Nassau Community College Life Sciences Building

Garden City, NY

Technical Report Three

Mechanical Systems Existing Conditions Evaluation

Prepared By: Michael W. Reilly Jr.

Prepared For: James D. Freihaut, PhD

Dustin Eplee

Date: 11.29.10

Table of Contents

List of Tables

List of Figures

Executive Summary

Nassau Community College's Life Sciences Building located in Garden City, New York is a new facility currently under construction. The Life Sciences Building contains general classrooms, offices and chemistry laboratory and will house both the established chemistry and growing nursing departments. The chemistry department will have laboratories located on the second floor and the nursing department will have skill teaching laboratories on the third floor. The second floor is a main concern for indoor air quality due to the handling of hazardous chemicals.

The mechanical system was designed with three air handling units. One air handling unit is a 100% outdoor air unit serving the laboratories and accompanying storage spaces. Two variable air volume units serve the general classrooms, nursing laboratories and offices. The chemistry laboratories are designed with fume hoods connected to a dedicated exhaust system located on the roof. The Life Sciences Building is served with electricity, high temperature hot water and chilled water from a campus system as its utilities. The high temperature hot water is both converted to hot water through heat exchangers and used directly in heating coils. The chilled water is routed throughout the building to serve the necessary loads.

The mechanical system first cost is $5,320,000, which is approximately 17% of the total budget. The annual energy cost for the Life Sciences Building is calculated to be $241,000 for electricity, high temperature hot water and chilled water. The mechanical system first cost and annual energy cost break down to $73.50 and $3.33 per square foot respectively. The system first cost resides within the industry's average range while the annual energy cost is above average.

Nassau Community College and the design team both have a goal of achieving a Gold Rating from the Leadership in Energy and Environmental Design (LEED). A LEED analysis was performed using the most current rating system and the LEED checklist submitted by the Life Sciences Building architect to the United States Green Building Council (USGBC). The analysis was performed only on the Energy and Atmosphere and Indoor Environmental Quality sections because of their relation to the mechanical system.

An overall system evaluation and critique was performed on the designed mechanical system in order to determine areas that can potentially be redesigned. Aspects of the mechanical system that were evaluated were the construction and energy costs, mechanical space requirements, indoor air quality and environmental control. While the mechanical design is appropriate for educational buildings, there are potential design changes that may increase energy savings, decrease mechanical space requirements and provide savings in construction cost. These changes will be provided in future reports.

Existing Mechanical System Description

Mechanical Design Objectives

The Life Sciences Building is an educational building located at Nassau Community College. The building was designed with general classrooms and computer labs to be utilized by students of all majors as well as chemistry and nursing laboratories on the upper floors and faculty offices. Therefore a variable air volume system was chosen to accommodate the fluctuations in occupancies throughout the day.

The chemistry laboratories contain hazardous chemicals and require fume hoods and a dedicated one hundred percent outdoor air ventilation system. Because of the high energy consumption of a one hundred percent outdoor air system, a heat recovery system is used between the outdoor air intake and exhaust outlet. The heat recovery system needed careful consideration. Cross-contamination between the supply and exhaust air streams is undesirable. Therefore, a run-around loop pre-heat coil was selected as the major heat recovery component. Furthermore, minimum air change rates must be met in order to maintain proper pressurization within the laboratories. The fume hoods and minimum air change rates are the primary design criteria that determined the structure of the mechanical system for the chemistry laboratories.

Other than the laboratories fume hoods and good practice ideas, all spaces in the Life Sciences Building must comply with the ventilation rates specified 2007 New York State Mechanical Code. This code was also a prime factor in the mechanical system design.

Energy Sources

The Life Sciences Building is served with high temperature hot water and chilled water from a local central utility plant owned by the Nassau Energy Corporation. The central utility plant is a cogeneration facility that produces nearly 60 MW of electricity, which is sold to the Long Island Power Authority (LIPA). The Nassau Community College receives its electrical service from LIPA and the campus high temperature hot water and chilled water directly from the central utility plant. Due to the availability of the campus high temperature hot water and chilled water, it is advantageous for the Life Sciences Building to use those utilities rather than to have on-site combustion. Furthermore, the absence of on-site combustion decreased the annual maintenance costs of the building.

According to LIPA, the electrical rates for demand and consumption are not affected by on and off peak hours. Rather they are dependent on the time of year that the electricity is being used. The purchased high temperature hot water and purchased chilled water rates remain the same throughout the year. A summary of the electrical consumption and demand rates can be found in Table 1, high temperature hot water and chilled water rates in Table 2 and Table 3 respectively.

Utility	June – September	October - May
Electrical Consumption	$0.053/kWh	$0.0381/kWh
Electrical Demand	$9.33/kW	$8.25/kW

Table 1 - Electrical Consumption and Demand Rates

Utility	January - December
Purchased High Temperature Hot Water	$12/Therm

Table 2 - Purchased High Temperature Hot Water Rate

Utility	January – December
Purchased Chilled Water	$1.25/Therm

Table 3 - Purchased Chilled Water Rate

In order to visualize the cost of each utility relative to each other, a comparison was made in the units of dollars per Mbtu of energy in Table 4. For the purpose of this comparison, the most expensive electricity rate was used, which occurs from June through September. As seen in Table 4, the most expensive utility is the high temperature hot water. This is due to the nature of the high temperature hot water being delivered to the end user at 270°F rather than a typical hot water temperature of 180°F. The electricity and chilled water costs are similar per Mbtu.

Utility	$/Mbtu
Electricity	0.0155
HTHW	0.12
CHW	0.0125

Table 4 - Energy Cost Comparison

Tax Incentives

The Life Sciences Building receives its electrical service from the Long Island Power Authority (LIPA). LIPA provides a series of incentives that had an influence in the design of the building. Incentives include credits for LEED Certification and lump sums for surpassing the minimum standard set by the 2007 New York State Energy Conservation Code. Based on LIPA, a summary of the incentives available for the Life Sciences Building can be found in Table 5.

Opportunity	Whole Building Projects	LEED Green Building Projects
Project Incentives	Up to $400,000 per project	Up to $500,000 per project
	$800,000 annual cap per customer	$800,000 annual cap per customer
LEED Certification Points	N/A	In addition to Project Incentives, program participants may also receive $1,000 per LEED Certification point related to energy efficiency, up to $25,000
Technical Assistance	LIPA will fund the first $10,000 of the TA Study related to energy conservation measures and cost share with customer 50/50 for the additional amount of the study not to exceed $50,000	LIPA will fund the entire cost of the study up to $50,000 per project
Commissioning	Up to $50,000 per project	LIPA will provide funding up to $100,000 per project for electric energy conservation related equipment and/or systems

Table 5 - 2010 LIPA Incentive Schedule

The Life Sciences Building has submitted an application to the USGBC for LEED accreditation. According to the application, there is a potential for enough points to earn a LEED Gold rating, which is the goal of Nassau Community College and the design team. This presents a potential for a credit from LIPA based on the number of LEED points that have been approved.

While the New York State Energy Conservation Code does not specifically reference ASHRAE Standard 90.1, LIPA requires that the base case for the project must conform to the minimum requirements of Standard 90.1. The mechanical design of the Life Sciences Building was influenced by these opportunities for cost savings.

Design Conditions

The weather data from the ASHRAE Handbook of Fundamentals for the New York City, JFK International Airport station was used in this load and energy analysis due to its similarity in weather conditions to Garden City, NY, which is located 15 miles to the east. The interior design conditions are uniform throughout the building. Table 6 below provides a summary of the heating and cooling weather design and interior conditions, which were input in the Trane TRACE 700 for a load and energy analysis.

Season	Indoor Design (°F)	Outdoor DB (°F)	Outdoor WB (°F)
Summer (0.4%)	75	89.7	73.5
Winter (99.6%)	72	12.8	-

Table 6 - Interior and Interior Design Conditions

Design Ventilation Requirements

ASHRAE Standard 62.1-2007 is the typical source for the minimum ventilation requirements for conditioned spaces. However, the Life Sciences Building is located on Long Island, New York, which makes the New York State Mechanical Code of 2007 is the governing ventilation code. Table 403.3 in Chapter 4 provides minimum required outdoor air ventilation rates for specific occupancy classifications, similar to that of Table 6-1 in ASHRAE Standard 62.1-2007. The air handling unit serving the laboratory spaces is a one hundred percent outdoor air unit, in which the ventilation requirements will be exceeded by the cooling load requirements.

The requirements specified in Table 403.3 in the New York State Mechanical Code were input into TRACE for the load and energy analysis for all three air handling units. Table 7 compares the designed and the calculated ventilation airflow rates for two of the air handling units. The 100% outdoor air unit was left out of the comparison because of its nature. The designed airflow rates far exceed those calculated. The calculated airflow rates hover around the industry average of 20% of design load airflow, but the designed airflows are upwards of 50% of the design load airflow. The high design ventilation airflows can be attributed to the use of a variable air volume system. When a VAV box is turned down to its minimum position with a fully occupied space, the minimum ventilation requirements must still be met. This causes an increase in the outdoor airflow percentage.

Unit	Designed (CFM)	Calculated (CFM)
AHU-1	12,775	5,358
AHU-2	12,775	7,632

Table 7 - Designed and Calculated Ventilation Rates

Design Load Estimates

To evaluate the heating, cooling loads of the Nassau Community College Life Sciences Building, Trane TRACE 700 was used along with Autodesk Revit Architecture. Revit was used to create a 3-dimensional model of the Life Sciences Building, which was exported as a gbxml file. The gbxml allows for the translation of geometries from the model to TRACE. TRACE was then used to develop an 8,760 hour to determine the design heating and cooling loads. More information about the heating and cooling loads can be found in Technical Report Two.

Table 8 below provides various engineering checks from the heating and cooling design load results. Engineering check values for the designed Life Sciences Building were not provided by the mechanical engineer, nor were they provided by the outside consultant WSP Flack + Kurtz who developed a preliminary energy model using the U.S. Department of Energy's eQuest v3.6 building simulation software. Therefore, the calculated cooling and heating loads were compared to the ASHRAE 2009 Pocket Guide. A comparison between the calculated and designed energy use of the Life Sciences Building can be seen in the next section of this report.

Air Handler Zone	Cooling (ft^2/ton)	Heating (Btu/h-ft^2)	Supply Air (CFM/ft^2)
East AHU	294.1	29.76	1.35
West AHU	245.9	28.55	1.44
Lab AHU	208.7	34.84	1.25
ASHRAE Guide	185	-	1.60

Table 8 - Design Load Engineering Checks

Design Energy Usage Estimate

Trane TRACE 700 was also used to calculate a full year energy simulation of the Life Sciences Building. The energy model was created using the proposed equipment from the mechanical construction documents. Assumptions were made regarding the laboratory electrical loads as well as other miscellaneous loads throughout the building. These assumptions can be viewed in Technical Report Two. The cooling and heating equipment are supplied from a campus chilled water and high temperature hot water system. Electricity is also supplied from the same central utility plant that produces the high temperature hot water and chilled water.

The electrical consumers are the source that uses the most energy at 62.3% of the total Life Sciences Building's yearly energy consumption. Over one half of the building's yearly energy consumption use is due to the receptacle loads throughout the building, which incorporates the chemistry laboratories and nursing skill teaching laboratories, which were estimated at a high electrical equipment power density. The receptacle loads also include the office equipment and computer labs. The energy used for heating is at a measly 7.8% of the total building energy, which can be attributed to the use of high temperature hot water through heating coils in two of the three air handling units as well as a heat recovery run-around loop utilized in the 100% outdoor air unit. A summary of the Life Sciences Building's yearly energy consumption can be viewed in Figure 1.

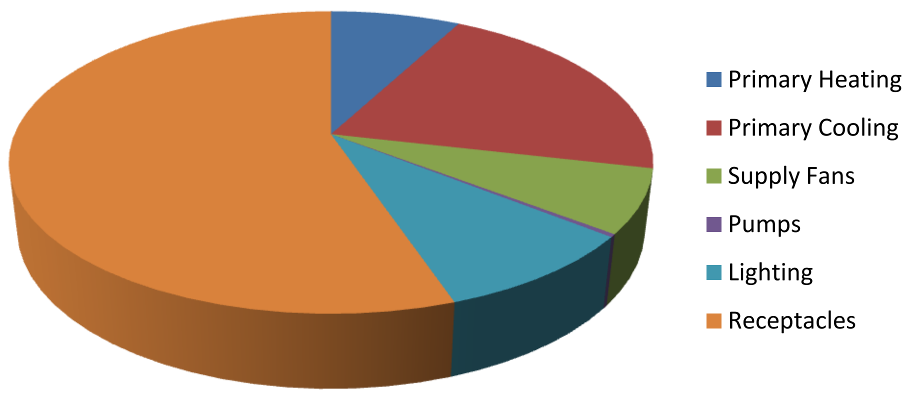

Figure 1 - System Energy Consumption

The consultant recorded results from their energy analysis of the Life Sciences Building in the units of MBtu per square foot per year, where one MBtu equals 1,000 Btu's for each of the purchased utilities; electricity, high temperature hot water and chilled water. The results are compared in Table 9. The yearly energy consumption determined by the designed energy analysis is 9.96 MMbtu per year and the yearly energy consumption according to the calculated energy analysis is 9.79 MMBtu per year. The designed energy consumption is 1% larger than the calculated energy consumption.

Analysis	Life Sciences Building Energy Usage (MBtu/ft^2-yr)			
	Electricity	Purchased Hot Water	Purchased Chilled Water	Total Building
Calculated Values	96.5	10.6	28.1	135.2
Designed Values	40.6	50.0[1]	46.0	136.6

Table 9 - Calculated and Design Energy Consumption

There are several justifications that can account for the differences between the calculated and designed energy usage values. The designed energy model was created using assembly heat transfer coefficients and solar heat gain coefficients from ASHRAE Standard 90.1-2004 rather than the actual coefficients provided by the architect. Furthermore, the designed energy analysis did not incorporate equipment and lighting schedules into the system. However, night setback temperatures and occupancy schedules were used. Also, the designed energy analysis used a lighting power density on a whole building spectrum, 1.2 Watts per square foot rather than on a space-by-space basis. A more detail comparison of the differences between the calculated and designed energy analyses can be found in Technical Report Two.

According to ASHRAE, a typical educational building uses 71.0 MBtu/ft^2-year of total energy. The calculated energy analysis concluded a total of 135.2 MBtu/ft^2-year, which is 190% larger than the typical ASHRAE educational building. The designed energy analysis found a total of 136.6 MBtu/ft^2-year, which is nearly twice the value for a typical educational building. The designed energy analysis is 1% larger than the calculated, which is a much closer margin than when compared to the typical ASHRAE educational building. The differences between the calculated and designed model and the ASHRAE educational building can be attributed to the Life Sciences Building being a laboratory facility. The requirements of fume hoods and high equipment loads cause the electrical consumption to be significantly larger than an educational building that consists of simply classrooms and lecture halls.

The similarity between the calculated and designed energy consumptions provide a reasonable idea as to the expected energy consumption of the Life Sciences Building. Furthermore, the large margin between the ASHRAE typical educational building and the projected energy consumptions provide opportunities for a redesign that reduces the building's overall energy consumption.

Mechanical Equipment Summary

The mechanical systems that serve the Life Sciences Building are segregated into two mechanical rooms. The basement mechanical room is the location of the service entrance for the high temperature hot water and the chilled water as well as eight pumps and three heat exchangers. The mechanical penthouse is the location of the three air handling units and the laboratory exhaust fans.

The series of pumps located in the basement mechanical room are those that serve the building's heating and cooling distribution. Chilled water pumps P-1 and P-2 serve as booster pumps to the central plant's chilled water campus system in the event that the loop loses pressure. Pumps P-6A, B are small inline pumps that circulate the high temperature hot water through the heating coils in air handlers AHU-1 and AHU-2. Due to the configuration of the penthouse, the glycol hot water pump is also an inline model. A summary of the Life Sciences Building's pumps can be found in Table 10.

Unit No.	System	Location	Capacity (GPM)	Head (ft)	Motor Size (HP)
P-1,2	Chilled Water Booster	Basement	600	50	15
P-3,4	Chilled Water Distribution	Basement	600	60	15
P-5	Glycol HW	Penthouse	90	30	1½
P-6A, B	AHU-1,2 Coil Pumps	Penthouse	55	20	¾
P-7,8	Radiation HW	Basement	115	65	5
P-9,10	Re-Heat HW	Basement	75	50	3
P-11	Heat Recovery	Penthouse	100	40	2

Table 10 - Pump Schedule

The campus high temperature hot water system from the central utility plant provides water at 270°F. However, Nassau Energy Corporation has stated that there is potential for temperature fluctuations in the system. Therefore, the heat exchangers have been designed with a 240°F entering water temperature on the shell side. The heat exchangers knock the temperature down to a usable 180°F for local re-heat, radiation and a glycol pre-heat system for one air handler. There is no booster pump for the campus high temperature hot water because of the assurance from Nassau Energy Corporation that there is sufficient pressure to circulate the high temperature hot water through the Life Sciences Building. All four heat exchangers are described in Table 11.

Unit No.	System	Location	Capacity (MBH)	Tube Side		Shell Side	
				EWT (°F)	LWT (°F)	EWT (°F)	LWT (°F)
HX-1	Glycol/HW	Penthouse	1,169	150	180	240	210
HX-2	Radiation/HW	Basement	1,124	160	180	240	210
HX-3	Re-Heat/HW	Basement	1,100	150	180	240	210
HX-4	Re-Heat/HW	Basement	1,100	150	180	240	210

Table 11 - Heat Exchanger Schedule

There are three air handling units that serve the Life Sciences Building. The air handling unit that serves that laboratory and chemical storage spaces is a 100% outdoor air unit. Air handling units AHU-1 and AHU-2, which serve the classroom spaces, receive high temperature hot water directly from the central utility plant modulated to 240°F. The one hundred percent outdoor air unit, AHU-3, uses a 40% propylene glycol solution for the main heating coil. AHU-3 also utilizes a heat recovery run-around loop to pre-heat the outdoor air with waste heat from the laboratory exhaust fans. All air handling units are connected to VAV boxes, which are configured with reheat coils. All supply and return fans are controlled with a variable speed drive to accommodate the changes in load requirements. Details on the air handling units and the laboratory exhaust fans can be found in Table 12.

Unit No.	Area Served	Total CFM	Min OA CFM	Supply Fan HP	Cooling Capacity (MBH)	Heating Capacity (MBH)	Return Fan HP
AHU-1	Classrooms - East	25,550	12,775	40	1,136	733	15
AHU-2	Classrooms - West	25,550	12,775	40	1,136	733	15
AHU-3	Laboratories	24,000	-	30	1,523	1,296	-

Table 12 - Air Handler Schedule

There are chemistry laboratories located on the second floor of the Life Sciences Building, which contain fume hoods that exhaust hazardous chemical vapors to the exterior. A series of three laboratory exhaust fans are located on the roof pull the dangerous fumes from the second floor up through the building. The three fans are used as a standby system with one fan producing most of the work. The laboratory fans are required to exhaust the air as a plume into the atmosphere, away from the building. Information on the laboratory exhaust fans is located in Table 13.

Unit No.	Location	Total CFM	Fan Power (HP)	Stack Height $(ft)^2$
E/F-9 A,B,C	Roof	24,050	20	52

Table 13 - Laboratory Exhaust Fan Schedule

Mechanical System Cost

The total cost for the mechanical system for the Life Sciences Building is $5,320,000. The price includes all mechanical equipment and distribution material and labor for both the hydronic and air systems. The equipment for the plumbing and fire protection systems are excluded. A breakdown of the mechanical systems in terms of equipment and distribution can be found in Table 14. Mechanical system testing and balancing as well as site utilities costs are not included in Table 14.

System	Cost ($)
Hydronic Equipment	262,000
Air Equipment	894,000
Terminal Equipment	689,000
Hydronic Distribution	1,500,000
Air Distribution	944,000
Controls	706,000

Table 14 - Mechanical Costs

The total of $5,320,000 broken down equates to $73.50 per square foot. As seen in Table 14, the hydronic distribution is the largest cost followed by the air distribution. The distributions systems include the large ducts that carry the significant amounts of air to the laboratories and big general classrooms. The air equipment is high due to the several fume hoods located in each chemistry laboratory and the sophisticated laboratory exhaust fans. Figure 2 provides a visual of the impact of each system towards to total cost.

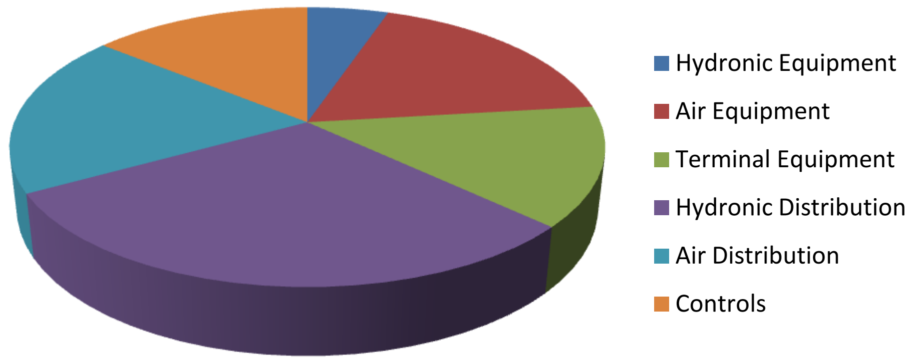

Figure 2 - Mechanical Equipment Cost

A computerized energy analysis was run in order to determine the Life Sciences Building's annual energy consumption. The rates in Table 1, Table 2 and Table 3 were used in the calculated energy analysis by created schedules for each of the utility costs. The utility costs were used in the energy analysis in order to develop the total monthly energy consumption for an entire year broken down by individual energy source. The monthly utility cost for a full year for the Life Sciences Building can be viewed in Figure 3.

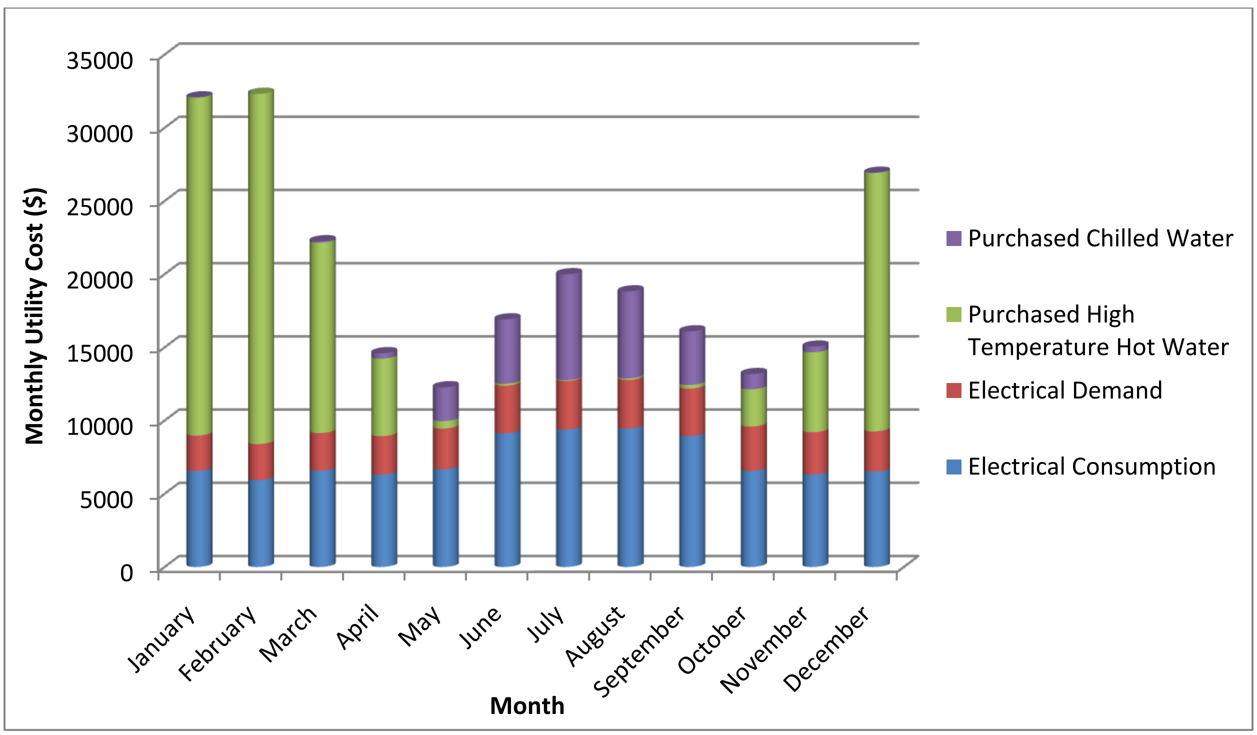

Figure 3 - Monthly Utility Cost

The total utility cost for an entire year was calculated to be $241,000 with the highest month being February with a cost of $32,327. Purchased high temperature hot water is the most expensive utility per unit and therefore is most costly. With a yearly cost of about $241,000, the utility cost per area equates to $3.33 per square foot.

Mechanical Space Requirements

Mechanical system equipment from air handling units to pumps and ductwork are essential to the operation of the mechanical system, but nevertheless they are space occupiers. Summarized in Table 15 are the areas that are taken up by the mechanical system. Included in the summary are the mechanical equipment rooms in the basement and penthouse and shaft spaces located on all floors. The total floor area occupied by the mechanical system is about 8.5% of the total building area.

Table 15 does not include spaces used for plumbing and electrical systems. There are several chases located throughout the Life Sciences Building the contain drain, waste, vent, laboratory gas and domestic hot and cold water systems. Furthermore, the electrical rooms located throughout the building, which contain the step-down transformers as well as the switchgear rooms for normal and emergency power spaces are not included. Also, the generator room is not included in the summary. The spaces should be included if a more accurate account of the area lost to the building systems.

Level	Area (ft^2)
Basement	1,140
First	170
Second	184
Third	209
Penthouse	4,427
Total	6,130

Table 15 - Mechanical Space Requirements

System Operations and Schematics

The Life Sciences Building was specified with a detailed sequence of operations due to the complexity of the air and water systems. The laboratory exhaust fan system needs to be properly interlocked with the one hundred percent outdoor air laboratory unit in order to assure proper building pressurization and adequate ventilation air. Furthermore, the high temperature hot water and chilled water that are supplied to the Life Sciences Building needs to be under constant monitoring in order to assure adequate pressure to properly condition the building.

Air-side Operations

Air Handling Units 1 and 2

Air handling units AHU-1 and AHU-2 are controlled identically since they serve similar spaces in the Life Sciences Building. AHU-1 and AHU-2 are both variable air volume systems, which serve terminal units with reheat coils throughout the building. The supply and return fans are equipped with variable speed drives to accommodate the change in system volume. The initial start sequence begins with the opening of the return air damper and activating the return fan. The energizing of the supply fan occurs after the opening if the supply air damper. Both air handling units are equipped with economizer settings, which are dependent on the outdoor air dry bulb temperature. The outdoor air, return air and relief air dampers are each controlled individually but are interlocked in order to provide adequate economizer control. The outdoor air dampers are to be at their minimum setting when the outdoor air temperature is above 55°F. Refer to Figure 4 for a schematic of air handling units AHU-1 and AHU-2

Air Handling Unit 3

Air handling unit AHU-3 is one hundred percent outdoor air, variable air volume system with a heat recovery run-around loop. The supply fan is equipped with a variable speed drive, but the laboratory exhaust fans do not modulate. The start sequence is similar to air handling units AHU-1 and AHU-2. The sequence begins with the confirmation of the operation of the laboratory exhaust fans. After the outside air damper is open, the supply fan is energized. The heat recovery run-around system contains a 30% glycol solution as the fluid that circulates between the laboratory exhaust fans and the pre-heat coil in AHU-3. The pump for the heat recovery system is to operate continuously when the outdoor air temperature is below 55°F or 80°F, which allows for the pre-heating or pre-cooling of the outdoor air. Figure 5 is a schematic of AHU-3.

Laboratory Exhaust System

The laboratory exhaust fan system consists of three exhaust fans connected to a common plenum. A series of make-up air dampers are connected to the intake plenum to ensure proper volume to allow for the required discharge velocity at 4,000 feet per minute. The three exhaust fans provide a degree of redundancy in the laboratory exhaust system. Figure 5 is a schematic of the laboratory exhaust system incorporated with air handling unit AHU-3.

Variable Air Volume Terminal Units

The variable air volume (VAV) terminal units are controlled by the local space temperature sensor to adjust the terminal unit supply air damper along with the reheat coil. The VAV terminal unit supply air damper, reheat coil control valve and local radiation control valve are all interlocked in order to maintain space temperature. The terminal units will modulate to its minimum airflow position before the opening of the radiation control valve during the winter mode. The reheat coil will be used for supplementary heat if necessary. During the summer mode, the reheat coil is used to adjust the supply air temperature if the supply air damper is inadequate. The radiation control valve will be closed. The winter and summer operating modes are determined by the outdoor air temperature. When the outdoor air temperature is above 50°F, the system will operate in the summer mode. If the outdoor temperature is below 50°F and the system is calling for heat, the system will operate in the winter mode.

Water-side Operations

Hot Water System

The hot water system for the Life Sciences Building consists of four shell and tube heat exchangers that convert campus high temperature hot water to hot water used throughout the building. The heat exchangers convert the 270°F water to 180°F water, which is used for re-heat coils, perimeter radiation and to heat a 30% glycol solution for the 100% outdoor air unit. As mentioned in the mechanical equipment section, the heat exchangers have been sized for an entering high temperature hot water temperature of 240°F due to fluctuations that may occur in the high temperature hot water system. The 270°F water is also directly piped to the two classroom air handling unit pre-heat coils. The high temperature hot water system pressure is sufficient enough to distribute the water throughout the building without the need of booster pumps. The entering and leaving pressures are measured at the service entrance as well as a energy metering station in order to determine the energy consumption of the Life Sciences Building.

On the discharge of the heating hot water heat exchangers is 180°F hot water. Both heating hot water heat exchangers are controlled by control valves that modulate in order to maintain a hot water supply temperature of 180°F. The standby heat exchanger for the re-heat coils will be changed over by manual isolation values. The re-heat coils and perimeter radiation systems each have a lead/lag series of pumps with variable speed drives for distribution. The lead pump will run continuously. If the lead pump cannot maintain the minimum pressure differential sensed by pressure differential sensors throughout the system, the lag pump will start. The lag pump will turn off when the lead pump can deliver reduced flow. The lag pump will also start in the event of a failure of the lead pump. Both the lead and lag pumps will alternate based on accumulated run time determined by the building operator.

On the discharge side glycol system heat exchanger is an inline pump to circulate the solution through the pre-heat coil for the one hundred percent outdoor air unit, AHU-3. The glycol heat exchanger is control with a control valve that modulates to maintain at 180°F glycol solution supply temperature. The glycol pump will run continuously when the outdoor air dry bulb temperature is below 60°F.

Figure 6 below provides an illustration of the hot water system in the Life Sciences Building.

Chilled Water System

The chilled water system for the Life Sciences Building consists of four pumps. Two pumps serve as a lead/lag set of booster pumps to the campus system in the event of a loss in system pressure. The second set of pumps are configured as a lead/lag system for chilled water distribution. The chilled water from the central utility plant is distributed at a constant 42°F in a constant flow system. However, the central utility plant has stated that there may not be sufficient pressure to accommodate the peak cooling load requirements. Furthermore, to accommodate fluctuations in chilled water supply temperature, the cooling coils in the building have been sized at an entering water temperature of 44°F. Therefore, the piping arrangement in the Life Sciences Building is organized such that the booster pumps are bypassed unless there is a decrease in the campus system pressure. In the event of a drop in system pressure, the booster lead pump will energize.

The Life Sciences Building's chilled water distribution pumps are variable speed pumps in a lead/lag configuration. The lead pump is to provide flow to maintain a preset pressure differential in the distribution system in order to provide adequate flow through each cooling coil. In the event that the lead pump cannot provide sufficient flow to satisfy the pressure differential, the lag pump will start. Furthermore, in the event of a failure of the lead pump, the lag pump will start.

Figure 7 below provides an illustration of the chilled water system in the Life Sciences Building.

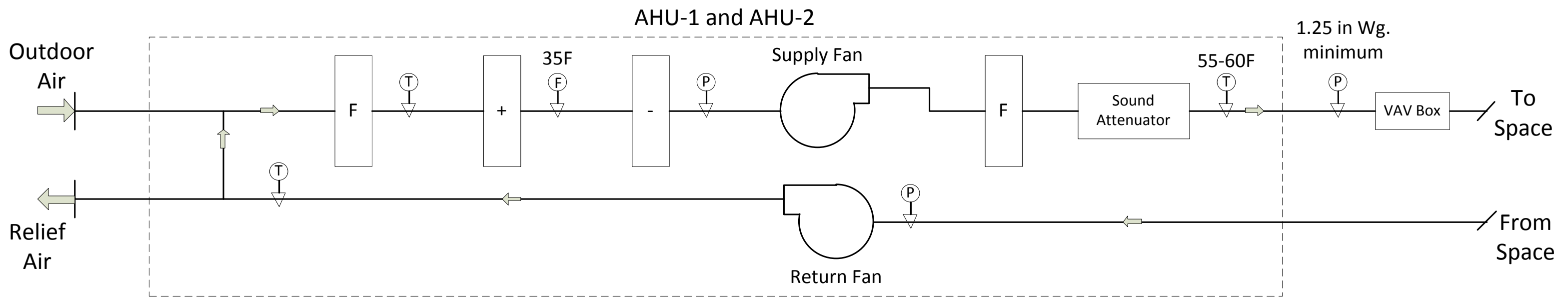

Figure 4 - AHU-1 and AHU-2 Schematic

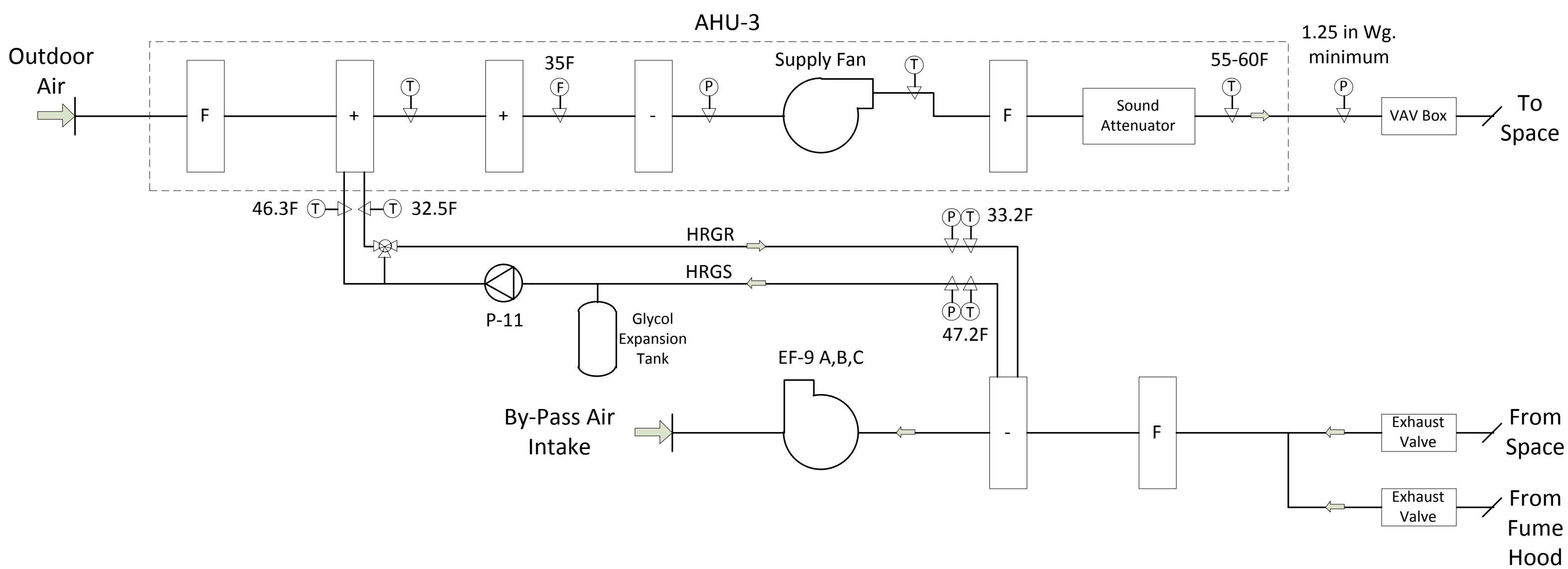

Figure 5 - AHU-3 Schematic

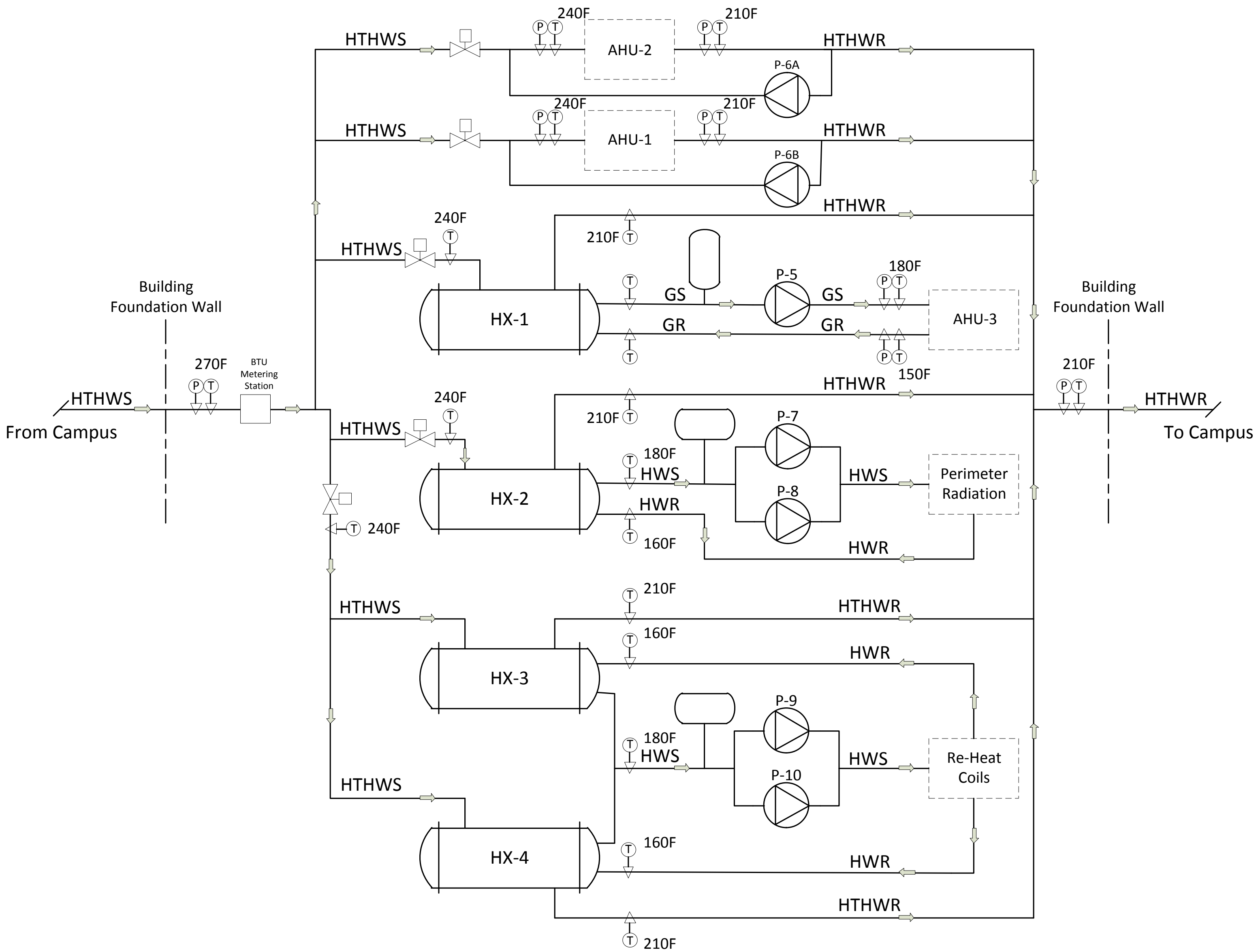

Figure 6 - Hot Water Schematic

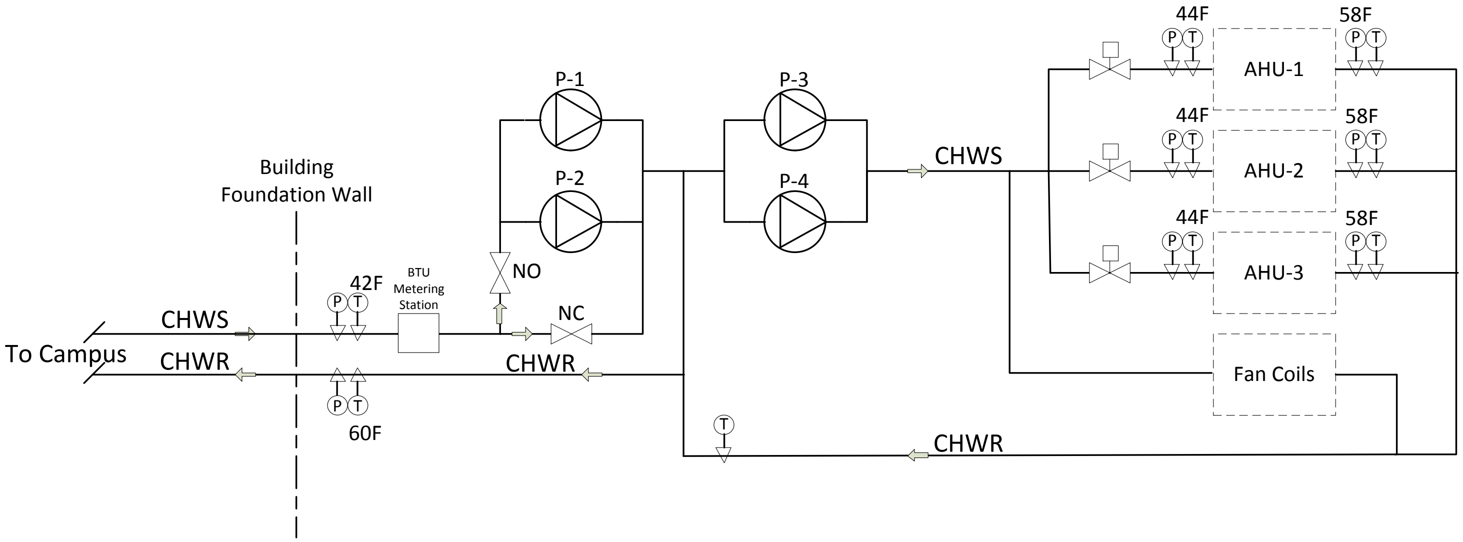

Figure 7 - Chilled Water Schematic

LEED Analysis

The United States Green Building Council (USGBC) has created the Leadership in Energy and Environmental Design (LEED) certification system in order to implement more energy efficient designs in the building industry. Two of the LEED criteria directly affect the mechanical design – Energy and Atmosphere and Indoor Environmental Quality.

The Life Sciences Building has submitted a checklist to the USGBC totaling 50 potential points, which would achieve a LEED Gold rating. Nassau Community College is striving for a LEED Gold rating for the new Life Sciences Building.

Furthermore, LIPA provides a credit for LEED certification and a credit for every LEED point related to the mechanical system, either Energy and Atmosphere or Indoor Environmental Quality, up to $25,000. This provides a further incentive for achieving LEED certification. A summary of all the projected credits pertaining to the mechanical systems to be earned by the Life Sciences Building are summarized in this section.

Energy and Atmosphere

In the Energy and Atmosphere category, there are three prerequisites that are required in order to be considered for any points within the category. The Life Science Building meets the prerequisites and is estimated to receive 5 points.

Prerequisite 1: Fundamental Commissioning of the Building Energy Systems

This prerequisite is required in order to verify that the Life Sciences Building's energy-related systems are installed and calibrated properly to perform according to the design and construction documents. A commissioning company has been brought onboard the design and construction team in order to provide the assurance that the designed system will operated as designed. Furthermore, the commissioning company has been contracted to provide enhanced commissioning in accordance with one credit within this category.

Prerequisite 2: Minimum Energy Performance

The purpose of this prerequisite is to establish a minimum level of energy efficiency for the Life Sciences Building. A consultant was contracted to provide a baseline energy simulation of the Life Sciences Building in order to meet the requirements of this prerequisite. The Life Sciences Building is designed to perform above the 10% improvement in the designed performance rating.

Prerequisite 3: Fundamental Refrigerant Management

The purpose of Prerequisite 3 is to reduce the stratospheric ozone depletion caused by the refrigerants used in the HVAC industry. There is no designed use of chlorofluorocarbon-based refrigerants in the Life Sciences Building, which complies with the requirements of the prerequisite.

Credit 1: Optimize Energy Performance – 2 Points

The purpose of Credit 1 is to achieve higher levels of energy performance beyond the minimum requirements of Prerequisite 2. The design engineers chose the Option 1 compliance path for the whole building energy simulation. It was determined that the Life Sciences Building will perform 14% above the baseline building performance rating determined by the outside consultant. The baseline energy consumption for the Life Sciences Building was determined to be 9.96 MMbtu per year.

Credit 2: On-Site Renewable Energy – 1 Point[3]

Credit 2 is designed to provide a reward to the engineers who make use of new technology and utilize on-site renewable energy to offset the environmental impact of fossil fuel combustion. Even though the Life Science Building does not have any onsite combustion, the high temperature hot water and chilled water it receives from the campus are produced by a fossil fuel-burning power plant. However, Nassau Community College is investigating as to the cost and benefits of installing solar photovoltaic cells on the Life Sciences Building. This 1 point is not a certainty, rather a potential point depending on NCC.

Credit 3: Enhanced Commissioning – 1 Point

The purpose of Credit 3 is to incorporate the commissioning process early in the design. Nassau Community College has contracted a commissioning company to comply with Prerequisite 1 and has extended the contract to include the enhancement called for in Credit 3.

Credit 4: Enhanced Refrigeration Management – 1 Point

The purpose of Credit 4 is to reduce the ozone depletion further than Prerequisite 3 by complying with the Montreal Protocol. The Life Sciences Building complies with option 1 of the requirements by not using refrigerants in the mechanical system.

Credit 6: Green Power – 1 Point

Credit 6 encourages the building owner and the design team to explore the use of grid-source, renewable energy. LIPA provides voluntary programs that allow customers to purchase green power from two individual marketers, Community Energy and Sterling Planet. Nassau Community College is investigating the potential for green power for the Life Sciences Building to receive the point for Credit 6.

Indoor Environmental Quality

The Indoor Environmental Quality category contains two mandatory prerequisites that must be met in order to receive points in this category. The Life Sciences building complies with the prerequisites and is estimating to total of 13 points.

Prerequisite 1: Minimum IAQ Performance

The purpose of Prerequisite 1 is to establish a minimum indoor air quality performance, which provides a comfortable environment and contributes to the well-being of the occupants. Prerequisite 1 requires the building to comply with Section 4 through 7 of ASHRAE Standard 62.1-2007. The Life Sciences Building is mechanically ventilated. However, the Life Sciences Building complies with both ASHRAE Standard 62.1-2007 and the New York State Mechanical Code of 2007 and therefore complies with the requirements of this prerequisite.

Prerequisite 2: Environmental Tobacco Smoke (ETS)

The purpose of Prerequisite 2 is to prevent the exposure of the building occupants, indoor surfaces and ventilation system to environmental tobacco smoke (ETS). There are two options to comply with this prerequisite – either prohibit smoking in the building or prohibit smoking except in designated smoking areas. The Life Sciences Building prohibits smoking inside the building and within 25 feet of entries, outdoor air intakes and operable windows, which complies with the requirements of this prerequisite.

Credit 1: Outdoor Air Delivery Monitoring – 1 Point

Credit 1 is designed to assure the proper ventilation is being provided for occupant comfort and well being. The Life Sciences Building has specified monitors to guarantee the minimum amount of ventilation is supplied and has tied the monitors into the building automation system for air handling units AHU-1 and AHU-2. Air handling unit AHU-3 is a one hundred percent outdoor air unit and therefore does not require monitoring for minimum ventilation.

Credit 2: Increased Ventilation – 1 Point[4]

Credit 2 is intended to improve indoor air quality and promote occupant comfort through the additional supply of outdoor air above the minimum requirements. The Life Science building provides one hundred percent outdoor air through air handling unit AHU-3 to the laboratories and 50% outdoor air to the remaining areas of the building. The excess amount of outdoor ventilation air is attributed to the nature of the variable air volume boxes ability to turn down but still provide adequate ventilation air during full occupancy. However, Credit 2 requires ventilation rates to be increased by 30% above the minimum rates provided by ASHRAE Standard 62.1-2007 for mechanically ventilated spaces. Due to the 30% increase above the minimum ventilation rate requirement for Credit 2, the one point is a potential point rather than a certainty.

The excess ventilation air that has been designed into the Life Sciences Building is due to the functionality of the variable air volume boxes, not to achieve a point for Credit 2. The point will be awarded if the excess air coincidently above the 30% increase above the minimum rates.

Credit 3.1: Construction IAQ Management Plan, During Construction – 1 Point

The purpose of Credit 3.1 is to reduce indoor air quality problems due to construction or renovation. The Life Sciences Building has been included in the specifications of its air handling units to comply with Credit 3.1 during construction. Furthermore, the ductwork has been specified to comply with the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) guidelines in order to meet the requirements of Credit 3.1.

Credit 3.2: Construction IAQ Management Plan, Before Occupancy – 1 Point

The purpose of Credit 3.2 is to reduce indoor air quality problems due to construction or renovation. Credit 3.2 is similar to Credit 3.1. However, Credit 3.2 aims at purging the building from harmful substances that may have accrued during construction. Two approached can be taken to satisfy the requirements of this credit. One option is to perform a building flush-out after all finishes have been installed and before occupancy. The second option is to test the air using protocols from the EPA Compendium of Methods for the Determination of Air Pollutants in Indoor air.

The Life Sciences Building is specified to conduct a two-week building air flush-out after the commencement of construction and prior to the building occupation. There will be an indoor air quality test that complies with the EPA protocol provided by Nassau Community College. This procedure complies with the first option for compliance with Credit 3.2. The Life Sciences Building will receive one point.

Credit 4.1: Low-Emitting Materials, Adhesives & Sealants – 1 Point

The purpose of Credit 4.1 is to reduce the quantity of indoor air contaminants that are odorous, irritating and potentially harmful to the occupants due to interior adhesives and sealants. The adhesives and sealants used on the interior of the building are to comply with the requirements according to the South Coast Air Quality Management District (SCAQMD) Rule #1168. Rule #1168 limits volatile organic compounds (VOC's) that are used as adhesives and sealants inside a building. Table 16 summarizes the VOC limitations as specified for the Life Sciences Building, which meets the requirements of Credit 4.1 and will receive one point.

Adhesive/Sealant	VOC Limit (g/L)
Wood Glues	30
Metal to Metal Adhesives	30
Adhesives for Porous Materials (Except Wood)	50
Subfloor Adhesives	50
Plastic Foam Adhesives	50
Carpet Adhesives	50
Cove Base Adhesives	50
Gypsum Board and Panel Adhesives	50
Ceramic Tile Adhesives	65
Multipurpose Construction Adhesives	70
Structural Glazing Adhesives	100
Contact Adhesive	250
Plastic Cement Welding Compounds	350
ABS Welding Compounds	400
CPVC Welding Compounds	490
PVC Welding Compounds	510
Adhesive Primer for Plastic	650
Sealants	250
Sealant Primers for Nonporous Substrates	250
Sealant Primers for Porous Substrates	775

Table 16 - VOC Limitations for Adhesives and Sealants

Credit 4.2: Low-Emitting Materials, Paints & Coatings – 1 Point

The purpose of Credit 4.2 is to reduce the quantity of indoor air contaminants that are odorous, irritating and potentially harmful to the occupants due to interior paints and coatings. Architectural paints and coatings used on the interior are not to exceed VOC content limits according to Green Seal Standard GS-11, Paints. Anti-Corrosive and anti-rust paints applied to ferrous materials are not to exceed a VOC limit of 250 g/L established in Green Steal Standard GC-03, Anti-Corrosive Paints. Clear finishes such as coatings, stains, primers and shellacs used on interior elements are not to exceed VOC limits according to the South Coast Air Quality Management District (SCAQMD) Rule #1113.

The Life Sciences Building has specified acceptable VOC limits for paintings and coatings that can be used on interior surfaces that comply with the requirements of Credit 4.2. Therefore, one point is achieved through Credit 4.2

Paint/Coating	VOC Limit (g/L)
Flat Paints and Coatings	50
Non-Flat Paints and Coatings	150
Anti-Corrosive Coatings	250
Varnishes and Sanding Sealers	350
Stains	250
Aromatic Compounds	<1% by weight, total aromatic compounds

Table 17 - VOC Limitations for Paints and Coatings

Credit 4.3: Low-Emitting Materials, Carpet Systems – 1 Point

The purpose of Credit 4.3 is to reduce the quantity of indoor air contaminants that are odorous, irritating and potentially harmful to the occupants due to flooring systems. There are two options that allow for the compliance of Credit 4.3. The first option provides a list of codes that different flooring materials must meet if they are applicable to the project scope. The second option requires compliance of the California Department of Health Services Standard for Testing of Volatile Organic Emissions from Various Sources using Small-Scale Environmental Chambers including 2004 Addenda. The Life Sciences Building's carpets have been specified to comply with the Carpet and Rug Institute Green Label Plus program. The carpets have also been specified to use adhesives that comply with Credit 4.1. One point will be awarded for Credit 4.3

Credit 4.4: Low-Emitting Materials, Composite Systems – 1 Point[5]

The purpose of Credit 4.4 is to reduce the quantity of indoor air contaminants that are odorous, irritating and potentially harmful to the occupants due to composite wood systems. Credit 4.4 requires that the composite wood and agrifiber products used on the interior of the building must not contain urea-formaldehyde resins. The Life Sciences Building has specified the medium density fiberboard used in the building to contain no urea-formaldehyde. However, on the LEED Checklist, the point associated with Credit 4.4 is not a guarantee.

Credit 5: Indoor Chemical & Pollutant Source Control – 1 Point

Credit 5 is designed to limit occupant exposure to potentially hazardous particulates and chemical pollutants. Credit 5 requires disconnects between the interior spaces and the exterior at major entryways via vestibules at least 10 feet long in the direction of travel. There also must be sufficient exhaust is spaces that contain hazardous gases or chemicals as well as provided a MERV 13 filter or higher in the ventilation system.

The Life Sciences Building complies with Credit 5 by provided vestibules at the major building entrances with the required dimensions and grates in order to capture dirt and particulates that may enter the building. Furthermore, fume hoods provide a safe environment for the handling of hazardous chemicals in the laboratory setting and provide negatively pressurized storage spaces for the chemicals in the basement. The filtration system will contain at least a MERV 13 filter to process both the return and outdoor air streams. One point will be received for Credit 5.

Credit 6.1: Controllability of Systems, Lighting – 1 Point

The purpose of Credit 6.1 is to provide a lighting system control that promotes productivity and comfort for the occupants. The lighting system is required by Credit 6.1 to provide individual controls for 90% of the building occupants that can accommodate adjustments to suit individual task needs. A lighting system for shared spaces is required to meet the group needs.

The Life Sciences Building provides a lighting control system for the different spaces in the building. The classrooms have the dimming capability for enhanced teaching. The offices contain individual lighting controls per spaces in order to accommodate individual preferences. One point will be received for Credit 6.1.

Credit 6.2: Thermal Comfort – 1 Point

Credit 6.2 aims at providing the occupants with a higher level of thermal comfort control by providing controls on an individual basis or by multi-occupant space basis to promote productivity and comfort. To receive a point for Credit 6.2, at least 50% of the occupants must have individual comfort controls to allow for adjustments for individual preferences. Multi-occupant spaces are required to have controls to allow adjustments as the group prefers.

The Life Sciences Building has been designed with thermostats in each laboratory and classroom to provide group settings to each space. Offices are combined into small groups in order to tie together spaces with similar load profiles as well as to allow at least 50% of individual occupants to control the thermal comfort settings as required by Credit 6.2. One point will be awarded for Credit 6.2.

Credit 7.1: Thermal Comfort, Design – 1 Point

Credit 7.1 is designed to provide a comfortable indoor thermal environment for the occupants. Credit 7.1 requires the designed HVAC system and the building envelope to comply with ASHRAE Standard 55-2004. The Life Sciences Building has been designed according to requirements set forth by ASHRAE Standard 55-2004 and will receive one point.

Credit 7.2: Thermal Comfort Verification – 1 Point

The purpose of Credit 7.2 is to provide an assessment of the building occupant thermal comfort over time. Credit 7.2 provides a possible extra one point on top of Credit 7.1 if a permanent monitoring system is incorporated into the design to ensure that the building performance maintains the comfort criteria specified in ASHRAE Standard 55-2004. The Life Sciences Building will conduct a survey within 6 to 18 months after occupancy as mandated by Credit 7.2. The survey will determine if more than 20% of the occupants are dissatisfied. In the event that more than 20% of the occupants are dissatisfied, corrective measures will been taken in order to correct the thermal comfort issues. One point will be awarded for Credit 7.2.

Credit 8.1: Daylight & Views, Daylight 75% of Spaces – 1 Point

Credit 8.1 is designed to connect the indoor and outdoor spaces through the use of daylighting and views in the spaces that are regularly occupied. The requirement of Credit 8.1 is that at least 75% of the regularly occupied spaces in the building are to achieve a minimum level of 25 footcandles (fc) and a maximum of 500 fc in a clear sky condition. Those spaces with illuminance levels outside the range do not meet the requirements of Credit 8.1.

There are a few different methods using either geometry or computer modeling programs that help the designers determine if Credit 8.1 is achievable. The designers of the Life Sciences Building have not provided information as to their analysis and time has not permitted a new analysis. However, the designers have assured that Credit 8.1 will be achieved.

Credit 8.2: Daylight & Views, Views for 90% of Spaces – 1 Pont

Credit 8.2 is similar in purpose to Credit 8.1 but the requirements have changed. Credit 8.2 requires that 90% of the regularly occupied spaces in the building are to achieve a minimum level of 25 fc and a maximum of 500 fc in a clear sky condition. The Life Sciences Building designers have not provided an analysis of Credit 8.2 and time has not permitted a new analysis. However, the designers have assured that Credit 8.2 will be achieved.

Mechanical System Evaluation

The Life Sciences Building resides on the campus of Nassau Community College. Typically educational buildings are mechanically designed as a variable air volume (VAV) system due to the fluctuations in occupancy and scheduling capabilities with offices and classrooms. A VAV configuration usually saves energy through the throttling of fans and control valves. However, the Life Sciences Building is also a laboratory facility that requires a dedicated exhaust system coupled with the large airflow requirements of the fume hoods. There is also a higher air change rate in chemistry laboratories due to the need of ventilation to dilute hazardous chemicals that may be present in the breathing zone. While a VAV design may be typical for an educational building, the energy savings is not as available in a laboratory building as it would be in an office and classroom only facility.

The Life Sciences Building's mechanical system has been estimated to cost a total of $5,320,000, which is approximately 17% of the total building cost. Typically, the mechanical system cost ranges from 15% to 20% of the total estimated budget. Therefore, the mechanical system serving this building falls within the typical range at $73.50 per square foot. However, while the mechanical system first cost is average, the annual energy cost is high. The total utility cost, including electricity, high temperature hot water and chilled water, is calculated to be $241,000. The total cost equates to $3.33 per square foot, which is above the average range from $2 to $3 per square foot. The above average energy cost can be due to the one hundred percent outdoor air handling unit used for the laboratories. Even with heat recovery, there are large quantities flowing through the unit, which require both heating and cooling conditioning. Furthermore, the high annual energy cost can be attributed to inaccurate utility costs determined during the computerized analysis.

The large equipment components of the mechanical system are located either in the basement mechanical equipment room or the penthouse on the roof. The basement mechanical room contains the majority of the water-side equipment such as the heat exchangers and pumps along with the campus high temperature hot water and chilled water service entrances. The penthouse contains the three air handling units as well as the laboratory exhaust fans. While a small 8.5% of the Life Sciences Building floor area occupied by the mechanical system, there is also space in the ceiling plenum that is displaced by mechanical equipment such as ductwork, variable air volume boxes and exhaust valves. The first and third floors of the building utilize a plenum return system, which decreases the need for ducted returns throughout the floor. However, the second floor has a dedicated ducted exhaust to both the fume hoods as well as the chemistry laboratories in order to prevent contamination of other spaces. The laboratories also require large quantities of supply air, which need large ducts to bring air to the spaces. Both of the supply and exhaust systems utilize a large majority of the ceiling plenum. There may be a potential ceiling height decrease as well as energy savings if a decentralized system is used for the laboratory spaces.

The laboratory floor of the Life Sciences Building is served by the one hundred percent outdoor air unit. While the system may use more energy, the abundant amounts of ventilation air provide for a higher indoor air quality. No recirculation of the air from the laboratories assures the hazardous contaminants from the laboratories will not be spread from zone to zone. The offices and classrooms are served by a variable air volume air handling system, which have a higher filter MERV rating than the code minimum due to LEED certification requirements. Furthermore, higher amounts of outdoor air are introduced into the ventilation system due to the nature of the variable air volume system. While the higher amounts of outdoor air cause higher heating and cooling costs, the increased ventilation allows for a higher indoor air quality.

Zones for the Life Sciences Building are organized based on small groups of spaces which contain similar load profiles. It is typical to have three or four offices on the same façade to be grouped into one zone. On the other hand, classrooms are each their own zone. Each zone is provided with an adjustable environmental control. The perimeter radiation and the VAV boxes are coupled and controlled by one device in order to provide the proper environmental settings as preferred by the occupants. There are sufficient controls throughout the building in order to satisfy the requirements for LEED certification.

The VAV design of the Life Sciences Building is adequate for providing conditioned air and ventilation to each space. However, a decentralized system may provide higher energy savings to the overall mechanical system as well as reduce the mechanical space requirements in the ceiling plenums. A decentralized system may be advantageous based on the availability of water to transfer more energy in a smaller area than air. Furthermore, for the one hundred percent outdoor air system, there appears to be a higher energy saving potential with a advanced engineered heat recovery system between the laboratory exhaust and outdoor air streams. There are areas of the designed mechanical system that may benefit from a redesign. Future reports will address redesign ideas.

References

ASHRAE. Handbook of Fundamentals. Atlanta: ASHRAE, 2009.

Cannon Design. "Architectural Construction Documents." New York, NY: Cannon Design.

—. "Electrical Construction Documents." New York, NY: Cannon Design.

—. "Mechanical Construction Documents." New York, NY: Cannon Design.

GE. MS6001B Gas Turbine. 2010. 24 October 2010 <http://www.gepower.com/prod_serv/products/gas_turbines_cc/en/midrange/ms6001b.htm>.

Kulkarni, N. Nina and A. Baseline Energy Usage for Nassau Community College Life Sciences Building. Rep. Boston: WSP Flack + Kurtz, 2010.

Long Island Power Authority. 2010 LIPA Incentive Schedule for Commercial Efficiency Custom and Whole Building Design Projects. 2010.

New York Department of State. Mechanical Code of New York State. Albany, 2007.

Parsons Brinckerhoff. Current Status of the Nassau Central Utility Plant Scheme. New York, NY: Parsons Brinckerhoff, 2009.

U.S. Energy Information Administration. "Table E2A. Major Fuel Consumption (Btu) Intensities by End Use for All Buildings, 2003." 2003. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. 24 October 2010 <http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/e02a.pdf>.

U.S. Green Building Council. LEED 2009 For New Construction and Major Renovations. Washington D.C., 2008.

---

[1] The designed energy and load analysis used purchased campus steam as the heating utility.
[2] The stack height for the laboratory exhaust fan is with a wind at 10 mph.
[3] The point for on-site renewable energy is not a guaranteed point according to the mechanical engineer. Nassau Community College is responsible for investigating the feasibility of solar photovoltaic panels.
[4] The point for increased ventilation is not a guaranteed point
[5] The point for low-emitting materials, composite systems is not a guarantee