Technical Assignment #2

Building and Plant Energy Analysis Report

Hilton Hotel at BWI Airport
Linthicum Heights, MD

Nathan Patrick
Mechanical Option

Monday, October 31, 2005

Table of Contents

Executive Summary

This report develops a detailed energy analysis of the Hilton Hotel at BWI Airport. Several different approaches to examining the buildings energy compliance are employed.

The U.S. Green Building Council's LEED for New Construction checklist is used to look at all aspects of the hotel building and site, not just the mechanical systems. Although the Hilton Hotel was not originally designed to have a LEED rating, it would be possible to obtain enough points for the building to be LEED Certified.

ASHRAE Standard 90.1-2004 is another non-mechanical energy performance baseline for the building envelope and lighting systems for the hotel. Section 5 of the Standard sets guidelines for measuring the thermal performance of the building envelope, and it applies the Prescriptive Building Envelope Option to determine compliance. It was found that the roofs, walls, and doors all met the criteria, but the floors did not comply. The Space-by-Space Method is described in Section 9 to measure the performance of the building's lighting systems. After running the calculations, most of the spaces in the Hilton Hotel meet the requirements in Standard 90.1.

The total amount of lost rentable space was determined to be almost 5% of the total building floor area. When other support spaces are included, the lost rentable space is more than 7% of the total area. The mechanical system first cost was calculated next. At a total cost of almost $6.5 million, this equates to $23.69 per square foot.

Carrier's Hourly Analysis Program (HAP) was used to calculate the design load and perform an energy analysis on the Hilton Hotel at BWI Airport. HAP also determined the yearly energy utilization data. Annual energy consumption and operating costs were found using the simulation program, as well.

Finally, an emissions analysis was performed on the hotel with its large yearly consumption of electric and natural gas power resources. The quantities of pollutants of carbon dioxide, SOx, NOx, and particulates are calculated using HAP and an emissions estimate associated with on-site electricity use.

Mechanical System Summary

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

One air handling unit and one rooftop unit 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 to provide adequate ventilation to the kitchen. 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. Since the sidewall supply registers in the lobby seating area dispense the necessary quantity of supply air, a parallel system of fin tube radiators help to balance the heat loss from the large sections of windows located along the exterior walls.

The second floor mechanical room houses several pieces of large mechanical equipment. One air handling unit (AHU) 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 rooftop unit 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, 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 all 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 construction, aims to prevent the spread of smoke to the other guest room floors without using smoke dampers in each of the ducts.

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 air handling units and guest room water source heat pumps. Each heat pump is tapped off 1-1/2 inch supply and return piping, and it also has 1 inch drain piping. The condenser water is then looped back to the cooling towers through a reverse return system through 8 inch 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 are the unit heaters, finned tube radiators, and hot air curtains located in the vestibules.

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 draw 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.

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.

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).

LEED-NC Certification

The LEED (Leadership in Energy and Environmental Design) rating system was developed by the U.S. Green Building Council to determine qualifications for high-performance, sustainable buildings. Since the Hilton Hotel at BWI Airport is currently under construction, LEED-NC (for New Construction) shall be used to determine the certification level (if any) for the new building. The six major categories include Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and LEED Innovation Credits.

When originally designed, the Hilton Hotel at BWI Airport was not intended to obtain LEED-NC certification. However, it is still possible to determine if the building could have that certification. Many possible options were found that could have been reviewed if an attempt was made to get LEED-NC certification for the building. Some of them are as follows:

Sustainable Sites (SS):

SS – Credit 4.4: It would be possible to have customers carpool together to the nearby BWI Airport and park at the hotel.

SS – Credit 6.1: Storm water management is required in the Baltimore area, so this would be easily obtained.

SS – Credit 7.1: Since landscaping is part of the hotel's operating expenses, it would be feasible to include this in the budget.

SS – Credit 7.2: This is possible because all of the roof areas on the hotel are mostly flat.

SS – Credit 8: This requirement for light emitting from the rooms would be much more difficult than for an office.

Water Efficiency (WE):

WE – Credit 1.1: Drip irrigation works for everything but the grass areas, but there is only minimal grass around the hotel.

WE – Credit 1.2: It is possible to buy this one for a point. Most building owners do not want to give up space for water storage or additional piping to route storm water to a tank with pumps. It could be possible to avoid permanent irrigation systems and make this a point. The piping can be installed above ground for a year while the plants are stabilized and then removed later.

WE – Credit 3.1: This is possible with low flow fixtures, but it may impact the customer's satisfaction with the building.

Energy and Atmosphere (EA):

EA – Credit 1: It is possible to buy 2 points with heat recovery systems, upgrading the building's thermal performance, and increasing either lighting or equipment efficiency.

EA – Credit 3: This point is easy to buy and does not cost too much money.

EA – Credit 4: This is possible, but the manufacturers do not list their refrigerant in the literature. A phone call to verify use of ozone-safe refrigerants for other small HVAC equipment would be necessary.

EA – Credit 5: This is easy to set up when a full control system is available.

EA – Credit 6: This one is possible to buy.

Materials and Resources (MR):

MR – Credit 6: Bamboo flooring and wheatboard for walls are two possibilities. The materials also react differently in humid climates, so this would not be a quick point to get.

MR – Credit 7: This is very expensive to buy, but it is possible.

Indoor Environmental Quality (EQ):

EQ – Credit 2: This is hard to get with typical hotel ventilation systems.

EQ – Credit 3.2: This will require the testing part for achieving this point. The smaller equipment cannot support a MERV 13 filter.

EQ – Credit 5: This is a straight-forward HVAC design.

EQ – Credit 6.1: This one requires control for individual occupants. It is unsure how a hotel's central areas would be applied to this point.

EQ – Credit 7.1: This requires humidifiers that add energy to the project. As a result, it goes against the energy credits previously listed.

EQ – Credit 8.1: This should be possible for a hotel where all the residents have a window.

Innovation and Design Process (ID):

ID – Credit 1.1: Most often designers receive one or two innovation credits.

Discussion:

As shown on the completed checklist, the Hilton Hotel at BWI Airport could easily achieve a "Certified" LEED rating based on the estimates made. Already having 32 points, it would also be possible to spend some additional amount of money or redesign certain portions of the project to obtain a few more LEED points and try for the "Silver" rating.

Three more points could come from the designers being more aggressive with the energy use, diffuser selections and placement for the air distribution credit, and adding humidification for winter months. However, it is typically reasonable to plan on not getting 4 or 5 points during the review process since the evaluators do not always agree on each submitted point.

Also, the building needs to be designed for the daylighting, material selections, and zone controls for occupants early on in the design process. Looking at the site and architectural design after it has been completed makes the higher points very difficult and expensive to achieve. Also, the architectural design impacts the higher credits like the Gold and Platinum ratings.

Please refer to the LEED-NC Version 2.1 Registered Project Checklist for the Hilton Hotel at BWI Airport for the point breakdown in Appendix A – LEED-NC Checklist.

ASHRAE Standard 90.1-2004 Procedure

Section 5 – Building Envelope:

Step 1: Fenestration Areas

Determine which option to follow – the Prescriptive Building Envelope Option or the Building Envelope Trade-Off Option. The two critical points to determine this are these:

> The total vertical fenestration area shall be less than 50% of the gross wall area. The total skylight area shall be less than 5% of the gross roof area.

If the total vertical fenestration area is less than 50% of the gross wall area and the total skylight area is less than 5% of the gross roof area, then the steps for the Prescriptive Building Envelope Option shall be followed. If both of these points are not met, then the Building Envelope Trade-Off Option shall be used.

Step 2: Space-Conditioning Categories

Separate exterior building envelope requirements are specified for non-residential conditioned space, residential conditioned space, or semi-heated space. However, no spaces in the Hilton Hotel at BWI Airport were designated as either semi-heated or unconditioned.

Step 3: Climate

Determine the climate zone for the building location. Use Figure B-1 or Table B-1 in Appendix B to determine the required climate zone.

Step 4: Compliance

For the appropriate climate, space-conditioning category, and class of construction, the building envelope shall comply with the Prescriptive Building Option, provided that 1.) the vertical fenestration area does not exceed 50% of the gross wall area for each space-conditioning category and 2.) the skylight fenestration area does not exceed 5% of the gross roof area for each space-conditioning category.

Step 5: Prescriptive Building Envelope Option

For conditioned space, the exterior building envelope shall comply with either the “nonresidential” or “residential” requirements in Tables 5.5-1 through 5.5-8 for the appropriate climate.

For all opaque surfaces except doors, compliance shall be demonstrated by one of the following two methods: 1.) minimum rated R-values of insulation for the thermal resistance of the added insulation in framing cavities and continuous insulation only and 2.) maximum U-factor for the entire assembly.

The following surfaces shall be analyzed:

- Roof insulation
- Above-grade wall insulation
- Floor insulation
- Opaque doors

<u>Step 6:</u> Fenestration

Compliance with U-factors and solar heat gain coefficients (SHGC) shall be demonstrated for the overall fenestration product. Gross wall areas and gross roof areas shall be calculated separately for each space-conditioning category for the purposes of determining compliance.

The total vertical fenestration area shall be less than 50% of the gross wall area. The total skylight area shall be less than 5% of the gross roof area.

Fenestration shall have a U-factor not greater than that specified in Tables 5.5-1 through 5.5-8 for the appropriate fenestration area. Vertical fenestration shall have a SHGC not greater than that specified for “all” orientations for the appropriate total vertical fenestration area. In latitudes greater than 10 degrees, SHGC for north-oriented vertical fenestration shall be calculated separately and shall not be greater than that specified for north-oriented fenestration.

Section 9 – Lighting:

Space-by-Space Method:

Step 1:

Determine the appropriate building area type from the building area method column in Table 9.6.1. If a building area type is not listed, then a reasonably equivalent type from the table shall be used instead.

Step 2:

For each space enclosed by partitions 80% or greater than the ceiling height, determine the gross interior floor area.

Step 3:

Determine the interior lighting power allowance by using the columns designated space-by-space method in Table 9.6.1. Multiply the floor areas of the spaces times the allowed lighting power density for the space type that most closely represents the proposed use of the spaces. The product is the lighting power allowance for the spaces. For space types not listed, then a reasonably equivalent category from the table shall be used instead.

Step 4:

The interior lighting power allowance is the sum of the lighting power allowances of all the spaces. Trade-offs among spaces are permitted provided that the total installed interior lighting power does not exceed the interior lighting power allowance.

In cases where both a common space type and a building specific type are listed, the building specific type shall be used.

Building Envelope Compliance

Step 1: Fenestration Areas

	Elevation Area (sf)				
Material	North	South	East	West	Total (sf)
Tagged Windows	2094	9855	1869	840	14,658
Other Windows	1402	4432	2269	348	8451
Total Windows	3496	14,287	4138	1188	23,109
Gross Exterior Wall Total	34,433	33,583	13,147	14,706	95,869
Exterior Wall	30,937	19,296	9,009	13,518	72,761
% Windows	11.30	74.04	45.93	8.79	31.76

Total vertical fenestration area = 31.76% < 50%

Skylight area = 0% < 5%

Therefore, use the Prescriptive Building Envelope Option.

Step 2: Space-Conditioning Categories

Use exterior building envelope requirements for non-residential conditioned space and residential conditioned space.

Step 3: Climate

Table B-1: Maryland is in Zone 4A.

Step 4: Compliance

As shown above:

Total vertical fenestration area = 31.76% < 50%

Skylight area = 0% < 5%

Step 5: Prescriptive Building Envelope Option

Use Table 5.5-4 – Building Envelope Requirements for Climate Zone 4A.

Please refer to the spreadsheets shown in Appendix B – Prescriptive Building Envelope Option.

Step 6: Fenestration

Viracon VE 1-85 low-e insulating glass:

Visible Light Transmission	U-value	SHGC	Shading Coefficient
0.76	0.29	0.54	0.63

Use Table 5.5-4 – Building Envelope Requirements for Climate Zone 4A.

Please refer to the spreadsheets shown in Appendix B – Prescriptive Building Envelope Option.

Assumptions:

It was assumed that all the residential and nonresidential conditioned spaces for the Hilton Hotel at BWI Airport have the same materials and properties. The wall, floor, and fenestration constructions for the non-residential spaces on the ground and second floors are similar to those of the residential spaces in the guest room tower (third through eleventh floors).

There were no semi-heated spaces analyzed for the Hilton Hotel at BWI Airport because there were not any along the exterior of the building.

All spaces in the Hilton Hotel at BWI Airport are enclosed by partitions greater than 80% of the ceiling height.

All the exterior glazing was also assumed to have similar U-values and Solar Heat Gain Coefficients (SHGC) since all the windows are made of 1 in thick low-e insulating glass in the curtain wall systems. Viracon low-e insulating glass VE 1-85 was used since there were no U-values or SHGC given in the project specifications.

Discussion:

As can be seen from the spreadsheets in Appendix A, all but one of the building envelope elements comply with Standard 90.1-2004. The mass floors have a U-value that is too large, and they do not have any insulation.

For the window glazing, neither situation is compliant. Even though the U-values all comply, the SHGC values are too high and the whole fenestration is therefore not compliant.

Lighting Compliance

Use the Space-by-Space Method to determine the lighting compliance since many of the building spaces are known.

Step 1:

Use Table 9.6.1 – Lighting Power Densities Using the Space-by-Space Method as provided in ASHRAE Standard 90.1-2004.

Please refer to the spreadsheets in Appendix C – Space-by-Space Method for common space types and building specific space types.

Step 2:

Calculate the gross interior floor area for every individual space. Then summate all the spaces with the same common space type or building specific space type. There are 18 different space types in the Hilton Hotel at BWI Airport.

Please refer to the spreadsheets in Appendix C – Space-by-Space Method for space areas.

Step 3:

Multiply the floor areas of the spaces times the allowed lighting power density (LPD) for the space type that most closely represents the proposed use of the spaces. The product is the lighting power allowance for the spaces.

Please refer to the spreadsheets in Appendix C – Space-by-Space Method for space power densities.

Step 4:

The interior lighting power allowance is the sum of the lighting power allowances of all the spaces. Simply add together the wattages in all the rooms for each of the 18 different space types to find the lighting power allowances.

Please refer to the spreadsheets in Appendix C – Space-by-Space Method for lighting power allowances.

Assumptions:

All spaces in the Hilton Hotel at BWI Airport are enclosed by partitions 80% or greater than the ceiling height.

For space types not listed in the Space-by-Space Method tables, assume a reasonably equivalent category from the table, and use that power density instead.

The following spaces were assumed to have these equivalents:

Communications Room → Control Room
Elevator Lobby → Lobby
Emergency → Equipment Room
Vestibule → Corridor/Transition
Receiving → Active Storage
Janitor’s Closet → Active Storage
Swimming Pool/Deck → Exercise Room
Vending → Corridor/Transition

In cases where a similar common space type and building specific type are listed, the building specific type will be used. For example, a Mechanical/Electrical space is listed as a common space type, and an Equipment Room is listed as a building specific type area. Therefore, the Equipment Room designation and power density is used since it is for the building specific type method.

Discussion:

Of the 18 different spaces analyzed using the Space-by-Space Method, only 5 of the spaces did not comply with ASHRAE Standard 90.1-2004 criteria in Section 9. Of these 5 non-compliant spaces, 4 of them had larger lighting power densities (LPD) that were less than 0.10 W/sf greater than the requirement. Only the Equipment Rooms had almost twice the LPD of the Standard.

Mechanical System Lost Rentable Space

The primary function of the Hilton Hotel at BWI Airport is to provide its customers with a comfortable place to stay for a good night's sleep. The primary means of income is through the business-class clientele that are looking for a place to spend the night near the Baltimore-Washington International (BWI) Airport. This is best accomplished by having available as many guest rooms as possible.

However, if the Hilton Hotel would have large mechanical spaces inside the building, it would be losing out on its source of income. Therefore, it is in the best interest of the building owner to have as much occupiable space as possible. This can be done by limiting the amount of mechanical and other equipment inside the building.

Of all the major mechanical equipment in the building, only three of the four air handling units (AHUs) are located inside. The six rooftop units (RTUs) are all located on one of the roofs of the hotel. This allows for more rentable space inside the building.

The analysis done on the lost rentable space is done in two ways. First, a straightforward calculation determined the total amount of floor area occupied by mechanical rooms and vertical mechanical shafts inside the building. Next, all the other additional support spaces were totaled in a separate calculation. Finally, the mechanical areas and the other areas were added together to get a gross square footage and percentage of lost rentable space of the hotel.

The first calculation yielded results of 13,215 sf from the mechanical rooms and shafts, which is about 4.85% of the total floor space. The other computation came up with 6900 sf (or 2.53%) lost to other support spaces. Some of these support spaces include electrical rooms, communication rooms, the elevator machine room, and the elevators.

The grand total of both calculations added together came out to be 20,115 sf, or about 7.38% of the total building area. Please see Appendix D – Lost Rentable Space for the detailed breakdown of all the calculations.

Grand Total (sf)	
Mechanical Spaces	8568
Vertical Mechanical Shafts	4647
Other Spaces	6900
Total Lost Rentable Space	20,115
Total Building Area	272,567
Percent Lost Rentable Space	**7.38%**

Mechanical System First Cost

The data and information required for the mechanical system first cost was provided by Southland Industries, Inc., who is the mechanical contractor for the Hilton Hotel at BWI Airport project.

The first cost can be broken down into several pieces. The sheetmetal, pipe fitting, and plumbing are all listed with their related costs for labor, materials, and fabrication. The equipment, which totals about $1.7 million, is also broken down into smaller categories indicating both quantity and price of certain. Then the work being sub-contracted out is listed next, and it only totals about $350,000. Finally, the start/test labor and general conditions fees are accounted for. After totaling all of these costs together, the total mechanical system first cost is almost $6.5 million.

Once the total first cost has been calculated, the price per square foot can be determined. The cost per square foot was found to be $23.68/sf as is shown in the figure below.

Mechanical System Cost per SF	
First Cost	$6,454,337
Total Building Area (sf)	272,567
Cost per SF	**$23.68/sf**

Please refer to Appendix E – Mechanical System First Cost for the detailed breakdown of all the mechanical system first costs.

Design Load and Energy Estimate

The design load and energy estimate for the Hilton Hotel at BWI Airport was done using Carrier's Hourly Analysis Program (HAP). After computing all the loads, a comparison was done between the original design documents and the computed loads from HAP for the cooling load, total supply air, and ventilation supply air based on the square footages.

Please see Appendix F – Load Comparisons for the comparisons between the design documents and the computed loads.

Assumptions:

The outdoor air ventilation rates were calculated for each space based on the nominal and assumed supply air flow rates given in ASHRAE Standard 62-2004 (as were used in Technical Assignment #1). This was done because the actual values used in design were unavailable.

There were no provided occupancies for any of the space in the hotel, so it was assumed that the default occupancy densities would have to be acceptable. Again, these default values were taken from ASHRAE Standard 62-2004 (as were used in Technical Assignment #1). The design occupancies were calculated based on the default densities multiplied by the area for all of the office spaces in the building. However, if the calculated design occupancy for an office space was less than one, a minimum occupancy of one person per office was assumed.

Guest rooms are typically categorized as Bedrooms/Living Rooms in Table 6-1 with certain ventilation requirements. However, the eight levels of guest rooms on floors four through eleven of the hotel were granted a variance, which eliminated the usual numerical outdoor air condition. The designers received the variance because they justified using alternate means of introducing outside air to all the guest room spaces. Operable windows are used to directly ventilate the rooms. The other method employed involves drawing in supply air originally delivered to the corridors into the guest rooms via undercuts in the doors along the corridor.

Discussion:

In an attempt to accurately model the hotel building, water-source heat pumps (WSHPs) were added to the system in addition to the air handling units (AHUs) and the rooftop units (RTUs). However, the effort only resulted in several unsuccessful attempts at simulating the WSHPs.

This means that there is a significant amount of energy missing from the energy reports as calculated by HAP. As shown in the mechanical system first cost, there are 288 WSHPs in the Hilton Hotel at BWI Airport. This equips each guest room with an individual WSHP. However, as previously mentioned, none of the energy requirements for these WSHPs were completed successfully. Hopefully, future attempts at simulation will be more productive and a better determination of the building's energy usage will be calculated.

With that in mind, all of the fan energy, pump head loss, condenser water flow from the cooling towers, or hot water from the boilers was able to be modeled accurately with HAP for this assignment. All of the energy outputs from HAP will be too small as compared to those of the design documents. Except for the four AHUs and six RTUs, only part of the energy for the boilers and cooling towers was calculated.

A summary of all the load sources used in the building modeling can be found in Appendix G – Equipment Heat Gains. These equipment loads were used in the offices, vending areas, guest rooms, and meeting rooms.

Since the building is a hotel adjacent to a major airport, it was assumed that there will always be people coming and going to the hotel. Most of the schedules used in HAP used full 100% loads for 24 hours a day. While many business people may not be in the hotel during the day, the hotel's staff and building service workers will be there working. Conferences and assemblies could be using the meeting rooms and ballroom at any time. The restaurant may be serving meals to travelers and flight attendants at all odd hours of the day and night.

Yearly Energy Utilization Data

The Hilton Hotel at BWI Airport is still currently under construction, so there is no meter data or utility bills for the building at this point. However, it is possible to estimate the yearly energy utilization data for the hotel using Carrier's Hourly Analysis Program (HAP). The building has two sources of energy that keep the mechanical (and other) equipment running. The energy sources include both the electric power (kWh) and fossil-fuel, which is natural gas (therms).

The electric service comes from Baltimore Gas and Electric. Electric rates and tariffs were provided when inquired about. The information regarding the rates and hours can be found in Appendix H – Electric and Natural Gas Rates.

The natural gas service is through Washington Gas. The natural gas rates and tariffs were determined to be for the GL Schedule, which is General Service Large, for the hotel. The information dealing with the rates is in Appendix H – Electric and Natural Gas Rates.

The yearly energy utilization data was calculated through HAP. As can be seen below, the electric usage is much more significant than the natural gas. This can be accounted for in that nearly all the lighting and electric equipment loads were programmed into HAP. However, only a fraction of the natural gas was simulated in HAP since not all of the mechanical equipment was modeled in the systems (most notably, the 288 water-source heat pumps).

Totals	
Electric (kWh)	1,486,663
Natural Gas (Therm)	7,312

Annual Energy Consumption and Operating Costs

The annual energy consumption and operating costs were calculated with the HAP simulation. The majority of the occupancy, lighting, and equipment schedules operate at nearly 100% load as described previously. The fuel costs can be found in Appendix H – Electric and Natural Gas Rates.

The building design engineer was contacted about a hotel energy analysis. However, if an energy analysis was performed during the design stage, it was never released, and there was no chance of obtaining any information from the design engineer. It is unclear whether or not an energy analysis was ever done for the Hilton Hotel at BWI Airport. Also, no meter data or utility bills were available since construction is on-going at the new hotel.

All charts and graphs for the break down of the mechanical components, annual cooling cost per square foot, and other operating costs can be found in Appendix J – Annual Energy Costs. Only the electric and natural gas components were accounted for in the energy consumption analysis.

Also, all the data and other information required for the emissions analysis is located in Appendix K – Emissions Analysis. The energy mix for both the electric and natural gas was obtained from the respective energy suppliers.

Appendix A – LEED-NC Checklist

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

LEED-NC Version 2.1 Registered Project Checklist
Hilton Hotel at BWI Airport
Linthicum Heights, MD

Yes	?	No			
10	1	3	**Sustainable Sites**		14 Points
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
		N	Credit 1	**Site Selection**	1
		N	Credit 2	**Development Density**	1
		N	Credit 3	**Brownfield Redevelopment**	1
1			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1			Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
1			Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	1
1			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
1			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
1			Credit 6.1	**Stormwater Management**, Rate and Quantity	1
1			Credit 6.2	**Stormwater Management**, Treatment	1
1			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
1			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
	?		Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
2		3	**Water Efficiency**		5 Points
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
		N	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		N	Credit 2	**Innovative Wastewater Technologies**	1
1			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
		N	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Yes	?	No			
5	1	3	**Energy & Atmosphere**		17 Points
Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
2			Credit 1	**Optimize Energy Performance**	1 to 10
		N	Credit 2.1	**Renewable Energy**, 5%	1
		N	Credit 2.2	**Renewable Energy**, 10%	1
		N	Credit 2.3	**Renewable Energy**, 20%	1
1			Credit 3	**Additional Commissioning**	1
1			Credit 4	**Ozone Depletion**	1
1			Credit 5	**Measurement & Verification**	1
	?		Credit 6	**Green Power**	1

Yes	?	No			
3	5	5	**Materials & Resources**		**13** Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		N	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
		N	Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
		N	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1			Credit 2.1	**Construction Waste Management**, Divert 50%	1
	?		Credit 2.2	**Construction Waste Management**, Divert 75%	1
		N	Credit 3.1	**Resource Reuse**, Specify 5%	1
		N	Credit 3.2	**Resource Reuse**, Specify 10%	1
1			Credit 4.1	**Recycled Content**, Specify 5% (post-consumer + ½ post-industrial)	1
	?		Credit 4.2	**Recycled Content**, Specify 10% (post-consumer + ½ post-industrial)	1
1			Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
	?		Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	?		Credit 6	**Rapidly Renewable Materials**	1
	?		Credit 7	**Certified Wood**	1

Yes	?	No			
9		6	**Indoor Environmental Quality**		**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
		N	Credit 2	**Ventilation Effectiveness**	1
		N	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
		N	Credit 6.1	**Controllability of Systems**, Perimeter	1
		N	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
		N	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
1			Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		N	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No			
2		3	**Innovation & Design Process**		**5** Points
1			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
		N	Credit 1.2	**Innovation in Design**: Provide Specific Title	1
		N	Credit 1.3	**Innovation in Design**: Provide Specific Title	1
		N	Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED™ Accredited Professional**	1

Yes	?	No		
31	7	23	**Project Totals (pre-certification estimates)**	**69** Points
			Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points	

Appendix B - Prescriptive Building Envelope Option

Building Envelope

Non-Residential:

		Design		Standard 90.1-2004		
		Non-Residential		Non-Residential		
Building Envelope	**Opaque Elements**	**Assembly Max. U-Value**	**Insulation Min. R-Value**	**Assembly Max. U-Value**	**Insulation Min. R-Value**	**Compliance**
Roof:						
(Metal Roof Deck)	Insulation entirely above deck	0.031	30	U-0.063	R-15.0	**YES**
(Mass Roof)	Insulation entirely above deck	0.026	30	U-0.063	R-15.0	**YES**
Walls, above grade:						
	Steel Framed	0.047	14.5	U-0.124	R-13.0	**YES**
Floors:						
	Mass	0.117	0	U-0.107	R-6.3	**NO**
Opaque Doors:						
	Swinging	0.142	--	U-0.700	--	**YES**

Residential:

		Design		Standard 90.1-2004		
		Residential		Residential		
Building Envelope	**Opaque Elements**	**Assembly Max. U-Value**	**Insulation Min. R-Value**	**Assembly Max. U-Value**	**Insulation Min. R-Value**	**Compliance**
Roof:						
(Metal Roof Deck)	Insulation entirely above deck	--	--	U-0.063	R-15.0	**YES**
(Mass Roof)	Insulation entirely above deck	0.026	30	U-0.063	R-15.0	**YES**
Walls, above grade:						
	Steel Framed	0.047	14.5	U-0.064	R-13.0	**YES**
Floors:						
	Mass	0.138	0	U-0.087	R-8.3	**NO**
Opaque Doors:						
	Swinging	0.142	--	U-0.700	--	**YES**

Fenestration

Non-Residential:

		Design		Standard 90.1-2004		
		Non-Residential		Non-Residential		
Glazing	**Fenestration**	**Assembly Max. U-Value (Fixed/Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U-Value (Fixed/Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Compliance**
Vertical Glazing, % of wall:						
	30.1-40.0%	0.29	0.54	U_{fixed}-0.57	$SHGC_{all}$-0.39	**NO**
		0.29	0.54	U_{oper}-0.67	$SHGC_{north}$-0.49	**NO**

Residential:

		Design		Standard 90.1-2004		
		Residential		Residential		
Glazing	**Fenestration**	**Assembly Max. U-Value (Fixed/Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U-Value (Fixed/Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Compliance**
Vertical Glazing, % of wall:						
	30.1-40.0%	0.29	0.54	U_{fixed}-0.57	$SHGC_{all}$-0.39	**NO**
		0.29	0.54	U_{oper}-0.67	$SHGC_{north}$-0.49	**NO**

Appendix C - Space-by-Space Method

Common Space Types:

Common Space Types	Lighting Power Density (W/sf)
Office Enclosed	1.1
Conference/Meeting	1.3
Lobby	1.1
Dining Area	1.3
Bar Lounge	1.4
Food Preparation	1.2
Restrooms	0.9
Dressing/Locker Room	0.6
Corridor/Transition	0.5
Lounge/Recreation	1.2
Active Storage	0.8
Inactive Storage	0.3

Building Specific Space Types:

Building Specific Space Types	Lighting Power Density (W/sf)
Exercise Area	0.9
Laundry - Washing	0.6
Equipment Room	1.2
Control Room	0.5
Hotel/Motel Guest Rooms	1.1
Parking Garage - Garage Area	0.2

Space-by-Space Method:

Space Type	LPD (W/sf)	Total Space Area (sf)	Total Space Watts (W)	LPD (W/sf)	Compliance
Equipment Room	1.2	10,808	6784	0.63	NO
Active Storage	0.8	8087	6816	0.84	YES
Office Enclosed	1.1	4994	8082	1.62	YES
Inactive Storage	0.3	3108	2304	0.74	YES
Control Room	0.5	906	832	0.92	YES
Lobby	1.1	9920	12,944	1.30	YES
Conference/Meeting	1.3	11,394	60,440	5.30	YES
Corridor/Transition	0.5	14,324	13,590	0.95	YES
Dining Area	1.3	4872	7584	1.56	YES
Bar Lounge	1.4	3707	6594	1.78	YES
Restrooms	0.9	1661	3270	1.97	YES
Food Preparation	1.2	3363	3936	1.17	NO
Exercise Area	0.9	5142	4422	0.86	NO
Dressing/Locker Room	0.6	932	832	0.89	YES
Parking Garage - Garage Area	0.2	41,084	8750	0.21	YES
Laundry - Washing	0.6	2593	1536	0.59	NO
Hotel Guest Room	1.1	29,305	30,294	1.03	NO
Lounge/Recreation	1.2	999	1,603	1.60	YES

Appendix D – Lost Rentable Space

Mechanical Rooms and Vertical Mechanical Shafts:

Type	Floor	Room No.	Space Name	Space Area (sf)
Room	PL	S02	Water Service/Pump Room	483
Room	PL	S08	Main Mechanical Room	1248
Room	2	221	Mechanical Room	442
Room	2	206	Mechanical Room	1810
Room	PH	P02	Penthouse	4040
Room	PH	P03	Mechanical Room	545
Shaft	G	162	Vertical Mechanical Shaft	27
Shaft	G	105	Vertical Mechanical Shaft	23
Shaft	2	203A	Vertical Mechanical Shaft	5
Shaft	2	Stair 2	Vertical Mechanical Shaft	13
Shaft	2	Stair 1	Vertical Mechanical Shaft	6
Shaft	3	339	Vertical Mechanical Shaft	5
Shaft	3	--	(11) Vertical Mechanical Shafts	30
Shaft	3	--	(4) Vertical Mechanical Shafts	22
Shaft	3	302	(2) Vertical Mechanical Shafts	5
Shaft	3	--	(36) Vertical Mechanical Shafts	396
Shaft	3	332	(3) Vertical Mechanical Shafts	9
Shaft	3	Stair 2	Vertical Mechanical Shaft	13
Shaft	3	Stair 1	Vertical Mechanical Shaft	6
Shaft	4-10	429-1029	Vertical Mechanical Shaft	5 (each floor)
Shaft	4-10	--	(11) Vertical Mechanical Shafts	30 (each floor)
Shaft	4-10	--	(4) Vertical Mechanical Shafts	22 (each floor)
Shaft	4-10	402-1002	(2) Vertical Mechanical Shafts	22 (each floor)
Shaft	4-10	--	(48) Vertical Mechanical Shafts	396 (each floor)
Shaft	4-10	432-1032	(3) Vertical Mechanical Shafts	8 (each floor)
Shaft	4-10	Stair 2	Vertical Mechanical Shaft	17 (each floor)
Shaft	4-10	Stair 1	Vertical Mechanical Shaft	5 (each floor)
Shaft	11	1129	Vertical Mechanical Shaft	5
Shaft	11	--	(11) Vertical Mechanical Shafts	30
Shaft	11	--	(4) Vertical Mechanical Shafts	22
Shaft	11	1102	(2) Vertical Mechanical Shafts	22
Shaft	11	--	(42) Vertical Mechanical Shafts	396
Shaft	11	1121	(3) Vertical Mechanical Shafts	10
Shaft	11	1127	(3) Vertical Mechanical Shafts	10
Shaft	11	1130	(3) Vertical Mechanical Shafts	11
Shaft	11	Stair 2	Vertical Mechanical Shaft	17
Shaft	11	Stair 1	Vertical Mechanical Shaft	5
Shaft	PH	P03	Vertical Mechanical Shaft	7
Shaft	4-10	Stair 2	Vertical Mechanical Shaft	17

Mechanical Rooms and Shafts Total:

Total (sf)	
Mechanical Spaces	8568
Vertical Mechanical Shafts	4647
Total Building Area	272,567
Lost Rentable Space	13,215
Percent Lost Rentable Space	**4.85%**

Other (Support) Rooms:

Type	Floor	Room No.	Space Name	Space Area (sf)
Other	PL	S15	Telephone & Communication	401
Other	PL	S07A	Emergency	150
Other	PL	S07	Main Electrical Room	1100
Other	G	159	Electrical Room	235
Other	G	152	Electrical Room	216
Other	2	216	Elec./Comm. Room	110
Other	3	340	Comm. Room	105
Other	4-10	440-1040	Comm. Room	105 (each floor)
Other	11	1140	Comm. Room	105
Other	PH	P01	Elevator Machine Room	142
Other	PL-PH	--	Elevators	277 (each floor)

Other (Support) Rooms Total:

Other Total (sf)	
Total Other Spaces	6900
Total Building Area	272,567
Other Lost Space Percentage	**2.53%**

Grand Total:

Grand Total (sf)	
Mechanical Spaces	8568
Vertical Mechanical Shafts	4647
Other Spaces	6900
Total Lost Rentable Space	20,115
Total Building Area	272,567
Percent Lost Rentable Space	**7.38%**

Appendix E – Mechanical System First Cost

Mechanical System Total First Cost:

Mechanical System First Cost		Sub-Total	Total
Sheetmetal			**$905,000**
	Labor	$600,000	
	Fabrication	$115,000	
	Material	$190,000	
Pipe Fitting			**$940,000**
	Labor	$590,000	
	Fabrication	$140,000	
	Material	$210,000	
Plumbing			**$1,615,000**
	Labor	$1,020,000	
	Fabrication	$160,000	
	Material	$435,000	
Equipment			**$1,701,337**
	(288) Water-Source Heat Pumps	$430,000	
	(4) AHUs, (6) RTUs,(43) VAVs, (70') FTRs, and other equipment	$507,100	
	(2) Cooling Towers	$61,315	
	(2) Heat Exchangers	$31,810	
	(4) HW Boilers	$61,000	
	(23) Pumps	$33,686	
	(2) HW Generators	$46,430	
	(2) Water Heaters	$38,548	
	(43) Fans	$65,200	
	(5) Sump Pumps	$29,800	
	(1131) Diffusers	$26,971	
	(3) Valves and (3) Traps	$30,873	
	Plumbing Fixtures	$192,896	
	Sheetmetal Specialties	$25,785	
	Pipe Fitting Specialties	$17,418	
	Plumbing Specialties	$61,556	
	Misc. Equipment	$40,949	
Sub-Contractors			**$351,000**
	Insulation	$260,000	
	Firestopping	$30,000	
	Chem Treatment	$16,000	
	Excavation	$20,000	
	TAB	$25,000	
Start/Test Labor			$82,000
General Conditions			$860,000
Grand Total			**$6,454,337**

Mechanical System First Cost per Square Foot:

Mechanical System Cost per SF	
First Cost	$6,454,337
Total Building Area (sf)	272,567
Cost per SF	**$23.68/sf**

Appendix F – Load Comparisons

Cooling Comparison:

System	Design Load (sf/ton)	Cooling (sf/ton)
AHU-1	89.6	135.9
AHU-2	135.2	162.2
AHU-3	174.3	261.6
AHU-4	353.9	759.4
RTU-1	281.3	802.6
RTU-2	171.1	494.3
RTU-3	285.9	819.8
RTU-7	235.2	492.5
RTU-8	230.4	583.6
RTU-11	14.8	865.2

Total Supply Air Comparison:

System	Design SA (cfm/sf)	Supply Air (cfm/sf)
AHU-1	1.9	1.6
AHU-2	1.4	1.08
AHU-3	1.0	0.62
AHU-4	0.7	0.24
RTU-1	0.6	0.42
RTU-2	0.9	0.57
RTU-3	0.6	0.37
RTU-7	0.9	0.64
RTU-8	0.9	0.43
RTU-11	17.6	0.5

Ventilation Supply Air Comparison:

System	Design Vent (cfm/sf)	Ventilation (cfm/sf)
AHU-1	1.2	0.53
AHU-2	0.7	1.08
AHU-3	0.5	0.62
AHU-4	0.2	0.24
RTU-1	0.6	0.14
RTU-2	0.9	0.26
RTU-3	0.6	0.14
RTU-7	0.9	0.34
RTU-8	0.9	0.43
RTU-11	--	0.5

Appendix G – Equipment Heat Gains

Equipment Heat Gains:

EQUIPMENT HEAT GAINS		
Equipment Name	**Heat Gain (Btu/hr)**	**Heat Gain (W)**
Computer	450	135
Desktop Printer	450	135
Office Printer	1100	325
Fax Machine	250	75
Copier	3760	1105
VCR/DVD	100	30
TV	275	80
Projetor	3060	900
Refrigerator	1460	430
Icemaker	2560	750
Kitchen Stove	5320	1560
Coffeemaker	3750	1100
Dishwasher	200	60
Microwave	1360	400
Vending Machine	1080	320

*Provided by Mueller Associates, Inc.

Appendix H – Electric and Natural Gas Rates

Electric Rates from Baltimore Gas and Electric:

GENERAL SERVICE LARGE -- ELECTRIC SCHEDULE GL		
Delivery Service Customer Charge:	$110	per month
Demand Charges:	Summer	Non-Summer
Generation Market-Priced Service:	(per kW)	(per kW)
Type II	-	-
Transmission Charge for Market-Priced Service:		
Type II	$1.05	$1.05
Delivery Service	$2.67	$2.67
Energy Charges:		
Generation Market-Priced Service (¢/kWh): (Excludes Rider 8 – Energy Cost Adjustment)	Summer	Non-Summer
Type II		
Peak	9.319	5.534
Intermediate	8.802	5.406
Off-Peak	8.464	5.118
Delivery Service Charge:	1.239	¢/kWh
Hours:	Summer	Non-Summer
Peak	10 am - 8 pm	7 am - 11 am 5 pm - 9 pm
Off-Peak	11 pm - 7 am	9 pm - 7 am
Intermediate	7 am - 10 am 8 pm - 11 pm	11 am - 5 pm

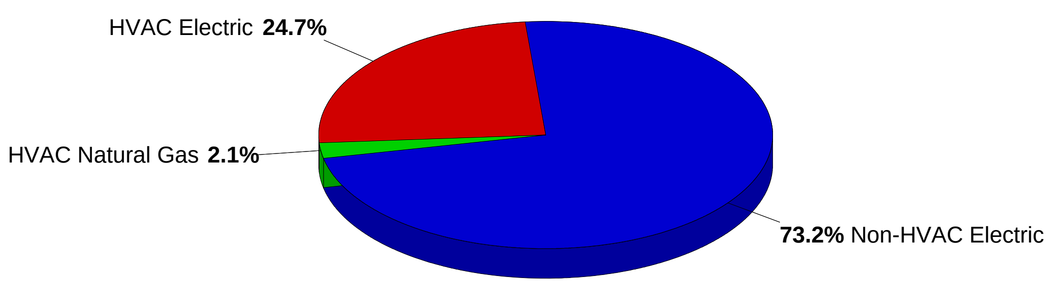
Natural Gas Rates from Washington Gas:

Natural Gas Utility Rates		
System Charge		
	$36.25	per customer
Distribution Charge		
First 300 therms:	$0.3158	per therm
Next 6700 therms:	$0.2152	per therm
Over 7000 therms:	$0.1573	per therm

Appendix J – Annual Energy Costs

Annual Energy Costs:

Component	Annual Cost ($/yr)	($/ft²)	Percent of Total (%)
HVAC Components			
Electric	25,642	0.304	24.7
Natural Gas	2,213	0.026	2.1
HVAC Sub-Total	**27,855**	**0.330**	**26.8**
Non-HVAC Components			
Electric	75,905	0.898	73.2
Natural Gas	0	0.000	0.0
Non-HVAC Sub-Total	**75,905**	**0.898**	**73.2**
Grand Total	**103,760**	**1.228**	**100.0**



Annual Costs:

Component	Hilton Hotel at BWI Airport ($)
HVAC Components	
Electric	25,642
Natural Gas	2,213
HVAC Sub-Total	**27,855**
Non-HVAC Components	
Electric	75,905
Natural Gas	0
Non-HVAC Sub-Total	**75,905**
Grand Total	**103,760**

Annual Energy Consumption:

Component	Hilton Hotel at BWI Airport
HVAC Components	
Electric (kWh)	371,064
Natural Gas (Therm)	7,312
Non-HVAC Components	
Electric (kWh)	1,115,599
Natural Gas (Therm)	0
Totals	
Electric (kWh)	1,486,663
Natural Gas (Therm)	7,312

Annual Cost per Unit Floor Area:

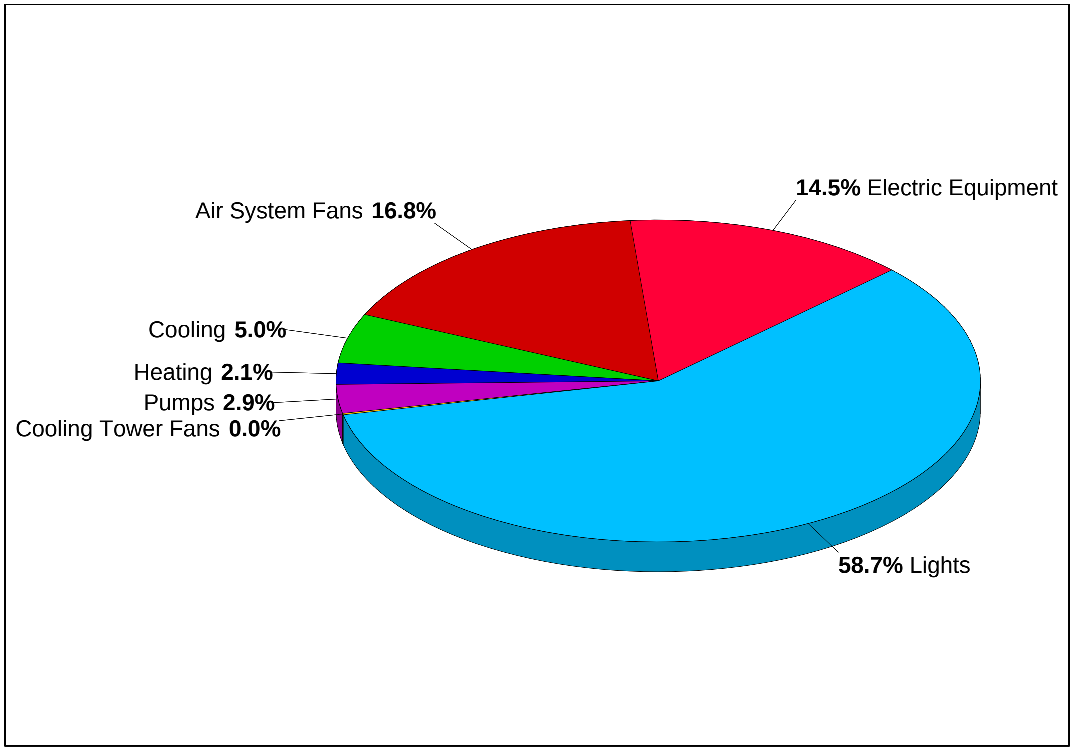
Component	Hilton Hotel at BWI Airport ($/ft²)
HVAC Components	
Electric	0.304
Natural Gas	0.026
HVAC Sub-Total	**0.330**
Non-HVAC Components	
Electric	0.898
Natural Gas	0.000
Non-HVAC Sub-Total	**0.898**
Grand Total	**1.228**
Gross Floor Area (ft²)	84492.0
Conditioned Floor Area (ft²)	84492.0

Component Cost as a Percentage of Total Cost:

Component	Hilton Hotel at BWI Airport (%)
HVAC Components	
Electric	24.7
Natural Gas	2.1
HVAC Sub-Total	**26.8**
Non-HVAC Components	
Electric	73.2
Natural Gas	0.0
Non-HVAC Sub-Total	**73.2**
Grand Total	**100.0**

Annual Component Costs:

Component	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	17,475	0.207	16.8
Cooling	5,167	0.061	5.0
Heating	2,213	0.026	2.1
Pumps	2,987	0.035	2.9
Cooling Tower Fans	13	0.000	0.0
HVAC Sub-Total	**27,856**	**0.330**	**26.8**
Lights	60,873	0.721	58.7
Electric Equipment	15,028	0.178	14.5
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	**75,900**	**0.898**	**73.2**
Grand Total	**103,756**	**1.228**	**100.0**

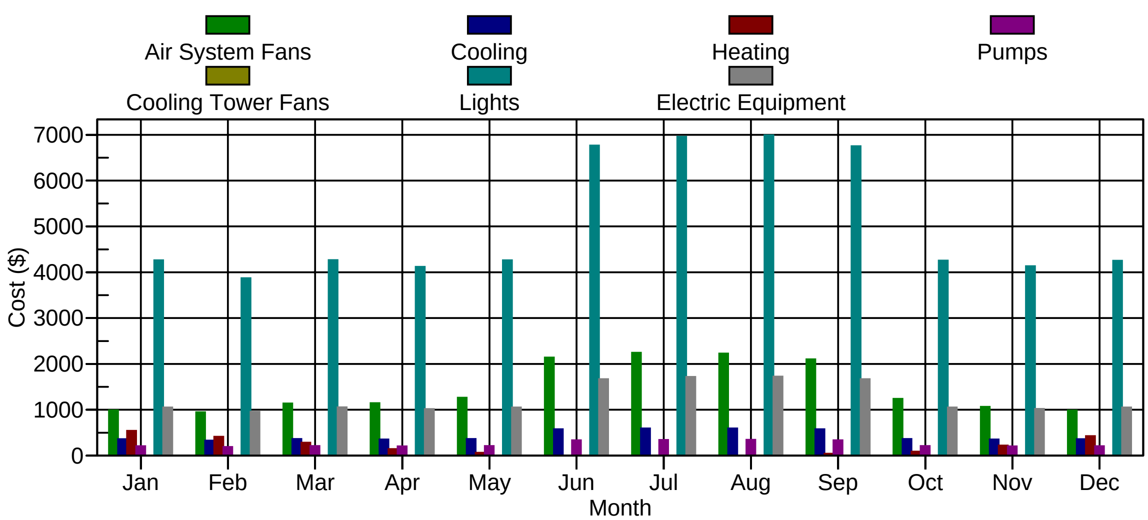


Energy Consumption by System Component:

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	856,731	10.140	3,059,755	36.214
Cooling	259,037	3.066	925,134	10.949
Heating	731,210	8.654	731,210	8.654
Pumps	149,679	1.772	534,568	6.327
Cooling Towers	666	0.008	2,380	0.028
HVAC Sub-Total	**1,997,324**	**23.639**	**5,253,046**	**62.172**
Lights	3,052,621	36.129	10,902,217	129.033
Electric Equipment	753,595	8.919	2,691,412	31.854
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**3,806,216**	**45.048**	**13,593,629**	**160.887**
Grand Total	**5,803,540**	**68.687**	**18,846,675**	**223.059**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area .... **84492.0** ft²
   Conditioned Floor Area .... **84492.0** ft²

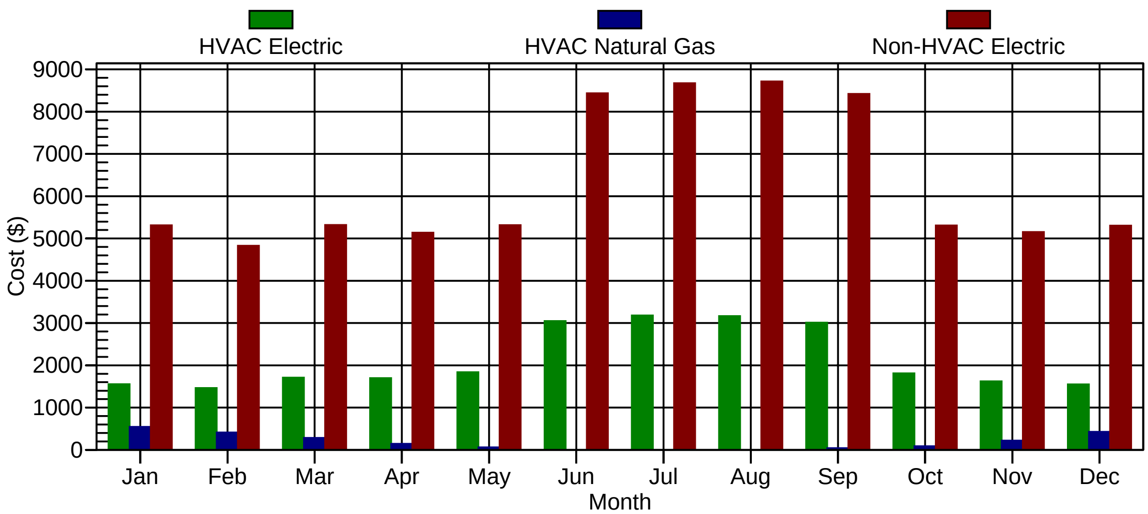
Monthly HVAC Component Costs:



Energy Consumption by Energy Source:

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
HVAC Components				
Electric	1,266,071	14.985	4,521,682	53.516
Natural Gas	731,210	8.654	731,210	8.654
HVAC Sub-Total	**1,997,281**	**23.639**	**5,252,892**	**62.170**
Non-HVAC Components				
Electric	3,806,424	45.051	13,594,373	160.895
Natural Gas	0	0.000	0	0.000
Non-HVAC Sub-Total	**3,806,424**	**45.051**	**13,594,373**	**160.895**
Grand Total	**5,803,705**	**68.689**	**18,847,265**	**223.066**

Monthly Energy Costs:



Appendix K – Emissions Analysis

Annual Emissions:

Component	Hilton Hotel at BWI Airport
CO2 (lb)	2,061,284
SO2 (kg)	5,084
NOx (kg)	2,996

Emissions Estimate Associated with On-Site Electricity Use:

Electricity		lbm $Pollutant_j$ /kWh U.S.			
Fuel	**% Mix U.S.**	**Particulates**	**SO_2/kWh**	**NO_x/kWh**	**CO_2/kWh**
Coal	52.6	5.79E-04	6.72E-03	3.90E-03	1.13E+00
Oil	1.1	1.21E-05	1.70E-04	3.11E-05	2.32E-02
Nat. Gas	6.9	0.00E+00	9.31E-07	1.75E-04	9.25E-02
Nuclear	37.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hydro/Wind	2.3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Totals	100.0	5.91E-04	6.89E-03	4.10E-03	1.25E+00

Natural Gas		lbm Pollutantj /kWh U.S.			
Fuel	**% Mix U.S.**	**Particulates**	**SO2/kWh**	**NOx/kWh**	**CO2/kWh**
Coal	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Oil	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nat. Gas	100.0	0.00E+00	1.35E-05	2.54E-03	1.34E+00
Nuclear	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hydro/Wind	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Totals	100.0	0.00E+00	1.35E-05	2.54E-03	1.34E+00

Thousand BTU/sq.ft.-yr.				lbm Pollutant/ft.^{2}-yr			
1995 Database	**Total**	**50% e^- ~**	**kWh e^- ~**	**NOx**	**SOx**	**Particulates**	**CO2**
All Buildings	90.5	45.25	13.26	6.54E-02	1.11E-01	9.47E-03	2.03E+01
Floorspace (sq. ft)							
200,001 to 500,000	114.6	57.3	16.79	8.28E-02	1.41E-01	1.20E-02	2.57E+01
Principal Building Activity	**Total**	**50% e^- ~**	**kWh e^- ~**	**NOx**	**SOx**	**Particulates**	**CO2**
Lodging	127.3	63.65	18.65	9.20E-02	1.56E-01	1.33E-02	2.86E+01
	Total	**50% e^- ~**	**kWh e^- ~**	**NOx**	**SOx**	**Particulates**	**CO2**
Climatic Zone							
Zone 4	79.9	39.95	11.71	5.77E-02	9.80E-02	8.36E-03	1.79E+01

References

"ANSI/ASHRAE/IESNA Standard 90.1-2004 – Energy Standard for Buildings Except Low-Rise Residential Buildings." ASHRAE, Inc. Atlanta, GA. 2004.

"Equipment Heat Gains." Mueller Associates, Inc. 2005.

"Firm Commercial and Industrial Sales Service Rate Schedule No. 2." Washington Gas. October 27, 2005. <http://www.washgas.com/>.

"General Service Large – Electric Schedule GL." Baltimore Bas and Electric. October 27, 2005. <http://www.bge.com/>.

Hilton Hotel at BWI Airport – plans and schedules. Construction Issue Set. April 20, 2005.

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

"LEED for New Construction." U.S. Green Building Council. October 22, 2005. <https://www.usgbc.org/Docs/LEEDdocs/LEED-NC_checklist-v2.1.xls>.

"Solarscreen Low-E Insulating glass." Viracon. October 28, 2005. <http://www.viracon.com/products.php?category=53>.