Technical Report Three

Mechanical Systems Existing Conditions Evaluation

APPELL LIFE SCIENCES

York College of Pennsylvania

York, PA

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Mechanical Option

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Executive Summary

The Appell Life Sciences Building consists of two separate buildings. The life sciences building houses laboratories, general classrooms, computer labs, and offices. The greenhouse building houses laboratories and five greenhouses. Because of the number of laboratories and offices there is a lot of equipment in this building.

The primary system for the life sciences building is a Variable Air Volume (VAV) system for the offices and Fan Coil Units (FCU) for the laboratories and classrooms. The main system for the greenhouse building is also FCU. Each system is supplied with chilled water by a water-cooled centrifugal chiller and supplied with hot water by three gas-fired boilers. The system is controlled by ATC Panels located on the equipment itself or at a remote workstation.

The energy sources that are being used for the system include Natural Gas for the boilers and Electricity for the chillers and other equipment. The initial cost of this equipment will be provided from the bid cost for mechanical systems. Since this was a renovation there were costs for temporary systems included in the cost. The bid cost for mechanical systems for the life sciences building was $5,020,720.

When considering the LEED Rating System for the life sciences building, was not designed to be a certified LEED building. It was instead designed by the design engineer, directed by the college, to have efficient mechanical systems with low first cost, maintenance cost, and maintenance. It was also designed to have a long life and be able to be modified over time if needed. However after running a LEED-NC Evaluation the life sciences building could have received a total of 7 points from the sections evaluated. At this rate the building most likely would not achieve LEED status, but again the college does not strive for this, only for smart design.

The systems were found to condition the building adequately. All thermal and ventilation requirements are met with the systems in place.

System Description

Design Objectives and Requirements

The purpose of any HVAC system is to properly ventilate the building for the specified occupancy while maintaining a comfortable temperature and humidity level for the buildings occupants. The life sciences building has a large amount of laboratories that require appropriate ventilation and exhaust. The design of the systems for the laboratories allowed for proper ventilation and exhaust with having heat recovery wheels in the air handling units that service the laboratories. These are required because of the high exhaust rates that laboratories have. The rest of the requirements for the systems were met by the design engineer. The systems were also designed with the budget of the college in mind.

Equipment Summary

The primary systems for the life sciences building include VAV for offices, FCU's for laboratories and classrooms, and Wall Hung Radiation Units and Evaporative Coolers, heating and cooling respectively, for the Greenhouses. These systems are supplied with chilled water by a water-cooled centrifugal chiller, seen in Table 1. There are two cooling towers on the roof that supply water to the chiller, seen in Table 2. They are supplied with hot water by three gas-fired boilers, seen in Table 3. The chiller and boilers are located in the central plant in the basement of the life sciences building. Along with the chiller and boiler there is a plate and frame heat exchanger used as a water-side economizer, seen in Table 4. Also located in the central plant are the chilled water and hot water pumps, seen in Table 5. They are run on a primary secondary loop. The secondary pumps, seen in Table 6, for the greenhouse building are located in the basement mechanical room of that building because of limited space.

Air Handling Units provide air to the VAV boxes and FCU's for the spaces in the life sciences building. There are five AHU's total for servicing the different spaces included in the life sciences building, seen in Table 7. The main air supply for the greenhouse building labs is from FCU's, seen in Table 8, with OA brought in from directly outside. For the greenhouses heating is done by Wall Hung Radiation Units, seen in Table 9. Cooling for the greenhouses is done by a combination of natural ventilation and Evaporative Coolers, seen in Table 10.

Table 1: Chiller

Chiller				
Symbol	Capacity	kW/ton	Evaporator	Condenser
			EWT/LWT	EWT/LWT
CH-1	400	0.57	53.99/44	85/94.19

Table 2: Cooling Towers

Cooling Towers				
Symbol	Capacity (GPM)	EWT/LWT (^{o}F)	Airflow (CFM)	Fan HP
CT-1	700	95/85	62,790	10
CT-2	700	95/85	62,790	10

Table 3: Boilers

Boilers			
Symbol	Output MBH	GPM	Thermal Efficiency
B-1	2640	250	88%
B-2	2640	250	88%
B-3	2640	250	88%

Table 4: Heat Exchanger

Heat Exchanger				
Symbol	Hot Side		Cold Side	
	GPM	EWT/LWT (F)	GPM	EWT/LWT (F)
HX-1	200	57/45	700	43/46

Table 5: Life Sciences Building Pumps

Pumps					
Symbol	GPM	Impellar Size	Water Temp	Motor HP	Note
CHWP-1	960	7.75	45	15	Primary
CHWP-2	900	11.25	45	40	Secondary
CHWP-3	900	11.25	45	40	Secondary
CDWP-1	1200	10.5	85	15	Condenser Water
CTWP-1	700	11.625	95	40	Cooling Tower
CTWP-2	700	11.625	95	40	Cooling Tower
HWP-1	250	5.625	180	2	Boiler Circulator
HWP-2	250	5.625	180	2	Boiler Circulator
HWP-3	250	5.625	180	2	Boiler Circulator
HWP-4	1000	8.875	180	10	Primary
HWP-5	1000	8.875	180	10	Primary
HWP-6	400	11.5	180	20	Secondary
HWP-7	400	11.5	180	20	Secondary

Table 6: Greenhouse Building Pumps

Pumps					
Symbol	GPM	Impellar Size	Water Temp	Motor HP	Note
CHWP-4	60	6.75	45	2	Secondary
HWP-8	85	6.75	180	3	Secondary
HWP-9	85	6.75	180	3	Secondary

Table 7: Air Handling Units

Air Handling Units							
Symbol	Supply CFM	Min. O.A. CFM	Cooling Coil Capacity		Heating Coil Capacity MBH	Supply Fan HP	Exhaust Fan HP
			Total MBH	Sensible MBH			
AHU-1	4200	1300	215.3	133.3	112.2	7.5	2
AHU-2	6900	6900	380	218	256.6	15	7.5
AHU-3	8000	8000	410.2	253.7	219.9	15	5
AHU-4	8100	8100	497.4	267.6	309.5	15	5
AHU-5	7550	7550	409.4	236.6	234.3	15	5

Table 8: Greenhouse Building Fan Coil Units

Fan Coil Units						
Symbol	Supply CFM	O.A. CFM	Cooling Coil Capacity		Heating Coil Capacity MBH	Supply Fan HP
			Total MBH	Sensible MBH		
FC-1	1200	420	47.6	31.1	58	1
FC-2	800	200	27.5	19.3	35.3	3
FC-3	200	80	7.3	5.3	12.1	1
FC-4	1600	560	54.4	37.7	75.6	1
FC-5	200	50	6.8	4.9	11.5	1
FC-6	1200	420	47.6	31.1	58	1
FC-7	1200	300	37.8	27.2	53.7	1
FC-8	200	50	6.8	4.9	11.5	1
FC-9	600	60	11.6	10.8	21.8	1
FC-10	1600	0	36.9	32.9	62.6	1

Table 9: Greenhouse Wall Hung Radiation Units

Wall Hung Radiation Units				
Symbol	Length	BTUH	GPM	Height
WH-1	20 feet	10,840	1.1	16 inches
WH-2	15 feet	8460	2.8	16 inches
WH-3	26 feet	14664	2.8	16 inches
WH-4	4 feet	2256	2.8	16 inches
WH-5	4 feet	2256	2.8	16 inches
WH-6	4 feet	2160	1	16 inches
WH-7	4 feet	2160	1	16 inches
WH-8	4 feet	2160	1	16 inches
WH-9	4 feet	2160	1	16 inches
WH-10	3 feet	1620	1	16 inches
WH-11	3 feet	1620	1	16 inches
WH-12	4 feet	2216	1.9	16 inches
WH-13	4 feet	2216	1.9	16 inches
WH-14	18 feet	9972	1.9	16 inches
WH-15	6 feet	3324	1.9	16 inches
WH-16	6 feet	3240	1	16 inches

Table 10: Greenhouse Evaporative Coolers

Evaporative Coolers		
Symbol	Supply CFM	Supply Fan HP
EC-1	2400	1
EC-2	2000	1
EC-3	2400	1
EC-4	2400	1
EC-5	3200	3

Design Factors

Most design factors for this project were set by the college and given to the appropriate engineers and architect. Some factors for the mechanical systems include being smart about mechanical systems with respect to longevity, maintenance, maintenance cost, efficiency, first cost, and the ability of the systems to be modified/expanded over time. Other factors taken into account by the design engineer could include the site of the project, the orientation of the building, and the spaces included in the building. Some spaces include many laboratories, offices, and classrooms. There are also greenhouses located in the greenhouse building which require specific requirements in design of the systems.

Design Conditions

The outdoor design conditions used for the energy model are for Harrisburg, PA, which is the closest location from the ASHRAE Fundamentals to the site of the building. The conditions can be seen below in Table 11.

Table 11: ASHRAE Design Conditions

Design Conditions		
Heating Design Temperature	Cooling Design Temperature	
10.4 F DB	92.8 F DB	74.7 F WB

Design Ventilation Requirements

To verify that the life sciences building is providing the proper ventilation air for its occupancy, an ASHRAE 62.1 analysis was done on each of the air handling units. For this analysis the rates from each diffuser and areas of spaces were tabulated to see if the ventilation rates matched or were close to the minimum from ASHRAE Standard 62.1.

The overall rates from the tabulation were as follows: AHU-1, 1151 OA cfm; AHU-2, 5974 OA cfm; AHU-3, 1632 OA cfm; AHU-4, 4644 OA cfm; and AHU-5, 4196 OA cfm. The design documents specify the following rates for each AHU: AHU-1, 1300 OA cfm; AHU-2, 6900 OA cfm; AHU-3, 8000 OA cfm; AHU-4, 8100 OA cfm; and AHU-5, 7550 OA cfm. The rates for the air handling units serving the labs could be a lower than the design because they were oversized to make an adequate amount of outdoor air was supplied to the laboratories. AHU-3 design is a much larger value than that of the calculated value. This could be because this particular AHU services two floors and needs to be oversized for this reason. It also could be oversized like this because the offices it serves are located on the two floors that have multiple laboratories.

Design Heating and Cooling Loads

The heating and cooling loads for the life sciences building were simulated using Carrier HAP. As seen from Table 12 below, the computed loads and the design document loads are relatively similar. The computed cooling load is within 2% of the documented cooling load. The computed heating load is much lower than the documented load, being within 31%. This could be due to the fact that the systems that I ran for the greenhouses could be much different than the systems that were run for the design documents. The greenhouses were most likely modeled inaccurately because it was difficult to model wall hung radiation units and horizontal unit heaters in Carrier HAP. The heating load from the greenhouses should have made the overall heating load larger, because they are enclosed in glass and the area the building is located normally has a large heating load for the winter months. The computed supply air rate is within 6% of the documented supply air rate. The computed ventilation rate is within 25% of the documented ventilation rate. This is most likely from AHU-3 which serves the second and third floor offices. The ventilation rate from the design documents is lower than the computed rate. The model for this system that was computed was taken from the design documents saying that AHU-3 needed the same amount of outdoor air as total supply cfm. This value was input into the system for ventilation cfm so this could be why they are different.

Table 12: Load and Ventilation Comparison

Load and Ventilation Comparison				
	Cooling (ft^2/ton)	Heating (BTU/hr-ft^2)	Supply Air (cfm/ft^2)	Ventilation (cfm/ft^2)
Design Document	325.9	32.75	0.61	0.41
Computed	320.6	22.4	0.65	0.55

System Operations and Schematics

Airside:

Note: These operations are for occupied cycles.

For the VAV system for the life sciences building, the supply fan is turned on minimum than set to maximum in about a 60 second period. After this the supply fan will be modulated to maintain the supply duct static pressure setpoint in AHU-1 and AHU-3. For ventilation control the outside air and return dampers are modulated to maintain the minimum outdoor airflow setpoint. The economizer will take control of the dampers when a greater airflow is needed for space cooling. The economizer will also take control whenever the outdoor air temperature falls below the setpoint of 55 F. For the cool down cycle the supply air should be fixed to maintain 55 F. For the warm-up cycle the supply air temperature should be fixed to maintain 70 F. For the Reheat-VAV boxes, on a rise in space temperature the supply air will be modulated to cooling maximum. On a decrease in space temperature the supply air will be modulated to the cooling minimum. For a continuous fall in space temperature, the supply air will be modulated to the heating setpoint and the unit reheat coil control valve will be modulated to maintain the setpoint. For the parallel-fan powered, the only difference is that on a continuous fall in space temperature the unit fan will be started and the heating coil control valve will be modulated to maintain the heating setpoint.

Fan coil units will be served by AHU's 2, 4, and 5. The unit supply and exhaust fans will run continuously. Prior to starting fans the outside and exhaust air dampers should be opened. The AHU's are equipped with energy recovery wheels because of the high exhaust rates of the laboratories. For a rise in outdoor air enthalpy greater than return air enthalpy, or for heating, close the bypass dampers and turn on the energy recovery wheel. Whenever the outside air temperature is below 40 F the same process should be followed. For supply air temperature when the outdoor air temperature is above 55 F, the setpoint should be 55 F. When the outdoor temperature is below 55 F the setpoint should be a minimum 55 F and maximum 68 F. For the fan coil units themselves, the unit fan should operate continuously. On a rise in space temperature, the cooling coil control valve should be opened to maintain the space cooling setpoint. For a fall in space temperature, the heating coil control valve should be opened to maintain the space heating setpoint. For ventilation the return air damper should be closed to its minimum position.

Waterside:

Hot Water Heating System

There are three boilers to supply hot water to the systems. The boilers use internal controls to maintain the water temperature setpoint in the boiler. The setpoint in the boiler shall be 2 F greater than the hot water supply temperature. The lead boiler pump, HWP-1, should be started first and after a time delay the lead boiler, B-1, should be started to run continuously. When the hot water supply temperature falls by at least 5 F below the setpoint the first lag boiler pump, HWP-2, and boiler, B-2, should be started. This should only happen after the lead boiler has been running for at least 10 minutes. The same sequence is to happen for the second lag boiler pump, HWP-3, and boiler, B-

3. This should only happen if the lead and first lag boiler have been running for at least 10 minutes. After a rise in temperature of 2 F above the setpoint and after a time delay of 10 minutes the last boiler and pump started should be stopped. This should happen until only the lead boiler and its associated pump are operating. The hot water supply temperature should be 180 F if outdoor air temperature is 0 F, and it should be 140 F if the outdoor air temperature is 60 F. The three hot water pumps associated with the boilers are circulators for the boilers.

The hot water supply pumps are run on a primary secondary loop. The primary pumps, HWP-4 and HWP-5 shall be run on a central plant hot water system operating schedule. The lead hot water pump, HWP-4, should be started and run continuously. Upon a failure of this pump, the lag pump, HWP-5, should be started on a time delay as the lead pump is de-energized and removed from the sequence. The primary hot water pumps should be alternated on cumulative run-time, or at least on a monthly basis.

The secondary pumps for the life sciences building, HWP-6 and HWP-7, should be run according to the Life Sciences hot water system operating schedule. The lead secondary pump, HWP-6, should be started and ramped up to the minimum speed of 25 Hz. The pump speed should be modified to maintain the minimum chilled water building differential pressure setpoints. Upon a failure of the lead pump the lag pump, HWP-7, should be started on a time delay while the lead pump is de-energizied and removed from the sequence.

The greenhouse building secondary pumps, HWP-8 and HWP-9, should be run on a similar sequence to that of the life sciences building secondary pumps. These two secondary pumps supply hot water to the greenhouse wall hung radiation units and fan coil units.

Chilled Water Cooling System

The chiller, CH-1, for the life sciences building can either be run on a refrigeration cycle or a free-cooling cycle. The chiller will be operated when the outdoor air temperature is at or above 50 F. First start the chillers associated evaporator, CHWP-1, and condenser, CDWP-1, water pumps. These pumps will operate continuously with the associated chiller operation. After they have been running the chiller will be started. The chiller itself will be started and run based on things such as schedule, load demand, and temperature. The chiller will have controls that will help it maintain the chilled water supply setpoint of 44 F. The condenser water temperature should maintain a temperature of 60 F when entering the chiller. If the temperature of that water rises above 60 F the control vale, CV-1, should be opened to the cold well in the sump tank. This will supply colder water to the chiller. When the temperature of the water gets to 60 F the control valve can be closed again.

The secondary pumps, CHWP-2 and CHWP-3, for the chilled water system will operate according to a user-defined operating schedule. The lead secondary pump will be started and ramped up to minimum speed of 25 Hz. The pump speed should be modulated to maintain the minimum chilled water building differential pressure setpoint. When the lead secondary pump fails the lag pump will be started after a time delay to prevent a false failure. The lead pump will then be removed from the sequence. If both pumps are working they should be alternated about every month to maintain a longer life. The secondary pump, CHWP-4, for the greenhouse building will operate continuously according to the schedule for cooling. From the secondary pump the supply water goes to the evaporative coolers and fan coil units in the greenhouse building.

When cooling with a refrigerant cycle control valves, CV-2, CV-4, and CV-6 should be closed. The control valves, CV-3, CV-5, and CV-7 should be opened. During a free cooling cycle the opposite should happen, control valves that were open for refrigeration will close and ones that were closed will open. The free cooling cycle allows for the use of a heat exchanger, HX-1, as a waterside economizer.

Cooling Tower Water System

Chiller Mode:

The cooling towers and cooling tower pumps will be operated according with the chilled water and free cooling user-defined schedules. When the temperature in the cooling tower water sump rises above the setpoint of 70 F, the lead cooling tower pump, CTWP-1 should be started. It should be started after a time delay of 5 minutes. On a continued rise in temperature above 72 F the lag cooling tower pump, CTWP-2, should be started. This should run until the temperature of the water decreases to 70 F, then turned off.

Waterside Economizer Mode:

When the temperature of the water in the cooling tower sump rises above the setpoint of 41 F, cooling tower pump, CTWP-1, should be started after a 5 minute time delay. When the temperature in the sump reaches below the setpoint of 39 F the pump can be stopped. If this pump should fail then stop it and start pump CTWP-2 as if it were the first cooling tower pump.

Schematics

The following figures, Figure 1 and Figure 2, are a hot water heating schematic and chilled water schematic, respectively.

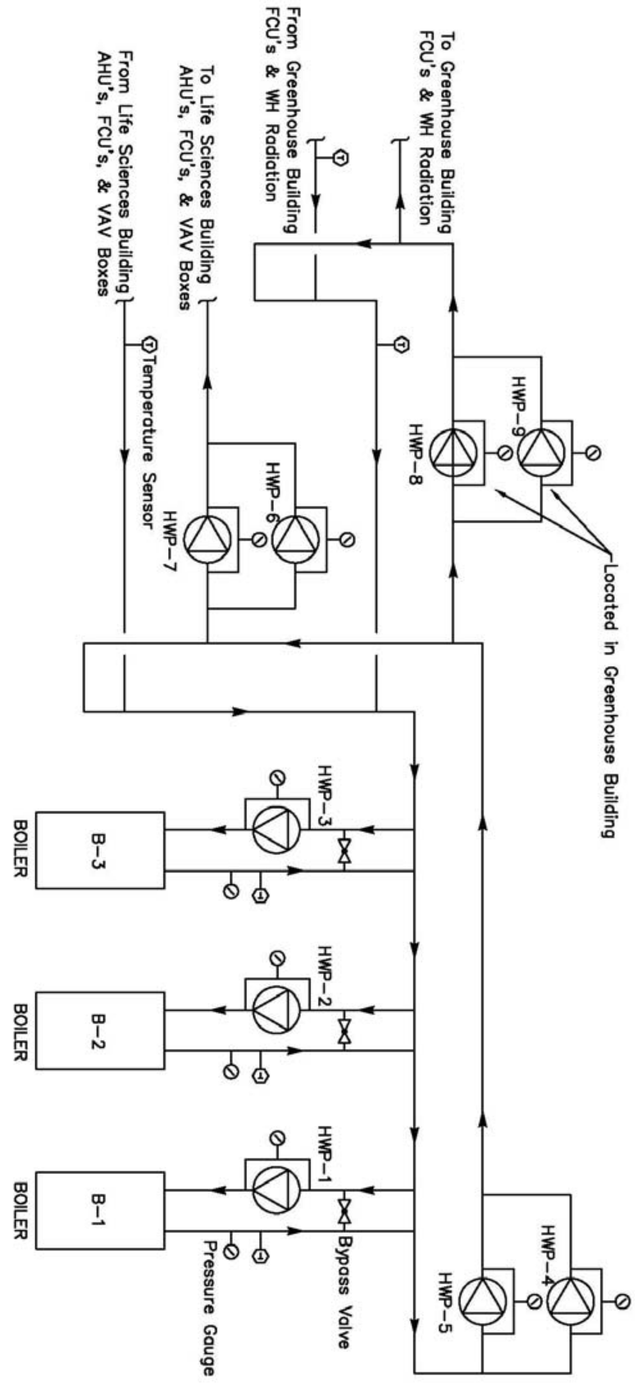


Figure 1: Hot Water Piping Schematic

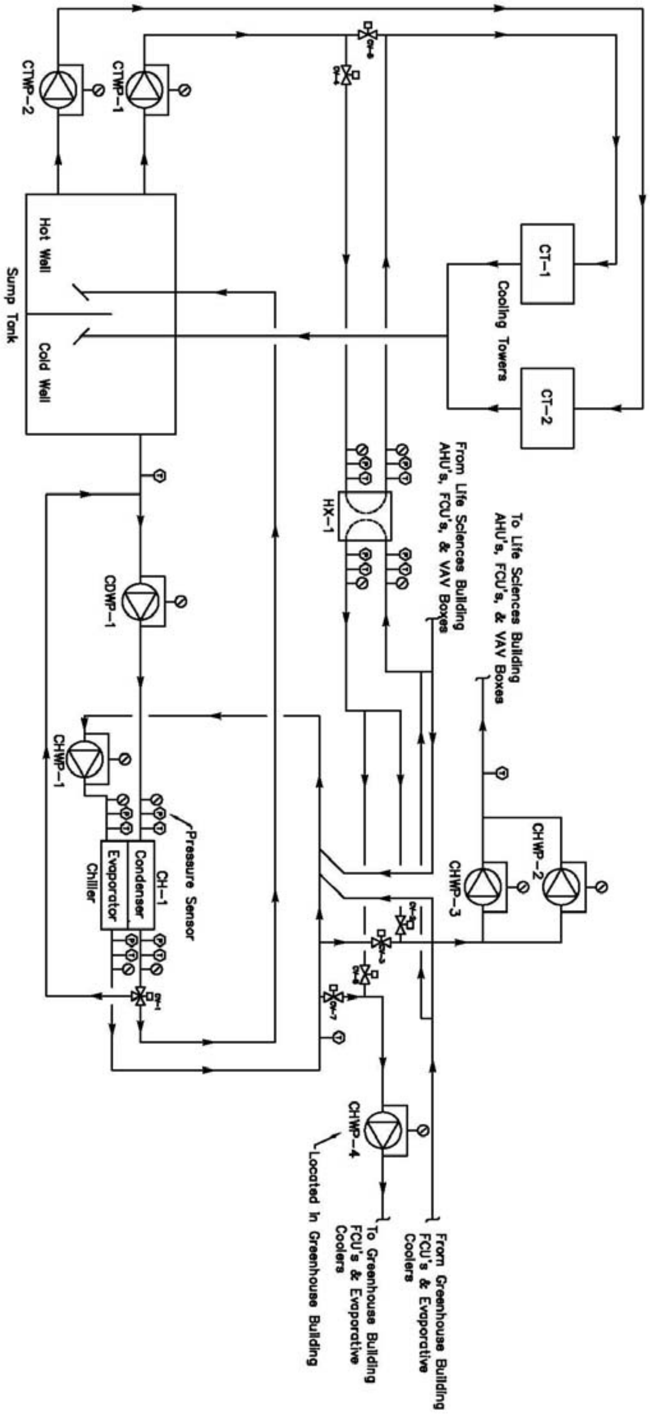


Figure 2: Chilled Water Piping Schematic

Mechanical System Area Usage

The total area for the mechanical systems is tabulated below in Table 13. The basement of the life sciences building houses the central plant where the chiller and boilers are located. On the second and third floor are mechanical rooms that each houses an AHU. The roof of the life sciences has two AHU's and the cooling towers located on it. In the greenhouse building, the mechanical room in the basement houses secondary pumps and ductwork for that building. The total lost area for the life sciences building from mechanical systems is estimated to be about 5400 sf. This area lost has the area from the roof that equipment is on. This should have not effect on the actual area lost inside the building which is about 4300 sf.

Table 13: Mechanical Area Usage

Mechanical Area Usage	
Floor	Area (ft^2)
Life Sciences	
Basement	2502
Second	446
Third	446
Roof	980
Vertical Shafts	316
Greenhouse	
Basement	415
First	50
Roof	160
Vertical Shafts	52

Mechanical System First Cost

The mechanical systems first cost for the life sciences building will be taken from the bid cost given by the lead design engineer on the project. The price for mechanical systems in the greenhouse building was $870,720. The cost for mechanical systems in the life sciences building was $4,150,000. This brings the total cost of mechanical systems to $5,020,720. The cost per square foot for mechanical systems ends up being about $49.22/sf.

Annual Energy Usage

The designer annual energy usage is not available for this report because an energy analysis was not run by the design engineer. This is because none of the systems, envelope or HVAC were in question. The annual energy consumption was calculated using the same model that was used for the load calculations. With the exception of the gas-fired boilers, the rest of the building is powered by delivered electric power.

Table 15 below shows the energy usage for the entire year separated into different loads for the building.

Table 15: Annual Energy Consumption

Annual Energy Consumption				
Load	Electricity (kWh)	Natural Gas (kWh)	Total (kWh)	% of Total
Heating				
Gas-Fired		2637639	2637639	31
Electric Heaters	190608		190608	2
Cooling				
Chiller	1991808		1991808	23
Cooling Tower	727097		727097	8
Condenser Pump	56390		56390	1
Auxiliary				
Supply Fans	221632		221632	3
Pumps	1573235		1573235	18
Lighting	703482		703482	8
Receptacles	487998		487998	6
		Total	8589889	100

The values above were computed using the energy model with equipment inputs taken from the design documents for the building.

From this analysis it can be seen that the largest load is from heating at 31%. This could be due to a number of things including, the buildings location, orientation, and boilers being the main supply for hot water to all the various systems in this project.

The buildings location is in York, PA, which can have very cold winters. The orientation of the building is mostly north, which is not the best for winter solar gain. The boilers supply a large amount of hot water to ahu's, fan coil units, horizontal unit heaters, wall hung radiation units, vav boxes, and cabinet unit heaters.

The second largest load is from cooling at 23%. This is most likely because of the large amounts of various equipment in the computer labs, office, laboratories, and workroom/mail facilities.

As seen in Chart 1 and Chart 2 below, the energy usage for natural gas and electricity changes throughout the year with the seasons. For electric energy consumption the highest peaks are during the warmer months. This is most likely because the chilled water pumps are working much harder to supply chilled water. The natural gas consumption is peaked during the winter months because of the boilers.

Chart 1: Monthly Electrical Energy Consumption

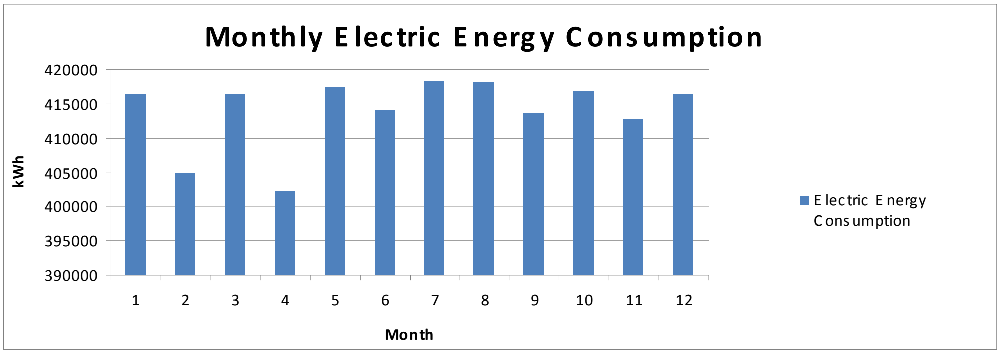
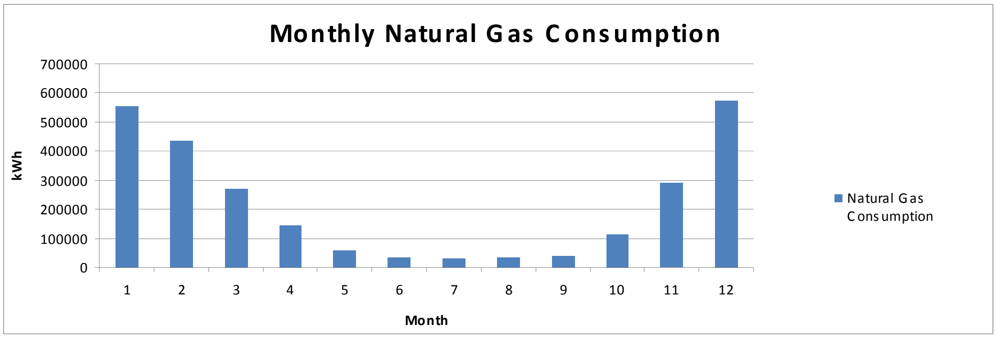


Chart 2: Monthly Natural Gas Consumption



Energy Sources and Rates

The costs per unit of electricity and fuel are listed in Table 16 below. Due to the lack of information, Met-ED and Columbia Gas rates were used for this analysis. These two companies are two of the largest for electric and natural gas service in the York area.

Table 16: Utility Cost Information

Utility Cost Information	
Electricity (cents/kWh)	Natural Gas ($/1000ft^3)
9.35	7.31

The energy sources used for this analysis were electricity and natural gas, which are both used in the life sciences building for the mechanical systems.

Operating History of System

This is not attainable because the life sciences building is currently undergoing its renovations and will not be done until next year.

LEED-NC Evaluation

Information on a LEED-NC evaluation for the life sciences building was not attained for this report because one was not run by the design engineer. The design engineer did not run an evaluation because the college that the building is for did not require a LEED-NC evaluation. The college gave the design engineer a directive to be smart about their building systems with respect to longevity, maintenance, maintenance cost, efficiency, first cost, and the ability of the systems to be modified/expanded over time. The LEED-NC evaluation for this report will be done using Version 3 of the U.S Green Building Council for New construction and major renovations. Information for this analysis will be taken from the design documents given to me from the design engineer. Therefore, not all the information may not be available to show that the building is LEED qualified.

Energy and Atmosphere

EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems

In order to achieve certification from the USGBC there must be a commissioning authority to oversee all commissioning for the project. Since the college is not interested in pursuing a LEED status with this building this may not be important to them. However if they were interested in this there is no question that they wouldn't hire someone that is appropriate for the job with the required experience in commissioning.

EA Prerequisite 2: Minimum Energy Performance

The life sciences building is currently undergoing renovations at this time. Because of this there are no energy analyses of the new mechanical systems to compare to this prerequisite.

EA Prerequisite 3: Fundamental Refrigerant Management

The refrigerant used in the life sciences building is R-134a, which is a HFC compound. This meets the requirement of not being a CFC refrigerant.

EA Credit 1: Optimize Energy Performance

Since the life sciences building is currently undergoing its renovations there are no energy bills to see if the building achieves any of these points.

EA Credit 2: On-site Renewable Energy

The life sciences building does not utilize any on-site renewable energies, therefore would receive no points for this section.

EA Credit 3: Enhanced Commissioning

As stated in prerequisite 1 the college does not typically look to achieve LEED status, therefore this section was most likely not looked into. However if the college were to aspire LEED status they would most likely get these points.

EA Credit 4: Enhanced Refrigerant Management

Because refrigerants are used in this building the following equation must be followed.

$$LCGWP + (LCODP \times 10^5) \leq 100$$

$$LCODP = [ODPr \times (Lr \times Life + Mr) \times rc]/Life$$

$$LCGWP = [GWPr \times (Lr \times Life + Mr) \times rc]/Life$$

LCODP: Lifecycle Ozone Depletion Potential
LCGWP: Lifecycle Direct Global Warming Potential
GWPr: Global Warming Potential of Refrigerant (1300)
ODPr: Ozone Depletion Potential of Refrigerant (0)
Lr: Refrigerant Leakage Rate (2%)
Mr: End of Life Refrigerant Loss (10%)

Rc: Refrigerant Charge (lb/ton)
Life: Equipment Life (20 years)

From the previous equation the value of 0.03267, which is much less than the maximum of 100. This value may be so low because the refrigerant R-134a has no effect on ozone depletion.

EA Credit 5: Measurement and Verification

The college will not be pursuing this step since it is not out to achieve a LEED status. Another reason that this step might not be pursued is that it is expensive to obtain measurement and verification of energy usage.

EA Credit 6: Green Power

Renewable energy from a grid will not be provided to the college for the life sciences building. Since this is the case no points can be rewarded for this credit.

Indoor Environmental Quality

IEQ Prerequisite 1: Minimum Indoor Air Quality Performance

Sections 4 through 7 of ASHRAE standard 62.1-2007 have been met as detailed in Technical Report 1. Mechanical ventilation was used in most of the spaces except the greenhouses themselves used natural ventilation.

IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

Smoking is prohibited in this university building and is only allowed at least 25 feet away from any entrance doors. This is in compliance with the requirements of this credit.

IEQ Credit 1: Outdoor Air Delivery Monitoring

The air handling units are all equipped with outside air dampers to provide the appropriate amount of ventilation air to each space. The dampers are connected to a

BAS, building automation system, to be monitored. Carbon Dioxide will be reported to the BAS with an accuracy of +/- 50 ppm. If the level of CO_2 gets to large an alarm will report to the BAS.

IEQ Credit 2: Increased Ventilation

Compliance with this credit requires a 30% increase in supplied ventilation air as compared to the minimum described in ASHRAE Std. 62.1-2007. These minimum values were defined in the calculations for Technical Report One. The systems were designed with more ventilation air than is required from Std. 62.1. When more ventilation air is required than minimum an air economizer will take over controls and supply the appropriate amount of outdoor air.

IEQ Credit 3.1: Construction Indoor Air Quality Management Plan-During Construction

Since the college did not seek to achieve a LEED status this section was not included in the design documents. However the design engineer most likely made sure that any hazardous and volatile materials were stored complying with code.

IEQ Credit 3.2: Construction Indoor Air Quality Management Plan-Before Occupancy

Since the life sciences building is not yet completed there is no specific documentation of how this will be handled by the college and design engineer. However it is assumed that proper measures will be taken to run the systems in order to remove any contaminants form the building before occupancy.

IEQ Credit 4.1: Low-emitting Materials – Adhesives and Sealants

All sealants and adhesives used for the mechanical systems meet the required level of VOC's to comply with this credit.

IEQ Credit 5: Indoor Chemical and Pollutant Source Control

All laboratories in the life sciences building are exhausted at proper rates to avoid contamination from chemicals in the laboratories. However the highest rating of MERV filters for ventilation purposes is 11, therefore not complying with this credit.

IEQ Credit 6.2: Controllability of Systems – Thermal Comfort

Due to the zoning of similar spaces such as offices there are less than 50% of occupants in the building have access to temperature controls. This credit is not attainable because of this.

IEQ Credit 7.1: Thermal Comfort – Design

All of the mechanical systems designed meet the criteria set forth by ASHRAE Standard 55-2004 for thermal comfort, therefore complying with this credit.

IEQ Credit 7.2: Thermal Comfort – Verification

Although the life sciences mechanical systems comply with credit 7.1 for thermal comfort, there are no recorded plans to conduct a survey on thermal comfort within 6 to 18 months after occupancy. Therefore no credit will be awarded from this section.

Overall Evaluation

The systems chosen for the life sciences building were chosen by the design engineer to be the most efficient for the various spaces that are included in this building, such as offices, classrooms, laboratories, and computer labs. The office spaces are conditioned with VAV system which is conventional for many offices. The rest of the spaces are conditioned using fan coil units with pretreated outdoor air. This is mostly because of the laboratories and the high exhaust rates they require. Although the building mechanical systems may not be LEED certified they are efficient, low in cost, and low in maintenance for the college.

The total construction cost of the building was about $16 million. The mechanical systems accounted for about $5 million of that cost because of the major renovations to the central plant in the basement and the air side systems. The operating cost per square foot for the life sciences building ended up being about an average of $1.21/sf. The Energy Information Administration estimated that universities spend an average of about $1.05/sf. The operating cost for the life sciences is larger because of the heating cost per square foot which is much larger than the average. This could be due to the location of the building, or inaccuracies from the energy analysis run with Carrier HAP from Tech Report 2.

The cost for maintenance for the life sciences building should b relatively low however because the systems were found to be efficient in conditioning and heating the various spaces for the building.

There is not much area lost to mechanical systems and vertical shafts in the life sciences building because the basement is used as a central plant for the building housing most of the systems required. There are a limited amount of vertical shafts due to the efficient layout of ducts and piping needed to be extended throughout the building. Most of the ductwork and piping for the building is laid out in the ceiling space of each floor. The roof houses two AHU’s and the cooling towers which most likely added to the structural cost of the building but did not affect the area lost in the building.

With having many laboratories to condition Indoor Air Quality can become an issue. This was taken into account when ventilating the offices on floors two and three where the laboratories are located. The ventilation load for these offices was oversized to make sure no chemicals would contaminate the spaces surrounding the labs. AHU-3, which conditions these offices, has much more ventilation air than required by ASHRAE Std. 62.1. With VAV boxes being used to condition the offices IAQ can also be an issue. If the system were to be designed or installed incorrectly, the modulated supply air by the VAV boxes can occur with no change in the outdoor air fraction. This would result in a ventilation air deficiency. Also the correct placement of filters is important to maintain that no contaminants from inside the building can be re-circulated into other spaces.

Overall, the life sciences building was designed to be efficient, low cost, and low maintenance. This can be seen through the many analyses of the mechanical systems in the building from the previous Tech Reports, as well as this report.

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