THESIS PROPOSAL

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Mechanical Option

Margaret M. Alkek Building for Biomedical Research
Baylor College of Medicine
Houston, TX
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Table of Contents

Executive Summary

This report reports the existing conditions for the Margaret M. Alkek Building for Biomedical Research in Houston, TX and the proposed redesign that was thought of during the first three technical reports conducted. The major issues of research laboratories tend to be indoor air quality and energy consumption. This current solution to the indoor air quality issues of the building is to use 100% outdoor air systems. The proposed redesign will use an active controls system to track the exhaust/return air and determine when it is acceptable to either return the air directly or use another sort of energy recovery device or technique. To have room for the new energy recovery equipment, it is suggested that the level 8 research laboratory is switched with the level 3 mechanical system. This allows for energy recovery devices access to all exhaust streams as well as the air handling units. Also the current configuration of air handlers will be changed and consolidated. Finally a parallel cooling system will be looked at if enough room is not created in consolidating all the air handling equipment for the energy recovery devices.

This report also discusses alternatives that were considered before the final proposed redesign was determined. The justification and integration/coordination issues involved with the proposed redesign are discusses. Finally the breadth topics that are associated with the design as well as the project methods are discussed, then a schedule for the spring semester is presented.

Building Background

The Margaret M. Alkek Building for Biomedical Research is an 8 story and approximately 200,000 square foot research tower being built on the existing campus at Baylor College of Medicine (BCM). The building is to be located between the Jewish Institute for Medical Research and the Texas Medical Center Garage #6. The research tower will be constructed on top of an existing subterranean Transgenic Mouse Facility. The building's 8 stories will include 2 levels of animal research facilities, flexible laboratory space and office space. Cardiovascular sciences, diabetes and metabolic disease, cancer, pharmacogenomics, imaging and informatics & proteomics are the research areas that will be covered within the new research tower.

Construction of the new research tower required BCM to replace one of the existing 800 ton chillers in the North Campus chiller plant with a 1300 ton centrifugal chiller to accommodate the extra load from the new research tower. The tower has access to the campus chilled water loop, as well as a high pressure steam loop. The campus chilled water is pumped into a plate and frame heat exchanger which is responsible for the process chilled water in the tower. The steam loop runs into 3 shell & tube clean steam generators which produce the steam needed in the building for process and humidification. The steam runs through the building in low pressure (15 psig) and medium pressure (80 psig) loops. A portion of the low pressure steam is sent to two shell & tube heat exchangers which generate the hot water for the building which feeds heating coils in the air handling units as well as all reheat coils.

There are 12 air handlers in total that supply the tower. Of the 12 air handlers 10 are located in the level 3 mechanical space and the other 2 are located on the roof. On the roof there is a 15,000 cfm and 10,000 cfm air handler which serves to pressurize the north and south stairwells, respectively. 4 25,000 cfm air handlers service the vivarium spaces, office and lab spaces on levels 1 and 2. There are 2 10,000 cfm air handlers that serve the level 3 mechanical space. The final 4 air handlers are 50,000 cfm and serve the main lab and office spaces on floors 4-8. Fan coil units are used in the emergency electrical rooms, elevator equipment room and in the eastern corridors on levels 4-8.

Levels 1 & 2 contain all of the animal research facilities and vivarium space. Level 2 is constant volume 100% outdoor air, as it contains no office space and all vivarium and research spaces are constant volume and exhausted through fume hoods and exhaust fans located on the roof (via exhaust risers). Level 1 contains the lobby of the research tower. This lobby space and the attached corridor are variable volume spaces and are the only spaces on level 1 in which the air is returned instead of exhausted. All the vivarium spaces and animal research spaces on level 1 are constant volume and exhausted similar to level 2. The animal facility cagewash on level 1 is variable volume and is exhausted through exhaust diffusers as well as exhaust hoods. There is office space on level 1 which is variable volume however the air in this space is also exhausted and not returned. There are many vestibules which separate the "dirty" and "sterile" sides of level 1 which is divided by the cagewash. The "dirty" side is the office side and also where dirty cages are brought into the

cagewash to be cleaned and the sterile side is the opposite side of the building where the sterile cages are removed from the cage wash.

Level 3 has only a few spaces to consider. In the northeastern corner of the building there is some storage space, corridor, glass wash and equipment service area that needs to be considers for heating and cooling. These spaces are all constant volume and exhausted. The rest of the space on level 3 is the mechanical area containing a majority of the air handlers. There are louvers along the north side of the building that allow for outdoor air to come in and feed the air handlers.

On levels 4-8 the research laboratories are variable volume, as are the office spaces on the opposite side of the floors. However not all spaces on levels 4-8 are variable volume there are a some laboratory support spaces that are constant volume, typically the presence of a fume hood will indicate constant volume. The air within the laboratory and laboratory support spaces is exhausted through exhaust fans located on the roof via exhaust risers or through fume hoods that also exhaust through the roof. The laboratory and office spaces on levels 4-8 are separated by a pressurized corridor/interaction space. Air in the office side and separating corridor/interaction space is returned.

Current System Operation

This section of the report will describe the current existing systems within the building. These systems are the steam, chilled water, heating hot water and air systems within the building. Each section will describe the system and reference and accompanying schematic of the system.

Building Steam System

The Margaret M. Alkek Building for Biomedical Research has an extensive steam system. Baylor College of Medicine's campus is located at the Texas Medical Center which produces its own steam via the Texas Medical Center Central Heating and Cooling Services Cooperative Association (TECO). The research tower utilizes this campus steam loop for many different uses.

The campus steam loop conditions are 398°F and 225 psig. The building draws in 26,000 lb/hr of steam at peak load. The amount of demand depends on the following; humidification in the air handlers, the amount of process of steam required, domestic hot water and heating hot water needs. The high pressure steam is brought into the building and then goes through a series of pressure reducing valves which creates medium pressure steam (80 psig) and low pressure steam (15 psig) loops.

The low pressure steam loop feeds two shell & tube heat exchangers (HE-1 & HE-2 on Figure 6 below) which create the heating hot water for the building. HE-2 unit is used as standby. The low pressure steam is then returned to a condensate pump (CP-1 on Figure 6 below) and then is fed back into the TECO condensate system. The high pressure return and low pressure return from the pressure reducing valves feed into a flash tank which vents off any existing steam and then connects to the same condensate pump as the low pressure steam system which again connects into the TECO condensate system.

The medium pressure steam loop goes to feed 3 clean steam generators and the domestic hot water heaters. As shown on figure 6, CSG-1 creates clean low pressure steam (CLPS) which feeds the air handling units for humidification needs. This CLPS then returns to a condensate cooler which connects to the existing water recovery system on campus. CSG-2 & CSG-3 create clean medium pressure steam which feeds all the process steam requirements throughout the building for sterilization of lab equipment and other needs. The process steam is then returned to a flash tank which then feeds clean low pressure return steam into the same condensate cooler as mentioned above which then connects to the existing water recovery system. The domestic hot water heaters connect right off of the medium pressure steam loop. All of the medium pressure return from the CSG's and domestic water heaters connects to a flash tank which connects back to CP-1 (same condensate pump as the other HPR and MPR connect into) and then into the TECO condensate system.

The amount of steam drawn off the high pressure steam loop depends entirely on the heating and steam generation needs of the building at any point in time. See the below schematic (Figure 1) for a complete view of steam usage in the building.

BUILDING STEAM SYSTEM

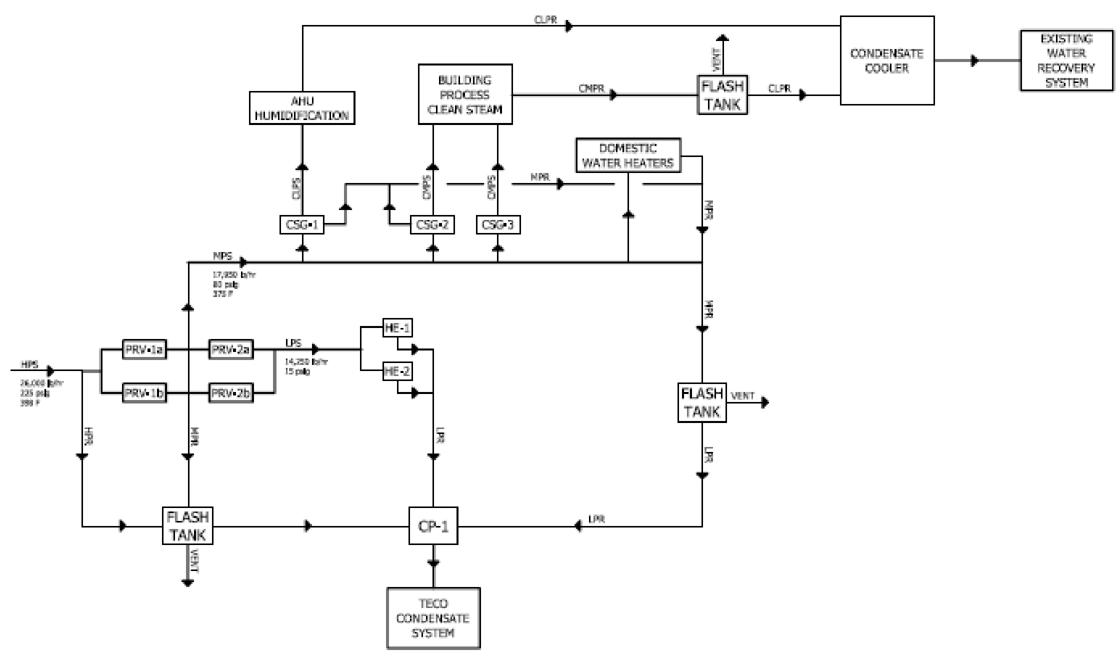

Figure 1

Building Chilled Water System

The Margaret M. Alkek Building for Biomedical Research utilizes the existing campus chilled water loop for all its chilled water needs. The chilled water is produced in the north campus chiller plant. With the addition of the new research tower, a chiller had to be replaced. An existing 800 ton centrifugal chiller was replaced with a new 1300 ton centrifugal chiller to assist in the handling of the new load on campus and for future expansion. The campus loop circulates chilled water at 45°F.

Chilled water is drawn into the building and separated into two loops. The first loop takes 45°F water through two pumps in parallel (CHP-1 & CHP-2). This chilled water is pumped to the cooling coils on the air handling units that serve levels 4-8's office and lab space (AHU-L.1a, AHU-L.1b, AHU-L.2a and AHU-L.2b) as well as the cooling coils on the stairwell pressurization air handlers. The sensors on the coils in the air handling units connect back to the two pumps (CHP-1 & CHP-2) which are connected to variable frequency drives for control of how much chilled water is brought into the building via this loop. At peak load this loop will draw in 2750 GPM. The chilled water used by these air handlers is then returned at 60°F to the campus chilled water return loop.

The second chilled water loop created within the building feeds the air handlers for the animal research facility floors (AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A.1d), fan coil units and process cooling throughout the building. Two parallel pumps (CHP-3 & CHP-4) draw in 1720 GPM (peak design load) of chilled water, of which, 1360 goes directly to the air handlers for the animal research facility floors. A sensor on the cooling coils connects back to the variable frequency drives attached to CHP-3 and CHP-4. The chilled water is returned from these air handlers at 60°F to the campus chilled water return loop. A 360 GPM branch breaks off to feed a plate and frame heat exchanger (PFX-1). Chilled water enters the PFX-1 at 45°F and leaves at 60°F, this water then is returned to the campus chilled water return loop. The plate and frame heat exchanger creates 50°F chilled water which then feeds fan coil units and any process cooling needs throughout the rest of the building. The water is then returned to the PFX-1 at 65°F. The schematic of this system can be seen below.

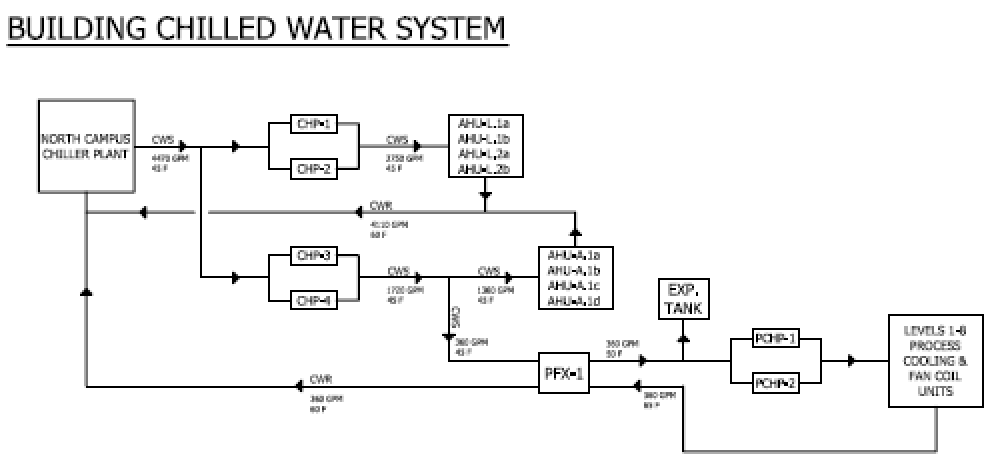

Figure 2

Building Heating Hot Water System

The research tower's heating hot water system is fairly simple. As stated above in the steam section two shell & tube heat exchangers (HE-1 & HE-2) are used for heating hot water creation for the building. HE-2 is a standby unit. At peak design HE-1 creates 950 GPM (peak design load) of heating hot water for distribution throughout the building. The two heat exchangers are connected to two parallel pumps (HWP-1 & HWP-2) which distribute the heating hot water. There are 3 loads that the heating hot water feeds; the reheat coils in the VAV/CV boxes on levels 1 and 2, the reheat coils in the VAV/CV boxes on levels 4-8 and level 3 which houses the air handling units for laboratory, office and animal research facilities. The heating hot water is distributed at 190°F and returned at 160°F.

The controls on the heating hot water are slightly more complex than the other systems. Each space (or zone) within the building has its own CV or VAV box. Each box (with the exception of cold rooms, electrical and mechanical rooms) has a reheat coil in the box. The thermostats in each room then connect to the diffusers and reheat coils. If the thermostat is set to where reheat is needed at the box, the reheat coil is turned on. The reheat coils in the boxes and heating coils in the boxes connect to the variable frequency drives connected to the pumps for control of how much heating hot water is distributed. The complete diagram can be seen below.

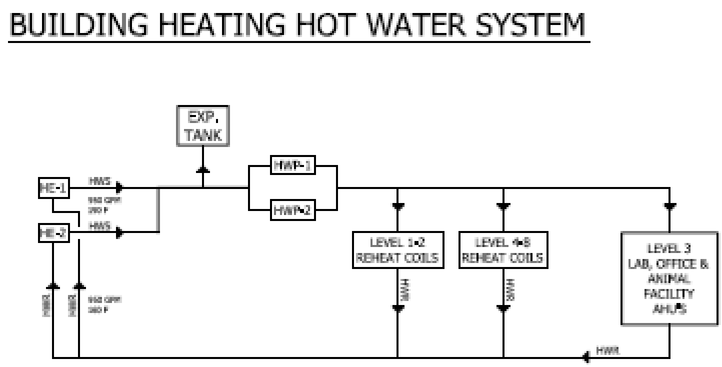

Figure 3

Building Air Side Systems

The research tower's air system is relatively simple as well. The building has three separate air systems with multiple air handling units serving each of these three systems. System 1 serves animal research facility on levels 1 and 2. System 2 serves the laboratory spaces on levels 4-8, while System 3 serves the office spaces on levels 4-8 as well as the remaining laboratory spaces not covered by System 2.

System 1: AHU-A.1a, AHU-A.1b, AHU-A.1c & AHU-A.1d

System 1 serves the animal facilities on levels 1 & 2. This system consists of air handlers; AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A1.d. The animal facilities on the first floor are made up of animal housing rooms in which animals to conduct experiments on are held. Connected to the animal housing rooms are procedure rooms where the experiments or preparation for experiments can be carried out. A majority of the space on level 1 is taken up by a cage wash facility for cleansing of all the cages in which animals are stored. Level 2 consists almost exclusively of the aforementioned animal housing rooms and adjacent procedure rooms.

System 1's four air handlers are stacked in a 2x2 configuration and "dump" all their supply air into a supply plenum where air from all 4 air handlers is mixed. Air is then supplied from there to the appropriate spaces on levels 1 & 2. The system is 100% outdoor air, this is due to needing the air as clean as possible so as to not influence experiments or spread contaminants/sickness. The air is exhausted from these spaces through four separate means; biological safety cabinets (similar to fume hoods), an exhaust riser dedicated to animal spaces, toilet exhaust and an exhaust for the cagewash exhaust which is a "wet" exhaust because of the steam used to sterilize during cleaning.

The thermostats determine how much air is required for these spaces which connect back to the variable frequency drives connected to the fans of the air handling unit as well as the VAV/CV boxes. The exhaust tracks the supply so that pressurization required in certain rooms are maintained. Many of the spaces within this system are constant volume to maintain pressurization due to the fume hoods and biological safety cabinets which draw a constant amount of air from the room. The diagram of this system can be seen below in Figure 4.

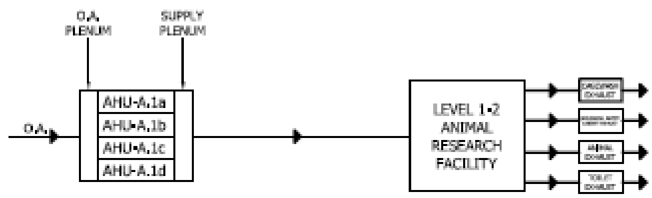

Figure 4

System 2: AHU-L.2a & AHU-L.2b

System 2 serves the laboratory spaces on levels 4-8. This system consists of air handlers; AHU-L.2a and AHU-L.2b. The laboratory spaces on these levels are for research purposes at the college. The adjacent spaces are laboratory support and are made up of spaces such as fume hood rooms, equipment rooms, microscopy and general lab support rooms. The air handlers are stacked on top of each other and supply into a supply plenum similar to system 1. This system is also 100% outdoor air for the same reasons as system 1.

System 2 is controlled the same as System 1. The difference being that much fewer spaces are constant volume due to only a few fume hoods being present (and in specific rooms). The spaces are exhausted via exhaust risers that connect to four exhaust fans connected in parallel. The diagram of this system can be seen below.

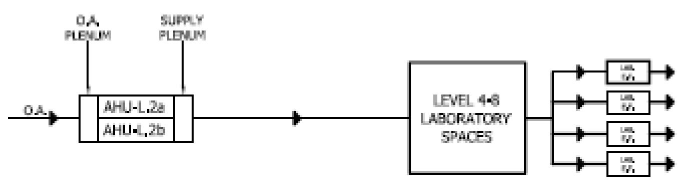

Figure 5

System 3: AHU-L.1a & AHU-L.1b

System 3 is the only system in the research tower that uses recirculated air. This system serves the rest of the laboratory spaces on levels 4-8 not covered by system 2, the office spaces on levels 4-8 and the main lobby and attached corridor on level 1. This system is made up of air handling units AHU-L.1a and AHU-L.1b. These units are also stacked one on top of the other and use the supply plenum like the other 2 systems. Air in the laboratory spaces on these floors is exhausted through the roof of the building. The office side of levels 4-8 and few level 1 spaces are the spaces that are returned. The system is approximately 50% outdoor air.

The controls on System 3 are similar to the other 2 systems. In this case return tracks the supply in the office spaces that return air. There are no constant volume spaces (outside of the restrooms) in this system because the few laboratory spaces that are covered by this system do not require it. The laboratory spaces are exhausted by exhaust fans located on the roof via duct risers. The diagram of this system can be seen below in Figure 6.

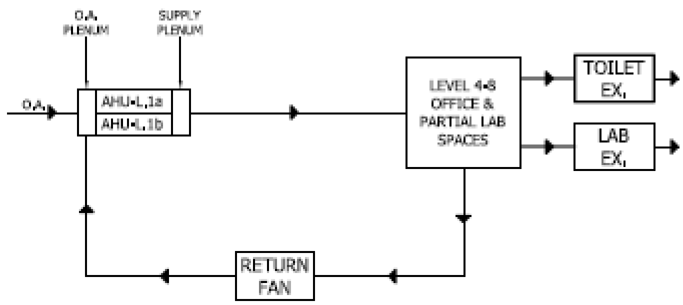

Figure 6

Alternate Redesigns Considered

There were two alternative redesigns considered before settling on the ultimate proposed redesign (to be discussed later). The two ideas were first to use an absorption chiller instead of the campus chilled water loop and the other was a combined heat and power system.

The campus chiller plant has an 800 ton chiller that is replaced by a 1300 ton chiller to accommodate the extra load on the campus' chilled water system as well as to have some room for future expansion. The idea behind this redesign was to instead of replacing the 800 ton chiller to place an absorption chiller in the building to produce chilled water for the building. The absorption chiller would have utilized the existing campus steam loop to drive it. This was considered not in depth enough to devote a semester to. The only areas to study would be cost and energy consumption of adding the absorption chiller versus the existing design. Also, finding the room in the building to place the chiller would've been an area to look at.

The second alternative was to put in a combined heat and power system. There were several problems with this idea. Since the building has not been constructed yet there are no load profiles available. Energy analysis and other activities so far have been conducted under an assumed profile for comparison sake. For a combined heat and power system a detailed load profile needs to be available to test the feasibility of the system. Also there is little room for a turbine and an absorption chiller within the building for this equipment. Another floor would have to be added or perhaps a penthouse for these systems which would cost way more than using an absorption chiller driven by exhaust gases would save over any number of years.

There was also two common problems with each of these redesign ideas. The first is that both designs take measures to remove the buildings mechanical systems from the existing campus loops. Since the building is being constructed on campus it does not make sense to remove it from the existing available loops. The main problem with both redesign ideas is that neither addresses the real issues involved with the building. The building, as with most research buildings, consumes a large amount of energy and indoor air quality is also a big concern. Neither of these designs takes any real measures to address these issues no neither was seriously persued.

Proposed Redesign

Scope

The proposed redesign intends to address the energy consumption and indoor air quality issues of the building. Currently the solution to controlling the indoor air quality is to use 100% outdoor air systems which contribute to the energy consumption of the building. This does not allow for any energy recovery within the system. The main point of the redesign will be using air quality sensors placed before and after filters in what is currently the exhaust stream to track the air quality and then when it is acceptable either return the air or use an energy recovery device such as an enthalpy, sensible or desiccant wheel in an attempt to cut down on the energy consumption of the building.

The first issue to deal with will be implementation of filters and the indoor air quality controls. The system will need to be able to monitor what will become an exhaust/return stream and determine when the air is acceptable to use or when it needs to be exhausted. It appears as though this sort of system is somewhat rare.

A fair amount of information will need to be gathered to set up controls like this. The first bit of information will be what sort of particles do mice release since the main animal being used for experimentation is mice. Also information on what sort of toxins and particles are typically released during the types of experiments that are going to be conducted in the research labs. Information on particles and pollutants that are in the outdoor air in Houston, Texas should be gathered. Then it needs to be determined what are acceptable levels of each for occupants of the buildings then the control system can begin to be constructed.

Once this information is gathered the next issue to address will be to look into what would be the best device to use for energy recovery in the system. It needs to be determined whether a sensible wheel, enthalpy wheel, desiccant wheel, direct return or a combination of those energy recovery devices will need to be looked at.

The redesign looks to address the indoor air quality and energy consumption issues associated with research labs. The current answer to this is to ignore the energy consumption and go with a 100% outdoor air system to ensure there are no problems with indoor air quality. This redesign will look to see if active controls in indoor air quality monitoring is a better design idea.

Justification

The redesign will allow for an opportunity to learn more about controls in the less than ordinary application of indoor air quality monitoring. This will also allow for a look at research lab design from an “outside the box” perspective. Also the redesign looks to save energy consumption which will become a bigger issue as natural resources deplete.

Integration & Coordination

The biggest integration and coordination concern for the proposed redesign of the Margaret M. Alkek Building for Biomedical Research will be finding space and a location for the energy recovery devices. Currently the mechanical systems are on level 3. This means that the exhaust streams for levels 1-2 pass through the mechanical systems floor but not levels 4-8 exhaust streams. So to allow for energy recovery on all exhaust streams it is proposed that the top level (level 8) research floor be switched in place with the level 3 mechanical systems floor. This allows for the energy recovery devices to have access to all exhaust streams as well as the air handling units that supply all the lower levels.

Then there is the issue of saving space on this floor by consolidating the current 2x2 or one on top of the other stacked design of air handlers into one air handler for each of the 3 above air-side systems. This should allow for some more room for energy recovery devices and the extra duct risers that will run through this floor. Another possible idea for saving floor area is to look into placing radiant ceiling panels into spaces to cut down on some of the air handling units load for cooling and thus being able to size them down.

Breadth Areas of Redesign

A main point of the redesign will involve switching Level 8 which is currently a research lab with Level 3 which is currently the mechanical systems floor. The biggest concern here will be the moving of that load from a lower floor to the upper floor. Once new equipment is in place a structural analysis will need to be done to ensure that the structure can handle the redistributed load or if the structural members will need to be resized (whether larger or smaller).

The new equipment will need be analyzed from a cost perspective versus the existing design. The cost of the extra or changed equipment and the energy savings will be analyzed to see how much of a savings it presents. It will then be determined whether the proposed redesign would be a reasonable alternative, cost wise. Also, the building's electrical system may need to be looked at with the moving around of the equipment.

Project Methods

The building's mechanical systems were already analyzed in technical report #2 in Carrier's Hourly Analysis Program. This will be used again once the new system is determined unless the extent of the redesign exceeds the capabilities (which it likely will) of HAP in which case a new program will be looked into. For determining of control points for the mixing of air or energy recovery device an excel spreadsheet or EES program will be written to simulate the particles in the air.

For the structural breadth area a simulation program such as RAM, Etab or STAAD will be used based on the recommendation of a structural student or professor. Cost analysis will be conducted based on engineering economics that have been learned through course work. Any electrical calculations will be done based on the NEC (National Electric Code).

Spring Semester Schedule

Week			Task
1	09-Jan-05	13-Jan-05	Research on indoor air quality controls & filtration
2	16-Jan-05	20-Jan-05	Research on indoor air quality controls & filtration
3	23-Jan-05	27-Jan-05	Research Energy recovery methods
4	30-Jan-05	03-Feb-05	Research Energy recovery methods
5	06-Feb-05	10-Feb-05	Air Handler Redesign
6	13-Feb-05	17-Feb-05	Combine active controls with energy recovery and air handlers, determine if there is enough room
7	20-Feb-05	24-Feb-05	If not enough room for equipment look into parallel cooling systems otherwise fine tune layout and design/control of new system
8	27-Feb-05	03-Mar-05	Implement parallel cooling system if needed, else Energy Analysis
9	06-Mar-05	10-Mar-05	Energy analysis of new system
10	13-Mar-05	17-Mar-05	Structrual/Cost/Electrical analysis
11	20-Mar-05	24-Mar-05	Structrual/Cost/Electrical analysis
12	27-Mar-05	31-Mar-05	Start compiling report
13	03-Apr-05	07-Apr-05	Finish report for April 5th
14	10-Apr-05	14-Apr-05	Present thesis