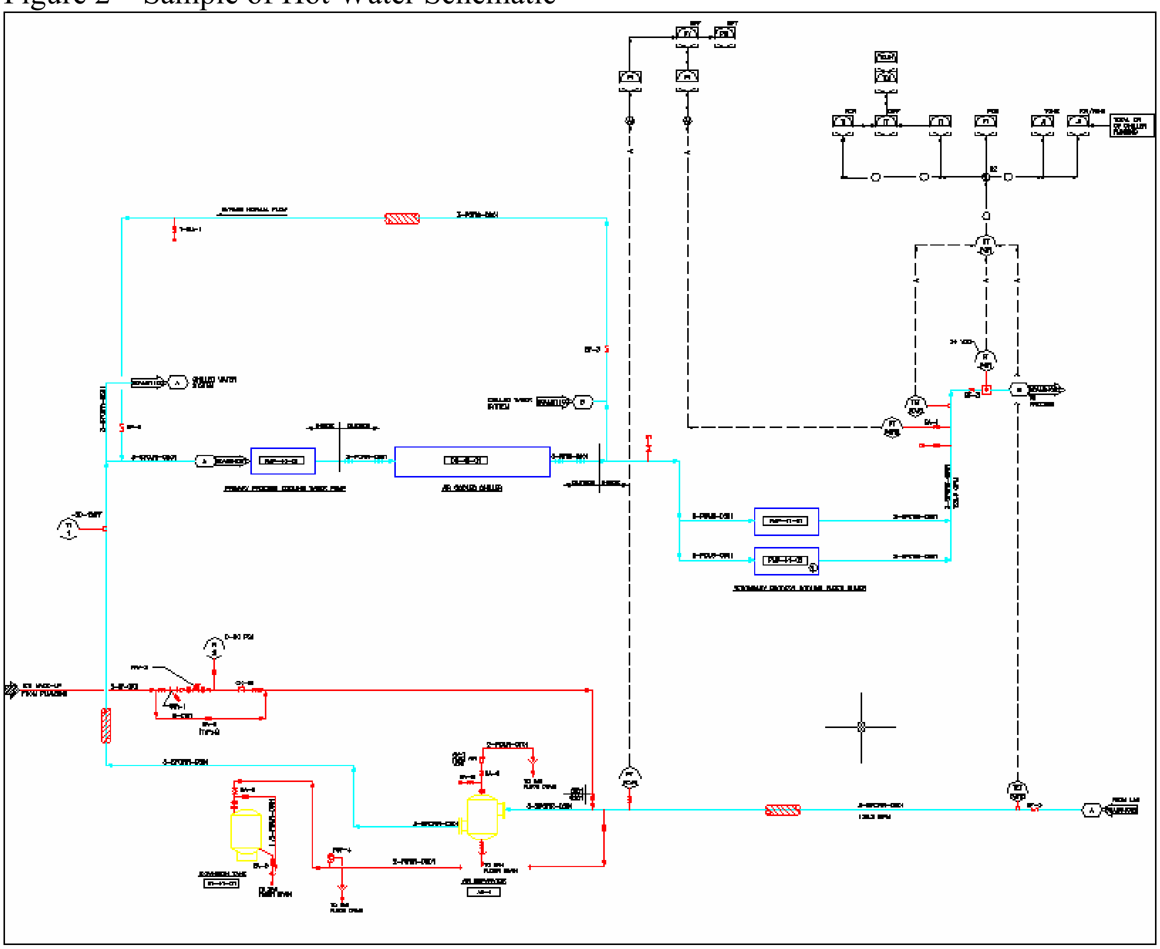

Figure 3—Sample of Condenser Water Schematic

Proposal Objective

The purpose of this thesis is to analyze different solutions to the design of Clemson AMRL's systems. This does not in any way imply that there are flaws in the current system. The chief goal is to alter the existing HVAC system to conserve energy and decrease yearly utility costs. Secondary goals include decreasing the power density and optimizing the lighting in the building where densities are much greater than needed. In return, the other goal is to resize the electrical system components throughout the building which were affected.

As found with Technical Assignment One, the AMRL was compliant with AHSRAE Standard 62.1 except AHU-11. This will be taken into consideration with the design process. As with Technical Assignment Two, the building was compliant with ASHRAE Standard 90.1 in the building envelope category. For the lighting compliance, the AMRL was over the 1.1 W/sq ft densities in many spaces. These spaces include offices, labs, and waste storage. All changes will have the original design in mind, and modifications will be made without adversely changing the system.

Potential Redesign

Considered Alternatives

Co-generation is one alternative to the design of Clemson AMRL building. A building using co-generation makes electricity of site, and thus less energy loss due to transmission. The heat from the burning fuel, can be utilized and help heat the building.

Ground source heat pumps were also taken into consideration. With the climate allowing for such a design, this would also be a great benefit to the owner. Since the building takes setting in a non urban environment, this also makes this design appealing. Similar to a GSHP, one could use water source heat pumps and store water in a large tank underground to help with the load of the building.

Thermal storage was another alternative to the design to help decrease energy costs. One could produce ice in the evening, when utilities are cheaper, and store it for the following day for cooling. Energy recovery wheels are also an option in design. The only downfall is that desiccant wheels can only be used to the laboratory spaces. Enthalpy wheels are able to recover energy and moisture since they mix the exhaust and supply air streams. A desiccant wheel does not transfer contaminants. Instead, the wheel is flushed with supply air in the purging section of the rotor.

All ideas are very plausible, but drawbacks will include the initial cost and the space the new equipment requires.

Proposed Redesign

In order to obtain the energy reduction desired, chilled beams will be one of the many options used in this study.

There are two different chilled beams, passive and active. One can incorporate a chilled ceiling with overhead or under floor ventilation, and or chilled slab with under floor ventilation. With overhead ventilation, there is a limited capacity to absorb heat gains. Under floor ventilation has improved capacity to absorb heat gains and excellent in comfort conditions. A chilled slab with under floor ventilation has a cooling capacity up to 70 W/sq m. Exposed lighting is required with this type of set up.

Passive chilled beams have a chilled surface formed into a linear finned coil, which is surrounded by a pressed steal casing. These are able to be suspended from the ceiling, with flush mounts also available. Warm air rises to the ceiling and enters the top of the beam, where it is cooled by contact with the cold coil. The cool air then descends into the room through slots underneath the beam.

Active chilled beams incorporate tempered ventilation air supplied through ducting in the beam itself. The tempered air leaves the supply ducting through slots with a higher velocity that induces warm air into the beam and through the cooling coil, reducing its temperature. The supply and chilled room air mix and enter the room out of the slots under the beam. With active chilled beams, room temperature is achieved by controlling of individual or groups of beams. They have a cooling capacity up to 100 W/sq m and also have integrated lighting as option and can be fully recessed.

The advantages of chilled beams include low maintenance since there are no internal fans or filters. Low fan speed is used to deliver air to the outlet diffusers which in return, have a low energy requirement. They also operate at relatively high chilled water flow temperatures, meaning the chillers have to do less work than for a fan coil system.

I will also be using energy recovery wheels in my design. The only downfall is that desiccant wheels can only be used to the laboratory spaces. Enthalpy wheels are able to recover energy and moisture since they mix the exhaust and supply air streams. A desiccant wheel does not transfer contaminants. Instead, the wheel is flushed with supply air in the purging section of the rotor.

Integration and Coordination

Using active chilled beams in the redesign process, there isn't any significant issues present. Space is available for extra equipment, but coordination with plumbing will be a must for the spaces due to the units. This could potentially work very well with the lighting problem, since some chilled beams and contain everything from lighting to data lines, to fire suppression systems.

Breadth Areas

-Lighting

Since it is important to minimize the amount of energy required and maximizing the energy usage, an analysis will be conducted on the lighting in areas of concern. Lighting can be one of the largest loads on a building. A well designed lighting system and conserve energy along with providing adequate lighting. Using energy saving lamps will benefit the owner with lower annual operating costs.

-Electrical

Integrating the chilled beams will have a noticeable reduction in energy consumption. Optimizing the lighting in the areas of concern will also show impact on the electrical load. Since both redesigns will show reduction of energy consumption, the electrical system will need to be re-evaluated with the new loads in mind. Since the electricity usage will change, all of the affected panels will be resized along with the circuits and feeders.

-Construction Management

I will also be conducting a small analysis on the cost of construction of the new system versus the existing system. Since ductwork, fans, and equipment will be downsized for the new system, this will adversely affect the cost of operation along with initial cost.

Project Methods

The proposed redesign of the AMRL will modeled by Carrier's Hourly Analysis Program (HAP) and will be compared to Technical Assignment One. This will be done prior to the electrical portion, since this will have bearing on the load of the building.

The breadth portion will be done after design of the system is partially completed. Extensive research will be done in order to select proper lamps and ballasts. Lexicon lighting analysis software will be used for space modeling to maintain adequate lighting in the spaces conditioned.

The final process will be completing a life cycle cost (LCC) analysis for the alteration of the system. Prior to the LCC, a new HAP simulation will be preformed along with resizing of the electrical system including feeders, branch circuits, and panel boards. The LCC will determine if the new system has more energy savings.

Preliminary Research Bibliography

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Anderson, David. *Technical Assignment #1: ASHRAE Standard 62.1-2004 Ventilation Compliance Evaluation Report.* October 5, 2006.

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Clemson University AMRL – plans and schedules. Construction Set. June 2004.

Philips Lighting. Division Webpage. 7 December 2006. <www.nam.lighting.philips.com/us>

TROX. Division Webpage. 5 December 2006. <http://www.troxusa.com/usa>

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Spring Semester Proposed Schedule

The calendar on the subsequent pages is a preliminary outline for the spring semester redesign process. Time was estimated for each portion, and is subject to change due to other course work.

January 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15 MLK Day	16 Classes Begin	17 Begin In-Depth	18 Begin Chilled Beam Analysis	19	20
21	22	23	24	25 Last Day Drop/Add	26	27 ASHRAE Winter Meeting (Dallas)
28 ASHRAE Winter Meeting (Dallas)	29 ASHRAE Winter Meeting (Dallas)	30 ASHRAE Winter Meeting (Dallas)	31			

February 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 Complete Chilled Beam Analysis	5 Begin Lighting Research	6	7	8	9	10
11 Complete Lighting Research	12 Begin Lighting Layout/Calcs for Total Power	13 ASHRAE Meeting-Larry Schoen	14	15	16	17
18 Complete Lighting Layout and Power Calc	19 Begin Electrical Design	20	21	22	23	24
25	26	27	28			

March 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 Complete Electrical Design	5 Begin HVAC Final Calculations	6	7	8	9	10
11	12 Spring Break	13 Spring Break	14 Spring Break	15 Spring Break	16 Spring Break	17
18 Complete HVAC Design	19 Begin Life Cycle Cost Analysis	20	21	22	23	24
25 Complete Life Cycle Cost Analysis	26 Begin Report	27 ASHRAE Meeting-Mark MacCracken	28	29	30	31

April 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 Finish Report	2 Rough Draft to Consultant	3	4	5	6	7
8 Begin Revisions	9 Create Presentation	10	11 ASHRAE Student Night (Harrisburg)	12 **Final Report Due**	13 Late Drop Deadline	14 Complete Presentation
15	16 Presentations	17 Presentations	18 Presentations	19 Presentations	20 Presentations	21
22	23	24	25	26	27	28
29	30					