Thesis Proposal – Updated

Mechanical Systems Redesign Report

Hilton Hotel at BWI Airport
Linthicum Heights, MD

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Monday, January 16, 2006

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Executive Summary

The Hilton Hotel at BWI Airport is a full-service hotel located less than two miles from the BWI Airport in Linthicum Heights, Maryland. The 277,000 sf building will cost about $27 million for design and construction. The ground and second floors of the building are serviced by four air handling units through a variable air volume system with hot water reheat coils at the boxes. The third through eleventh floors of the guest room tower have 280 guest rooms with individual water source heat pumps. Rooftop units provide 100% outdoor air to the guest room corridors, service areas, laundry rooms, and kitchen.

This report clearly details the proposed ideas for replacement and improvement of the BWI Hilton's mechanical systems. After several alternatives are discussed, the proposed redesign is described. The thesis proposal looks at redesign issues for both the main floors as well as the guest room tower. These include the replacement of the existing VAV system with parallel systems and a run-around heat recovery system in the guest room tower. The other part of the redesign deals with the research for improvement of the indoor air quality for the guest rooms.

In addition to the three main depth areas of the thesis proposal, two breadth areas are also developed. The first area deals with the replacement of incandescent downlights in the meeting rooms and guest rooms with compact fluorescent fixtures to achieve energy savings while maintaining the original light output. The second breadth area is a study of the acoustics in several critical spaces in the BWI Hilton. Sound pressure levels in the guest rooms from the water-source heat pumps will be evaluated. Noise criteria levels and sound transmission class ratings of certain wall constructions will also be studied.

The solution methods, tasks, and tools to be used during the research and development stages of the thesis redesign process are outlined for each of the depth and breadth areas. A new software program, BLCC4, will be learned and then used to calculate the life cycle costs the proposed systems. Carrier's Hourly Analysis Program and Microsoft Excel will be used extensively throughout the entire project. A detailed schedule is also laid out for each of the four months during the thesis redesign process.

Building Background Information

In order to accurately assess the design of the Hilton Hotel at BWI Airport, the following information was compiled from the plans to summarize several of the building systems related to the proposed thesis redesign project. The included information primarily focuses on the building background and the existing mechanical systems of the BWI Hilton. However, other important topics briefly discussed are the building envelope, plumbing systems, acoustics, and the lighting system. The lighting system is not listed here, but is covered in the Breadth Proposal section.

Background Information

The Hilton Hotel at BWI Airport is a full-service hotel located less than two miles from the Baltimore-Washington International Airport. The hotel will have the largest conference space in the area near the airport, and it will be a strong tool to attract business to the hotel and Anne Arundel County, Maryland.

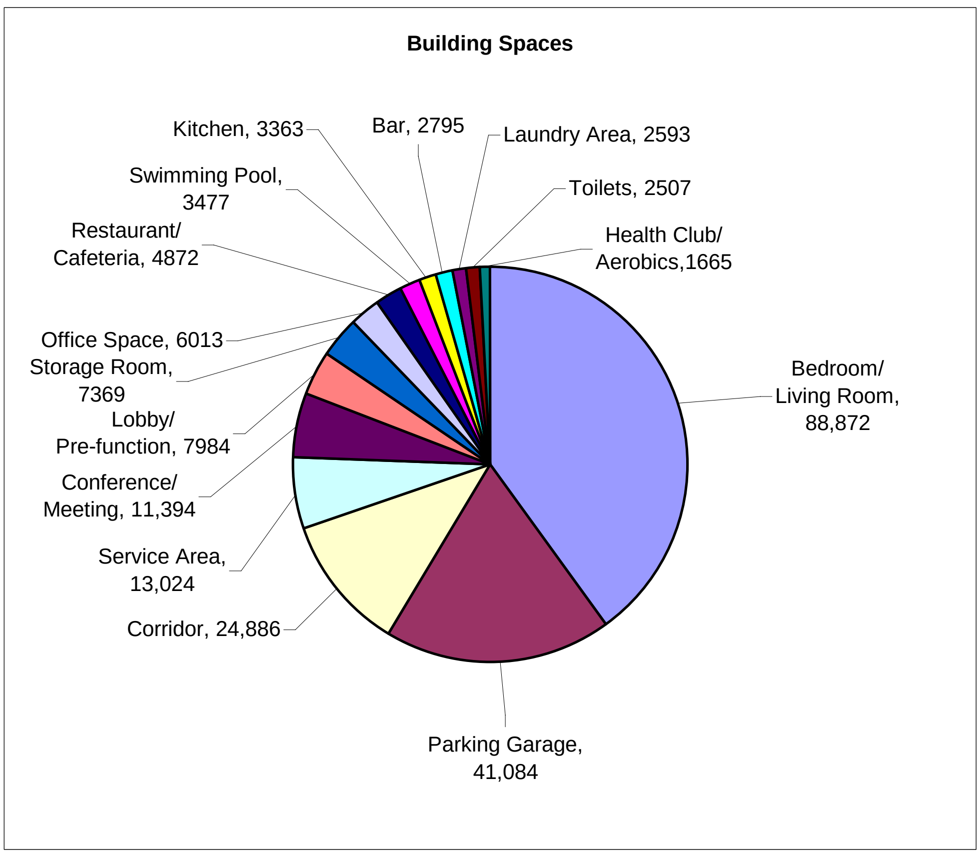
The hotel is primarily comprised of two different sectors – the public spaces and the private spaces. The public spaces include the lobby seating area, pre-function area, eating areas, egress/transportation areas, and the large and small meeting rooms. The eating areas include the restaurant, bar, coffee bar, and the bar lounge. The large meeting rooms are double-story height areas and have movable walls that can open up into one large ballroom. The means of egress in the building include the numerous corridors, two stairwells up through the guest room tower, and the four elevators.

The private spaces include the offices, employee rooms, kitchen, storage, laundry room, and the mechanical and electrical rooms. Some of the employee rooms are the offices, locker rooms, and cafeteria on the ground and second floors. There is also a concierge lounge on the eleventh floor. Other spaces in the building include the parking level below grade, exercise room, swimming pool, and the guest rooms. The guest rooms come in 15 different varieties, and there are a total of 280 guest rooms in the hotel.

All the previously discussed spaces in the BWI Hilton are listed with their corresponding areas and percentages of total building area in Figure 1 – Building Spaces Table. A visual representation of this information is shown next in Figure 2 – Building Spaces Chart.

Function / Use	Space Area (sf)	% of Total Area	No. of Spaces
Bedroom/Living Room	88,872	40.05%	280
Parking Garage	41,084	18.51%	1
Corridor	24,886	11.22%	26
Service Area	13,024	5.87%	48
Conference/Meeting	11,394	5.13%	9
Lobby/Pre-function	7984	3.60%	4
Storage Room	7369	3.32%	19
Office Space	6013	2.71%	31
Restaurant/Cafeteria	4872	2.20%	2
Swimming Pool	3477	1.57%	2
Kitchen	3363	1.52%	1
Bar	2795	1.26%	2
Laundry Area	2593	1.17%	3
Toilets	2507	1.13%	8
Health Club/Aerobics	1665	0.75%	1
Total Area	**221,898**		

Figure 1 – Building Spaces



Graph 1 – Building Spaces

Mechanical Systems

Air-Side Systems:

The primary air-side components of the mechanical system on the ground and second floors use a variable air volume (VAV) system with reheat hot water coils at the boxes in the public and service spaces.

One air handling unit (AHU) and one rooftop unit (RTU) on the north side roof of the ground floor provide conditioned air to many of the spaces on the ground level. Also located on the same roof is a make-up air unit (MAU) to provide adequate ventilation to the kitchen and to replace the quantity of air removed by the exhaust fan. A long string of linear slot diffusers provide the required amounts of supply air to the spaces from above the large areas of windows in the pre-function area, meeting rooms, coffee bar, and restaurant. The sidewall supply registers in the lobby seating area dispense the necessary quantity of conditioned supply air needed for ventilation in that space.

The second floor mechanical room houses several pieces of large mechanical equipment. One air handling unit conditions air for the large double-story height meeting rooms, smaller meeting rooms, and the pre-function area on the ground floor. A second AHU services many of the employee services rooms and offices on the ground floor. Also in the same mechanical room is a pool dehumidifier unit that conditions for the swimming pool area. A RTU on the ground level roof conditions air for several of the laundry and service spaces that are on the second floor. From the mechanical room on the northeast corner of the second floor, another AHU provides air to the offices, meeting rooms, and exercise room/health club.

On the third through eleventh floors, all the guest rooms are equipped with individual water source heat pumps (WSHP), master thermostats, and control valves in each room. Through the process of value engineering, two air conditioning units located in the penthouse, which were originally scheduled to supply each guest room with 60 cfm of outside air, and all the related ductwork and fire dampers were eliminated.

The positive pressure in both stairwells is maintained by two stair pressurization fans that deliver 11,700 cfm to each stairway. The pressurization required in the corridors on the third through eleventh floors is maintained by three rooftop units located in the penthouse. These rooftop units also provide supply air to the housekeeping areas on all the guest room floors.

Exhaust registers in each of the guest room bathrooms are ducted to sub-ducts and then tapped into the exhaust stacks. There are a total of 17 main toilet exhaust riser stacks connected to toilet exhaust fans mounted on either the eleventh floor roof or the penthouse roof. This sub-duct method, which received a variance prior to design and installation, aims to prevent the spread of smoke to the other guest room floors in the hotel without the use of smoke dampers in each of the ducts.

To achieve adequate ventilation of the automotive exhaust fumes in the parking level, two large outside air louvers located on the west side of the parking area let in 20,000 cfm. The mixed air is drawn out of the parking area through garage exhaust fans located on the east side of the building.

Water-Side Systems:

The primary water-side components of the mechanical system include the condenser water system and the hot water system. Due to initial budget constraints, the originally designed chilled water system was eliminated along with two water-cooled chillers and two chilled water pumps.

Two open-cell cooling towers are located on the north side of the building on grade with the ground floor level. These cooling towers provide condenser water to the four AHUs located on the ground and second floors. In addition, the condenser water system serves the condensers of the 280 WSHPs in all the guest rooms located on the third through eleventh floors of the guest room tower. Each WSHP is tapped off 1-1/2 in supply and return piping, and it also has 1 in drain piping. The condenser water is then looped back to the cooling towers through a reverse return system through 8 in piping.

Three fossil-fuel boilers in the parking level mechanical room provide hot water for all the reheat coils in the VAV boxes, the freeze protection pumps for the air handling units, and the pool dehumidifier unit. Other pieces of equipment served by the hot water system are the unit heaters, fin tube radiators, and hot air curtains located in the vestibules.

In the lobby seating area, a parallel system of fin tube radiators help to balance the heat loss from the large sections of windows located along the exterior walls. Other water-side equipment on the ground and second floors is the hot water reheat coils contained in all of the VAV boxes serving those spaces.

The large mechanical room located on the north side of the parking level contains much of the water-side equipment used in the hotel. This includes three boilers and their corresponding pumps, two condenser water pumps, one sedimentation separator filter, two plate and frame heat exchangers, two hot water pumps with variable frequency drives, two diaphragm expansion tanks, and some other pieces of equipment.

Controls:

All sequences of controls for the entire building are performed by direct digital controls (DDC). This DDC system monitors all the sensors, and it is able to adjust all the set points and time delays for the equipment. The DDC system also provides start/stop, speed control, monitoring, and alarms for the variable frequency drives (VFD).

Plumbing Systems

Natural Gas:

The natural gas service main has 22,905 MBH heating capacity and enters the building through 6 inch piping. The main pipe branches off and splits before entering the building in the parking level through water-tight sleeves with a 4 inch pipe at 12,105 MBH and an 8 in pipe at 10,800 MBH. The 4 inch pipe has a pressure of 2 psi, and it runs to the three fossil-fuel boilers in the parking level mechanical room. The 8 in pipe is at 10 in wc and runs through the hotel to all the RTUs and the laundry room equipment.

Domestic Hot Water:

The 4 in domestic water service main enters the building through the parking level. The piping then goes through a 250 gpm water softener system and a 270 gpm triplex domestic booster pump system. Also on the parking level are two hot water heat exchangers, two thermostatic mixing valves, and a 158 gal thermal expansion tank. A 4 inch cold water line runs up to the penthouse to two 900 gal duplex gas-fired domestic water heaters with a 77 gal thermal expansion tank and two thermostatic mixing valves.

There are three different temperature ratings for the hot water piping in the building. They include supply and return lines at 120^{o}F, 140 ^{o}F, and 160 ^{o}F running to various plumbing equipment throughout the hotel. The domestic hot water services all the plumbing fixtures, including the lavatories, sinks, showers, and bathtubs in all 280 bathrooms of the guest room tower.

Building Envelope

The exterior wall systems of the building consist entirely of different curtain wall systems, including metal panel systems and pre-cast concrete panels on the exterior. The majority of the walls consist of 5-1/2 in pre-cast concrete panels, 3-5/8 in metal studs with semi-rigid insulation, and 1/2 in gypsum wall board.

There is a significant amount of glass in the building envelope of the BWI Hilton. All along the pre-function area curved exterior wall is a large amount of store-front windows. Granite base panels on the first story and metal panels on the second story frame all this vision glass. The restaurant area is also primarily composed of store-front windows on the north side of the building.

In the nine floors of the tower part of the hotel, every guest room has both casement windows and sliding windows made of either spandrel glass or vision glass. However, all these window sizes differ due to the varying and numerous sizes of the guest rooms.

Most of the roofing system of the BWI Hilton consists of 3 in thick R30 rigid roof insulation and fully-adhered EPDM roofing membrane. Part of the roof is made of an 8 in thick concrete slab on the guest room tower and above the restaurant area. The sections of the roof above the lobby area and swimming pool area are built with 3 in metal roof decks spanning between the steel structure.

Acoustics

There is not much detail included in the plans of the Hilton Hotel at BWI Airport on the topic of acoustics. However, it is noted that several locations under the third floor slab require 2 in of rigid sound insulation to inhibit the transfer of sound from the mechanical rooms and laundry rooms on the second floor to the guest room areas above.

Also detailed in the BWI Hilton plans are several different wall construction required noise ratings. For the numerous types of walls used in the building, only several of the walls had a minimum STC (sound transmission class) value specified in the drawings. These STC values range between 35 and 55, depending on the wall construction materials and the location of the wall in the building. Also, it is important to point out that many of the walls have no minimum STC value assigned to them since noise considerations are not a major concern in those areas.

Proposal Objectives

The design of the Hilton Hotel at BWI Airport can be classified as typical, standard, or ordinary. The current design is a workable solution that could be used for the application as intended. However, it is definitely possible to develop improved mechanical systems that will either replace or supplement the existing design.

To improve the mechanical system design, a means of measuring the performance and relative costs must be established. The goals of this thesis redesign project for the BWI Hilton are to increase energy efficiency, decrease life cycle costs, and improve thermal comfort throughout the building. Other objectives sought for in this project include sustainability, improving the overall indoor environmental quality, and design innovation.

As stated above, one of the major goals the BWI Hilton is energy efficiency, and it is the primary objective of this thesis redesign project. All design ideas and decisions should reflect this ideal. To accomplish this goal of using energy more effectively, it is necessary to decrease the building's annual energy consumption of natural gas, electricity, or both. In doing so, it will also be possible to make a more environmentally-conscious facility with decreased emissions. The decrease in admissions will be better for the environment, as well as resulting in lower utility and operating costs.

Additionally, this could also result in the reduction in the life cycle costs of some of the mechanical equipment in the BWI Hilton. Reduced life cycle costs will also cause the payback period on some of the equipment to be more reasonable. However, despite the lower life cycle costs, the first costs of the equipment could possibly increase. If the first cost of the new systems does decrease, then this will be considered purely as an additional unforeseen benefit of the redesign.

Redesign Alternatives

There are several ideas to replace or improve both the VAV system on the main floors and the WSHP system in the guest room tower are explained next. Many of these different redesign options are considered to be possible alternatives to the existing mechanical systems of the BWI Hilton. However, after considering their cost implications and the feasibility of implementing the systems, these ideas were discarded. Some reasons for rejecting these alternatives are because they are not economical or not practical enough to include in the building redesign. Another reason for not using one of the alternative ideas is there is only a limited amount of time allotted to spend researching and developing the new systems.

Fan Coil Units

In evaluating the performance of various types of guest room space conditioning equipment, the next system up from a vertical stack WSHP system is the vertical fan coil unit (FCU). The FCU system could be an improvement over the WSHP because there are no compressors located in the guest rooms. The basis of design used on all Hilton Hotel building projects is the *Hilton Design and Construction Standards.* The standard recognizes both two-pipe and four-pipe FCUs as acceptable solutions for the guest room conditioning.

The four-pipe FCU system is a high quality system that is commonly being used in hotels. The four pipes used are chilled and hot water supply and return piping that serve all the FCUs in the system. However, the hot and chilled water usually continues to circulate whether guests use the FCUs or not. It is possible to save some energy with this system by turning off the chiller or boiler if there is no load based on the season. Also, the higher-end hotels often use this four-pipe FCU design because the room rates warrant the comfort and low noise.

A two-pipe FCU system with electric reheat can act similarly to a four-pipe system, and work as well as the WSHPs for comfort conditions. This could be better than the high-end design of a four-pipe FCU design that circulates hot and chilled water whether guests use it or not.

However, there are a few drawbacks to using a FCU system. The energy usage could increase since the fan coils are served by a chiller plant, changeover controls can be more complicated for a two-pipe system, and comfort conditions may be less consistent than the WSHP system. Therefore, the FCU system will not be used in the redesign BWI Hilton.

Ground-Source Heat Pumps

Another possible idea for the guest room improvement is to replace all 280 water source heat pumps with ground-source heat pumps (GSHPs). Each guest room could still have its own individual GSHP with master thermostat control, as in the original design. GSHPs use a geothermal source, such as the ground, surface water, ground water, wells, ponds, lakes, or oceans as both heat sources and heat sinks. Most have a reversible refrigeration cycle and either an open loop or closed loop for the geothermal loop.

GSHPs are usually preferred over air-source heat pumps (ASHPs) because ground or water temperature is nearly constant at depths as shallow as 10 feet below the surface. On the other hand, ASHPs are directly affected by the outside air temperature, which can vary by as much as 100^{o}F in some areas. When these extreme temperatures are encountered during some of the summer and winter months, both the efficiency and capacity of the ASHPs are greatly decreased.

GSHPs have two different types of ground piping schemes. The first type involves a system of bore holes throughout the site of the building. These vertical bore holes can be anywhere from 100 to 500 feet or more from the surface down into the ground or to underground wells. The other uses horizontal piping that is only about 10 feet below the surface, where the ground temperature is fairly steady all year-round. Horizontal piping can also be used to reach a nearby pond or lake.

Most GSHPs use closed loops that cycle water or a non-toxic refrigerant through the piping loops. If an open loop is used, then a heat exchanger will be used to transfer the heat from the ground loop to the building water loop used for the heat pump units. Both loops also have a required amount of pumping power to continually circulate the fluids.

One of the benefits of the GSHP system is that it has a good response time to the thermal comfort needs of the guests. It is possible to have either heating or cooling whenever it is desired, and it can put energy back into the loop for other GSHPs to use. This averages out if one GSHP is in cooling and another is in heating. This could also serve as means of energy savings for the system, if there is enough simultaneous heating and cooling load.

However, the application of GSHPs can be very limited since the site of a project often dictates whether GSHPs can be used. The BWI Hilton does not have an extremely large lot, and there may not be enough space to adequately layout the ground loops or bore holes. Also, there is not a significant water source either a pond or lake adjacent to the site or underground wells close enough to the surface. The first cost of drilling all the bore holes and laying the piping loops would be too much to pay back in a reasonable amount of time.

Domestic Hot Water

The majority of the domestic hot water usage in the BWI Hilton will be in the mornings when most guests will take showers. Since the load will be concentrated to a few hours, there is the opportunity to use a thermal storage system. Thermal storage could eliminate a large amount of hot water generation, which directly affects the capacity of the hot water heater. Water could be heated by electric coils in storage tanks to take advantage of off-peak electrical rates during the nighttime hours and decrease the instantaneous amount of hot water called for by the system in the morning.

Another reasonable option in improving the domestic hot water system is the use of drain water heat recovery. This is accomplished by the use of heat exchangers between the hot water drain lines and the water coming into the hot water heater.

Both of these ideas for improving the domestic hot water system are possible solutions. However, more research is required to adequately asses their benefits and payback period, and there may not be enough time to fully perform this analysis.

Proposed Redesign

After considering the possible redesign techniques and carefully analyzing their benefits and drawbacks, the following improvements are proposed for the redesign of the mechanical systems for the Hilton Hotel at BWI Airport. Several different options will be researched and developed for each area. After completing the necessary calculations, all the options will be compared, and the best ones will be selected and used as the final redesign.

Parallel Systems

There are many available options that could be used to adequately ventilate and heat or cool the spaces on the ground and second floors of the BWI Hilton. The current VAV system may not be the most energy efficient way to accomplish this. Therefore, different options using various types of parallel systems will be explored and researched to determine the best combination to achieve maximum energy efficiency.

The first option is to use a constant volume, minimum ventilation air system with total energy recovery, which is also known as a dedicated outdoor air system (DOAS). This system would be to supply minimum ventilation air and meet the latent load of the spaces. Another alternative to use with the DOAS is to meet the people loads (both sensible and latent) as well as the lighting loads. An occupancy sensor would be used to control the system since it would only run when the rooms are occupied.

The second option is to use another air system that could meet both the envelope and equipment loads as well as the minimum outdoor air requirements of the spaces. Two possible solutions for this option are either a constant air volume (CAV) system or a variable air volume (VAV) system.

The third option is to use a water-side system that would be coupled with one of the air-side systems for use on the ground and second floors of the hotel. The benefit of the water-side system is to meet part of the sensible cooling load of the space and decrease the amount of air provided by the supply air. This is possible because water has a much higher specific heat than air, which means that it can transfer energy more efficiently. In addition, another benefit is that the pipes take up less space than ductwork in the ceiling plenums and vertical mechanical shafts.

This option has several benefits along with the decreased the amount of air required by the spaces. The overall duct sizes could be made smaller, the ceiling plenums would be shorter, and the floor-to-floor height could be decreased. Also, the smaller quantity of air means that less fan energy would be required to move the air, less energy would be required to condition the air, and smaller air handling units could be used for the project.

On the other hand, the main drawback with a parallel system is that there will be increased costs with the additional systems. There will be increased first costs for the equipment and additional maintenance costs. However, the energy efficiency of the two coupled systems operating together will be much greater than the current VAV system, and the life-cycle costs will decrease.

Run-Around Heat Recovery System

In looking at the different possibilities for using energy recovery with the RTUs of the BWI Hilton, the use of a run-around heat recovery system seems to be the most practical. A run-around heat recovery system is composed of a piping loop between the outside air and the exhaust air streams. The fluid in the piping loop is circulated by a pump, and finned-tube coils exchange heat between the loop and each air stream. This can be used to either preheat the outside air by the warmer exhaust air during the winter or pre-cool the outside air by the cooler exhaust air in the summertime.

The main reason for the choice of the run-around heat recovery system over the enthalpy wheel or the desiccant wheel systems is because of the relative locations of the outside air ductwork and the exhaust air ducts. The two wheel systems require the two air streams to be adjacent to each other. This is not possible in this application for the BWI Hilton. However, since a piping loop with finned-tube coils at both ends will be used to run between the two air streams, the run-around system is the best option in this case.

Indoor Air Quality of the Guest Rooms

As was described previously in the Mechanical Systems part of the Building Background Information section, during the value engineering process for the BWI Hilton, two outdoor air conditioning units in the penthouse were eliminated. These provided 60 cfm of ventilation air to each of the 280 guest rooms in the guest room tower. After eliminating the primary source of fresh air, a variance was granted for the project to use an alternative method of ventilation. This method uses the supply air that the RTUs provide as pressurization to the guest room tower corridors. The corridor air is drawn into each of the guest rooms through the undercuts in the doors either by the mechanical exhaust fan in the bathrooms or by the use of operable windows.

The indoor air quality (IAQ) of the guest rooms is one of the biggest design issues of the building. There is major concern with the ventilation of the 280 guest rooms of the BWI Hilton. An improved system is needed to provide fresh air to the rooms, as well as reducing the concentration of odors and other contaminants that result from poor ventilation techniques. This would also allow the guest room corridors to be pressurized and properly mitigate the transfer of odors between guest rooms.

A possible solution to this issue is the addition of direct ventilation air ducted to each of the guest rooms. Another idea is the use of energy recovery ventilators. However, as was previously mentioned in the Mechanical Systems part of the Building Background Information section, the mechanical plans originally called for 60 cfm of outside air to all the rooms in the guest room tower. The building owner agreed that it would be more beneficial to eliminate this part of the system to save money on the project rather than properly ventilate the guest rooms.

This IAQ issue is very important to the health and well-being of the hotel guests, along with the continued business of the BWI Hilton. More research will be done on this topic, and an appropriate solution will be determined to effectively satisfy both the ventilation and budget requirements.

Breadth Proposal

The redesign the majority of the mechanical systems of the Hilton Hotel at BWI Airport have effects on some of the building's other systems. Also, the results of improving some of the other systems will directly affect the mechanical systems. The two main breadth areas for this project fit into these two categories. Changing the lighting systems will decrease the cooling load of the mechanical systems. Improving the equipment in the guest rooms and adding a chiller to the main mechanical equipment room will require acoustic studies to ensure proper performance of those spaces.

Lighting Systems

Some of the lighting fixtures used in the BWI Hilton consist of compact fluorescent downlights. However, the designer chose to use incandescent downlights in the large and small meeting rooms on the ground and second floors of the building. Incandescent lighting is also used in all the guest rooms, as well as several other rooms in the hotel.

Typically, incandescent bulbs can use more energy, give off more heat to their surroundings, and need replaced more often than compact fluorescent bulbs. For these reasons, a replacement of all the incandescent downlights in the meeting rooms will be done with compact fluorescent downlights. The effects of the bulb color rendering index, color temperature, and lumen output will be studied to ensure the redesign lighting schemes are just as good, if not better, than the original designs.

Acoustics

The WSHPs used in the original design are typically known for operating at somewhat high sound levels, but drywall enclosures in the guest rooms could lower the sound levels. The acoustical effects of the enclosures will be analyzed. The sound pressure levels in the guest rooms will be calculated from the manufacturer's sound data. The required noise criteria (NC) in the guest rooms and meeting rooms can be compared with the actual levels found in those spaces. In addition, it can be determined if the proposed sound transmission class (STC) values for some of the interior wall types are adequate.

Project Methods

Many different solution methods and tasks and tools will be used to accurately analyze all the redesign issues previously described in the Proposed Redesign section and the Breadth Proposal section. These methods are described next.

Parallel Systems

The parallel systems will be used as the main mechanical system on the ground and second floors of the BWI Hilton. The several options previously described will be researched and designed first. Information about equipment and manufacturers will be studied, and the best solution will be chosen.

Carrier's Hourly Analysis Program (HAP) will be used to model the energy usage of the building. The results of the energy simulation of all the different options for the parallel systems will be compared to each other, as well as with the results from the original design. This original design with only the VAV system serving the ground and second floors will be known as the base case.

A new software program called BLCC 4.9-05 will be used for the life cycle cost analyses. BLCC stands for "Building Life Cycle Cost", and the program was developed to analyze the cost effectiveness of alternative building systems. Tax and financing analyses can be done for private-sector projects, such as the BWI Hilton to include both the first costs as well as the operating costs. The BLCC4 program will first be used to calculate the life cycle cost (LCC) of the base case system. Then it will be used to determine the LCC of the parallel systems, and a comparison will be made between the two.

Run-Around Heat Recovery System

After the FPIU system has been analyzed, the run-around heat recovery system for the building will be researched and developed. It will be determined whether the heat recovery system should be used on the four AHUs serving the ground and second floors or the six RTUs serving different parts of the whole building.

HAP will again be used to simulate the energy usage of the run-around system and compare it to the base case. Both the run-around and the FPIU systems can be used together to compare to the base case, too. Also, the BLCC4 program will calculate the LCC for the run-around system and compare it to the base case and parallel system case.

Indoor Air Quality of the Guest Rooms

The next step in the BWI Hilton redesign involves the research and analysis of the indoor air quality of the guest rooms. Some calculations may need to be done to compare different schemes to remedy the problem. The HAP and BLCC4 programs can be used as needed, as well as Excel. Several recommendations will be made regarding which system will perform the best and within the budget constraints.

Lighting Systems

In order to appropriately select adequate lighting fixtures and bulbs, research will be done on the lighting system replacement. All the incandescent downlights in the meeting rooms and guest rooms will be replaced with compact fluorescent fixtures and lamps. The effects of the bulb color rendering index, color temperature, and lumen output will be studied to ensure the redesign lighting schemes are just as good, if not better, than the original designs.

The Philips Lighting website is very informative and helpful in selecting suitable replacement bulbs. Also, Philips has a large sustainability initiative, and the option to choose low-mercury bulbs is available. The provided Sustainable Lighting Index Worksheet will be used to assist in this process of selecting bulbs and calculating the amount of mercury in the bulbs.

Excel will be used to compare the varying power requirements of the two types of lighting systems. A comparison of the energy savings using all compact fluorescent fixtures will be made with respect to the base case.

Acoustics

The sound pressure levels in the guest rooms will be determined by hand calculations comparing the WSHPs with and without enclosures, and they will be tabulated in Excel spreadsheets. The required noise criteria (NC) in the guest rooms and meeting rooms can be compared with the actual levels found in those spaces with the appropriate charts. In addition, it can be determined if the proposed sound transmission class (STC) values for some of the interior wall types are adequate.

Microsoft Excel spreadsheets will also be used to evaluate the performance of some of the spaces in the BWI Hilton. The sound pressure levels from the new chiller will be calculated by hand for various spaces, including the parking garage and the rooms above the main mechanical equipment room.

<u>Schedules</u>

Two schedules are developed for the spring semester, and they cover the months of January through April 2006. The information on the schedule includes a basic timetable of the steps to be taken during the thesis redesign process, as well as several benchmark dates, holidays, and other notable activities.

Detailed Schedule

Information directly regarding specific steps in the thesis redesign process is only listed with a starting date. No ending date is shown since most of the work will be on-going throughout the semester.

Refer to the Thesis Calendar found on pages 23 through 26 at the end of this report for the calendar and topics of the Detailed Schedule.

Please note that all information contained on the schedule is subject to change at any time.

Planning Schedule

January
- 12 – Learn BLCC4
- 16 – Updated Proposal Due
- 17 – Parallel Systems
- 30 – Run-Around Heat Recovery System
- 31 – Progress Check

February
- 06 – Guest Rooms IAQ
- 20 – Lighting Breadth Work
- 27 – Acoustics Breadth Work
- 28 – Progress Check

March
- 13 – System Integration and Comparisons
- 15 – Table of Contents
- 20 – Finish All Unresolved Issues
- 27 – Write Final Report

April
- 03 – Final Report Due
- 10 – 1st Round of Presentations
- 28 – AE Banquet

Conclusions

The Hilton Hotel at BWI Airport is a project that has many areas where the possibility exists for mechanical systems redesign. The three main areas of redesign are as follows. The ground and second floors of the building will be redesigned, researched, and developed for the VAV system with the new parallel systems. The guest room tower will have a new run-around heat recovery system. The indoor air quality of the guest rooms will also be researched and improved.

Along with the research involved with the redesign, a new computer program (BLCC4) will be used to calculate the life cycle costs of all the new systems. Many comparisons will be made between the base case for each area and all the redesigned systems. Actual benefits and drawbacks for each of the proposed redesign systems will also be evaluated.

Preliminary Research

The following sources were used for preliminary research on the topics covered by this thesis proposal and redesign project. Additional sources will be needed as research continues and the project progresses.

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JANUARY 2006

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1 New Year's Day	2	3 Orange Bowl	4	5	6	7
8	9 1st Day of Class Review Proposal	10 Research New Proposal Topics	11 Update CPEP Update Proposal	12 Learn BLCC4	13 Create BLCC4 base case	14
15	16 Updated Proposal Due	17 Parallel Systems Research	18	19	20 Faculty Consultation	21 ASHRAE Winter Meeting – Chicago
22 ASHRAE Winter Meeting – Chicago	23 ASHRAE Winter Meeting – Chicago	24 ASHRAE Winter Meeting – Chicago	25 Parallel Systems Calculations	26	27 Faculty Consultation	28
29	30 Run-Around Heat Recovery Research	31 Progress Check				

FEBRUARY 2006

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1 Run-Around Heat Recovery Calculations	2 Update CPEP	3 Faculty Consultation	4
5	6 Guest Rooms IAQ Research	7	8	9	10 Faculty Consultation	11
12	13 Guest Rooms IAQ Calculations	14 Valentine's Day	15 Update CPEP	16	17 Faculty Consultation Dance Marathon	18 Dance Marathon
19 Dance Marathon	20 Lighting Breadth Work Research	21	22 Lighting Breadth Work Calculations	23	24 Faculty Consultation	25
26	27 Acoustics Breadth Work Research	28 Progress Check				

MARCH 2006						
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1 Update CPEP Acoustics Breadth Work Calculations	2	3 Faculty Consultation	4
5	6 Spring Break	7 Spring Break	8 Spring Break	9 Spring Break	10 Spring Break	11
12	13 System Integration And Comparisons	14	15 Table of Contents Due Progress Check	16 Update CPEP	17 Faculty Consultation St. Patrick's Day	18
19	20 Finish All Unresolved Issues	21	22 Check All Work Fix Calculations	23	24 Faculty Consultation	25
26	27 Write Final Report	28	29	30	31 Faculty Consultation	

APRIL 2006

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2	3 Final Report Due On CPEP	4	5 Make Presentation	6	7 Final Report Due Paper Copy	8
9 Palm Sunday	10 1st Round of Presentations	11 1st Round of Presentations	12 1st Round of Presentations	13 Update CPEP	14	15
16 Easter	17	18	19	20	21	22
23	24	25	26	27 Update CPEP	28 Last Day of Class AE Banquet	29
30						