TECHNICAL REPORT III

Mechanical Systems Existing Conditions Evaluation

10/21/08

WEST VIRGINIA UNIVERSITY ALUMNI CENTER

Morgantown, West Virginia

GREGORY SMITHMYER

PENN STATE UNIVERSITY

ARCHITECTURAL ENGINEERING

MECHANICAL OPTION

FACULTY ADVISOR:
Dr. Jelena Screbric

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1.0 Executive Summary

Technical Report III outlines and summarizes the intent, design, function and results of the current mechanical system design for the West Virginia University Alumni Center.

Section 3 of the report discusses the main factors that drove the design of the building including the project budget, and building location/orientation. Based on the factors listed in Section 3, a mechanical system design was created and its design and function are described in Section 4. That section describes the packaged rooftop system that was implemented and the control sequences that allow it to function properly.

Sections 5 and 6 summarize the requirements that the packaged rooftop systems were required to meet. Section 5 provides information on the required ventilation rates as per the calculations in ASHRAE Standard 62.1, while Section 6 summarizes the heating and cooling loads that the equipment needed to meet as calculated by Trane Trace 700. The equipment that was installed in the building closely matches the results of the ventilation rate and load calculations performed for this report.

Sections 7 through 10 provide insight on the impact of the current mechanical system design. The monthly and annual energy consumption and cost, lost usable space, first cost of the system and potentially available LEED credits are discussed in these sections. The annual energy cost is approximately average when compared with other building of similar usage, while lost usable space and first cost were minimized. The design of the current system allows for very few LEED credits and, as designed, the building would most likely not be able to achieve LEED certification.

The overall system evaluation in Section 10 of this report combines all of the information gathered and analyzes it based on three criteria: construction cost, space requirements, and maintainability. These three criteria along with other information on the refrigerant type used and lifecycle cost are included in the final thoughts declaring that other systems may potentially be better for the environment and provide a lower lifecycle cost.

2.0 Design Objectives and Requirements

For the Alumni Center project the design objectives and requirements were quite simple. The main design objective was to provide conditioning to the required spaces of the building while complying with several design requirements. The requirements included compliance with multiple ASHRAE Standards (62.1, 90.1 and 55). An additional requirement, set forth by the Alumni Association, was a low capital cost. These requirements led to the design of a simple system comprised of 9 rooftop air-handling units that operate as discussed in Section 4 of this report.

3.0 Design Factors

3.1 Building Location

The Alumni Center is located on the eastern most portion of the building site due to a storm retention area located at the center and western parts of the site as shown in Figure 1, without the Alumni Center, and Figure 2, with the Alumni Center. The storm water retention area is outlined in red in both figures.

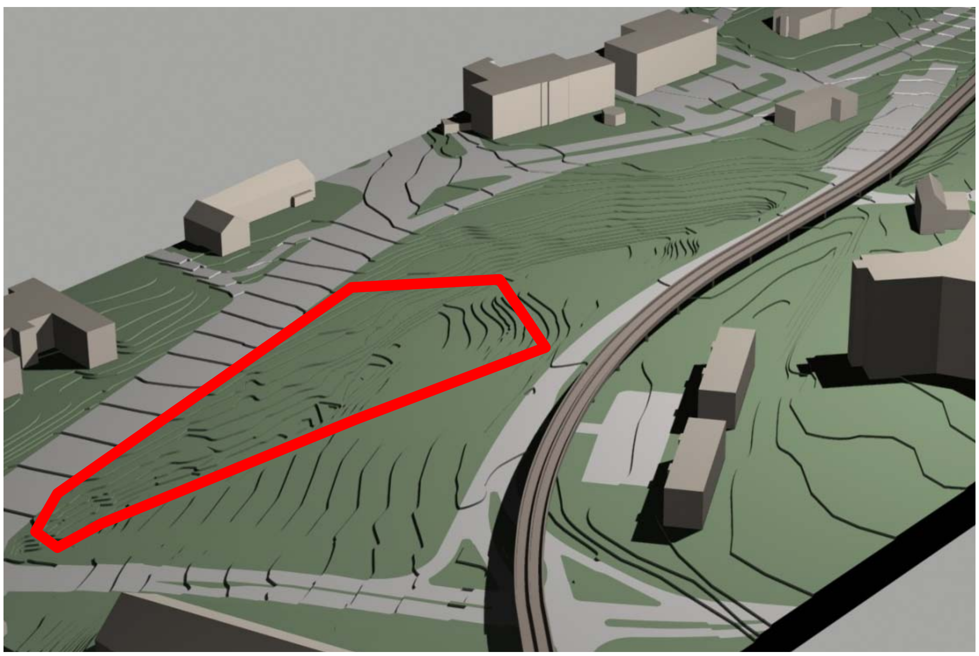

Figure 1 – Site Layout Prior to Construction - Storm Retention Area Outlined in Red

Figure 2 – Site Layout Post Construction - Storm Retention Area Outlined in Red

3.2 Project Budget

All of the funds for the Alumni Center project were donated from members of the West Virginia University Alumni Association. As such, the budget for the project was strictly limited to the amount of money that could be raised by the Alumni Association. The Alumni Association received several large donations for naming rights to various portions of the building. Additionally, bricks, pavers, brick columns, and benches could be purchased and engraved for various donation amounts. The total budget for the project is $12 million.

4.0 Equipment Summary/Schematic Drawings

4.1 Mechanical System Overview and System Operation

The 48,000 ft^2 West Virginia University Alumni Center is conditioned by 9 Air Handling Units that serve four distinct space types. As shown in Figure 3, AHU-1, AHU-2, AHU-3, and AHU-9 serve the lobbies, hallways, and office areas of the ground floor, first floor and second floor. These four AHU's provide conditioning through air-cooled direct expansion cooling and gas-furnace heating. AHU-1, AHU-2 and AHU-3 are variable volume AHU's and serve VAV boxes with electric reheat. AHU-9 is a single zone constant volume AHU.

Figure 3 also show AHU-4, AHU-5 and AHU-6 which each provide conditioning to 1/3 of the Banquet Hall while AHU-7 serves the two loggias surrounding the Banquet Hall. These four AHU's also operate with air-cooled direct expansion cooling and gas-furnace heating and they are all single zone constant volume systems with AHU-7 supplying 100% outdoor air.

AHU-8 is a make-up air unit that provides air directly to the kitchen exhaust hoods and is only equipped with gas-fired furnace heating designed to provide 100% outdoor air.

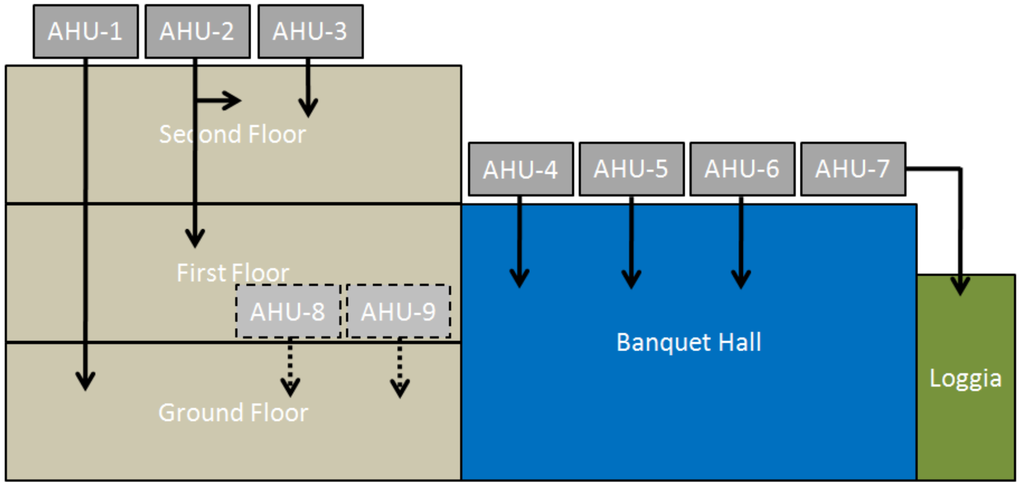

Figure 3 – Simplified AHU Distribution Schematic

AHU-1, AHU-2 and AHU-3 all follow the same sequence of operation. These AHU's will operate in one of two control modes, occupied or unoccupied, which allow for heating or cooling anytime a VAV box requires. The cooling supply air temperature is 55°F leaving the AHU and the VAV boxes modulate to control the room cooling set point at 72°F during occupied mode 85° F during unoccupied mode. The heating supply air temperature is 75° F leaving the AHU and the VAV boxes modulate to control the room heating set point at 70° F during occupied mode and 55° F during unoccupied mode. Optimal starting of the AHU's in the morning allows each zone to reach their occupied set points prior to occupancy each day. Because these AHU's serve variable volume boxes, the fans in each AHU are equipped with variable frequency drives (VFD's) that modulate the supply fan speed to maintain the required static pressure in the system based on a static pressure reading 75% down the longest duct run. The return fans for these systems runs continuously when the supply fan is running and the VFD's for the return fans modulate in unison with the supply fan VFD's. These AHU's are equipped with an economizer control sequence that allows for free cooling under specified conditions.

AHU-4, AHU-5, AHU-6, and AHU-9 all follow the same sequence of operation. These AHU's will operate in one of two control modes, occupied or unoccupied. The cooling supply air temperature leaving the AHU modulates to control the room cooling set point at 72°F during occupied mode 85° F during unoccupied mode. The heating supply air temperature leaving the AHU modulates to control the room heating set point at 70° F during occupied mode and 55° F during unoccupied mode. Optimal starting of the AHU's in the morning allows each zone to reach their occupied set points prior to occupancy each day. Because these AHU's serve constant volume systems the supply fan operates in two modes, ON or OFF. The return fan runs anytime that the supply fan is in ON mode. These AHU's are equipped with an economizer control sequence that allows for free cooling under specified conditions.

AHU-7 follows the same sequence of operation of AHU-4, AHU-5, AHU-6 and AHU-9 except for one small difference. Because AHU-7 serves the kitchen area, the system is designed to provide the minimum required ventilation during occupied mode. However, when Kitchen Exhaust Fans 1, 3 and 4 are on the

AHU provides 100% outdoor air. All cooling and heating set points are the same as stated for the previous air handlers and the supply and return fan operations are also the same as stated for AHU-4, AHU-5, AHU-6 and AHU-9.

4.2 Major Equipment Summary

Important information for all AHU's including CFM, fan power, cooling capacity and heating capacity, is summarized in Appendix 1.

4.3 Air Distribution Schematics

Air Distribution Schematics for the Main Building, Kitchen, and Banquet Hall/Loggia are available in Appendices 2, 3 and 4 respectively.

5.0 Design Ventilation Rate Requirements

The ventilation requirements as calculated by the system designer vary slightly from the ventilation requirements calculated in Technical Report I. A summary of the results is included in Table 1 of this report with a detailed description of all the required calculations located in Technical Report I.

Table 1 – Ventilation Rate Compliance Summary

	Ventilation Rate Compliance Summary			
	Calculated OA (cfm)	Design Supply Air Flow (cfm)	Design Minimum OA (cfm)	ASHRAE 62.1 Compliance
AHU 1	2980	8690	2173	No
AHU-2	5969	15215	5325	No
AHU-4	5000	1218	2500	Yes

AHU-1 and AHU-2 both did not meet the requirements of ASHRAE Standard 62.1 as calculated in Technical Report I. However, those calculations did not take into account the short term conditions of several conference rooms and pre-event lobbies as specified in Section 6.2.6.2 of Standard 62.1. If the requirements of Section 6.2.6.2 were included in the calculations, both AHU-1 and AHU-2 would comply with the standard.

6.0 Design Heating and Cooling Loads

6.1 Design versus Estimated

In Technical Report II a load estimation calculation was performed for the Alumni Center project. The results of this load estimation are similar to the equipment specified by the designer. Table 2 summarizes and compares the results of the load estimation to the specified equipment.

Table 2 – Modeled Results versus Designed System

AHU-1	AHU-2	AHU-3	AHU-4	AHU-5	AHU-6	AHU-7	AHU-8	AHU-9

ft²/ton-Modeled	272	220	414	127	127	127	129	N/A	90
ft²/ton-Designed	306	182	563	127	127	127	142	N/A	75
CFM/ft²-Modeled	1.01	1.16	0.74	1.25	1.25	1.25	1.39	N/A	3.43
CFM/ft²-Designed	1.09	1.58	0.59	2.1	2.1	2.1	1.51	N/A	4.6
OA CFM/ft²-Modeled	0.31	0.41	0.14	1.1	1.1	1.1	1.1	N/A	0.92
OA CFM/ft²-Designed	0.27	0.55	0.15	1.1	1.1	1.1	1.51	N/A	0.92
Cooling Load-Modeled (Tons)	28.7	43	19.4	18.7	18.7	18.7	28.1	N/A	24.1
Cooling Load-Designed (Tons)	25.5	52	14.25	18.7	18.7	18.7	25.4	N/A	28.9
Heat Load-Modeled (MBh)	236	350	171	238	238	238	414.5	671	238
Heat Load-Designed (MBh)	270	780	270	390	390	390	780	750	540

There are a few discrepancies in the modeled versus actual heating loads. The heating loads as calculated in the model are all lower than the actual design. Some of them are close enough that the difference can be as trivial as the implementation of a small safety factor. Others, however, show significant differences between the calculated load and the actual designed load. This could be due to the simplified office schedule as described in Section 3.1 of Technical Report II. Spaces such as the loggias, served by AHU-7, are assumed to have a large number of occupants throughout the day, which would greatly decrease the need for heating. However, that is most likely not the case as the loggia is only used sparingly through the day, which is difficult to model. AHU-2 probably also suffers from the simplified schedule since it conditions mostly conference rooms, which most likely are not all occupied at the same time. Reducing the number of occupants increases the need for heat because each occupant produces a significant amount of sensible and latent heat.

There are a few small discrepancies in the modeled versus actual cooling tons. There are a few instances where the modeled cooling load is a few tons higher than the actual design. This may be due to the simplified schedule which put every space on a generic office schedule. Many of the conference rooms and offices will most likely not all be utilized at the same time period and therefore the cooling load was increased in the model. However, the overall cooling tons for the entire building as calculated in the load estimation model was 199.4 tons while the equipment selected by the designer has a maximum capacity of 202.15 tons. This shows that selected equipment should be able to handle the maximum load that the building may have on it at any time.

7.0 Annual Energy Use

7.1 Design versus Estimated

The MEP design engineers at H.F. Lenz did not perform an energy analysis during the design of this building. An analysis was not performed because it was not a LEED building, it was not required by code, and the owner was not willing to spend the extra money for the service. The system was chosen based on the available budget, best practice and knowledge of the energy usage of various designs.

7.2 Assumptions

All assumptions for the modeling of the Alumni Center's annual energy use are detailed in Section 4.1 of Technical Report II.

7.3 Energy Sources and Rates

The energy sources that are used on site by the current systems are electricity and natural gas. The utility rates for these energy sources are detailed in Section 4.2 of Technical Report II. The only additional energy source that could be utilized after redesign of the mechanical systems is Fuel Oil as there is no potential for using district chilled water or steam. The average price for #2 Fuel Oil in the state of West Virginia is provided in Table 3.

Table 3 – Average Cost of Energy Source in State of West Virginia

	Cost ($/gal)
#2 Fuel Oil	3.855

7.4 Annual Energy Use and Cost Results

The West Virginia University Alumni Center, as modeled, consumes a total of 3,266 MMBH/year with 1,129 MMBH/year in natural gas usage and 2,137 MMBH/year in electricity usage as shown in Figure 4.

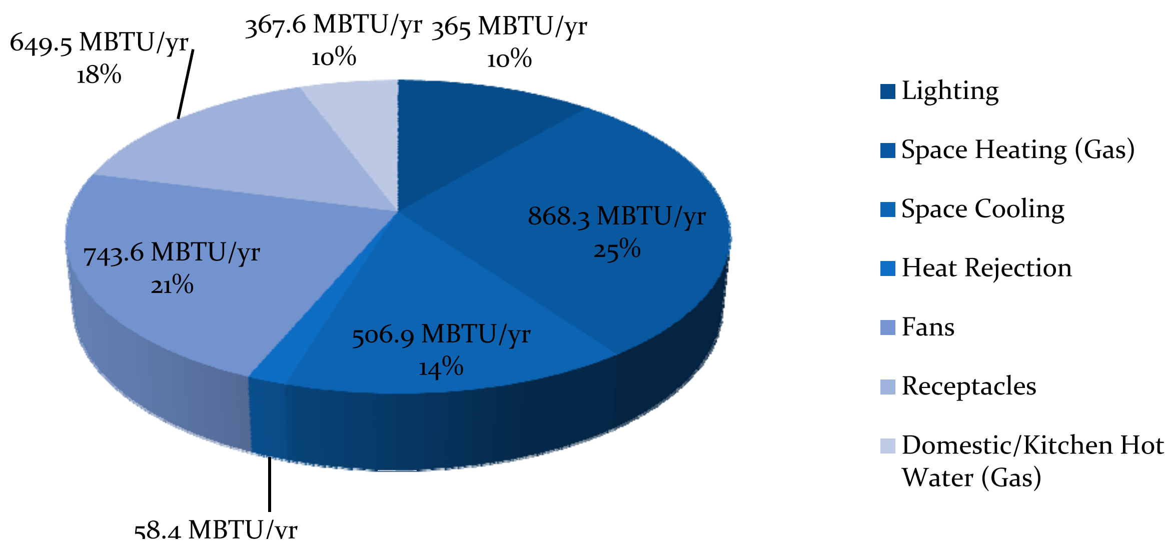

Figure 4 – Annual Energy Consumption by Category

The total annual energy cost is $68,714 or about $1.43/ft^2 with an annual cooling cost of $0.245/ft^2. The overall energy cost per square foot value is comparable to the value in the ASHRAE Application Handbook-2003. The ASHRAE Application Handbook provides a cost of $1.51.ft^2 for the average office building. The values in the Application Handbook are based on data from 1995 and are therefore somewhat outdated. Even though the modeled annual energy cost is lower than the value from the Application Handbook, it does not mean that the Alumni Center uses less energy than the average office building. Energy standards have improved since 1995 and the Alumni Center most likely consumes more energy than the average office building constructed in more recent years.

7.5 Monthly Energy Use and Cost Results

It is also important to review the month by month energy usage and energy costs to help identify where energy cutting measures should be focused. Figure 5 shows the monthly combined usage of natural gas and electricity. From this figure it is obvious that electric consumption increases in the summer (air-conditioning usage) and that gas usage decreases in the summer (little heating needed). However, Figure 6 shows how energy costs change month by month.

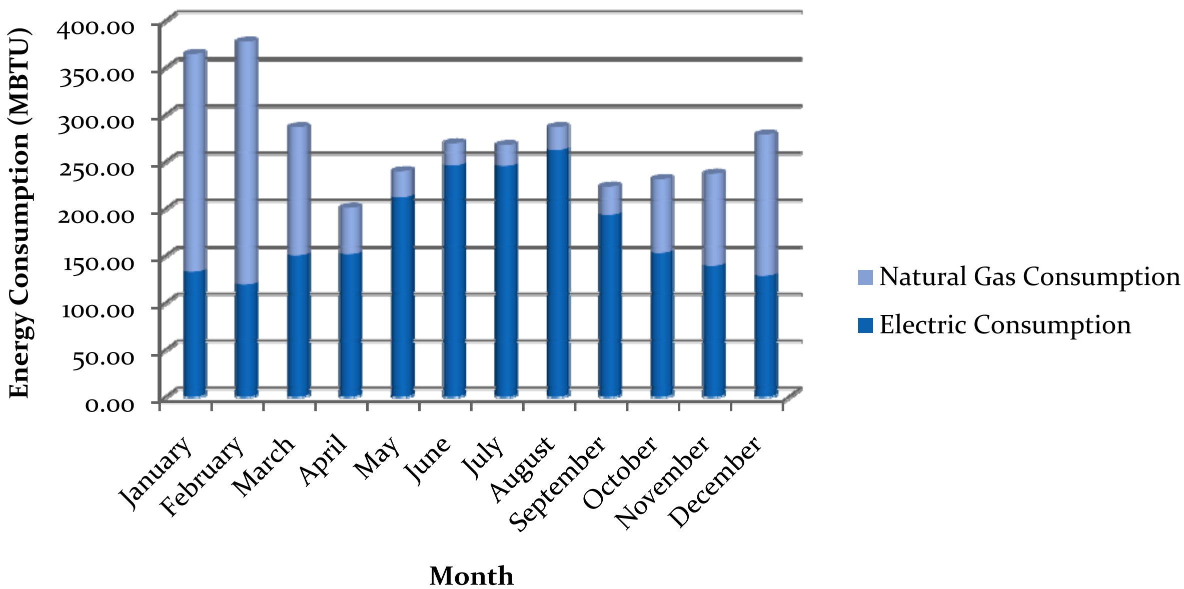

Figure 5 – Monthly Combined Natural Gas and Electric Consumption

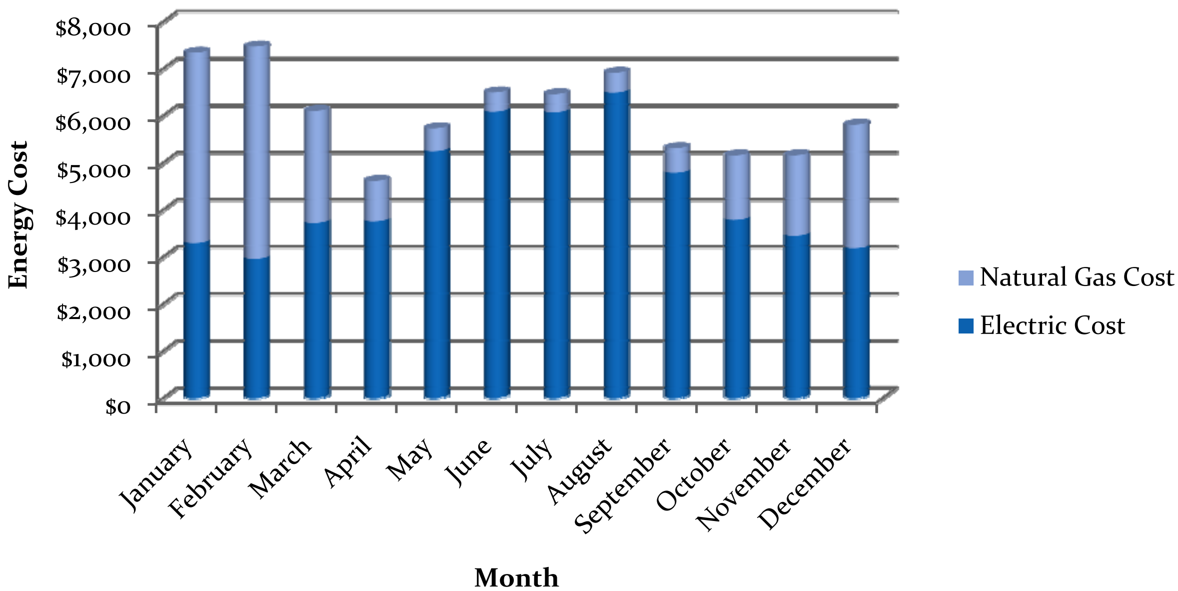

Figure 6 – Monthly Combined Natural Gas and Electric Cost

Figures 5 and 6 show that while in winter months electricity only accounts for 1/3 of the building's energy consumption it accounts for almost half of the overall energy bill. This means that electricity usage is the driving factor of the energy bill during every month of the year, and the focus should be on reducing electrical usage.

Since a majority of the electrical consumption comes from the HVAC systems the possibility is presented to achieve lower energy costs by improving equipment efficiencies or looking for different HVAC systems to utilize for the building to reduce energy costs. The design engineer estimated that during the value engineering phase of the project that utilizing electric reheats in all VAV boxes would add an additional $19,000 in energy cost per year over the use of a system that would be utilizing a central boiler and chiller system.

8.0 Lost Usable Space

Lost usable space is the space that is lost to equipment rooms, mechanical penthouses, and vertical mechanical shafts. The Alumni Center has all of its mechanical equipment placed on the roof, not in equipment rooms or penthouses. Therefore the only lost usable space is from vertical mechanical shafts. Table 3 summarizes the lost usable space in this project.

Table 3 – Lost Usable Space Summary

Floor	Square Feet Lost	Total Square Feet	% Lost
Ground	33	27000	0.12%
First	75	10500	0.71%
Second	76	10500	0.72%

9.0 Mechanical System First Cost

The contracts for the plumbing and mechanical systems for the Alumni Center project were awarded to the same sub-contractor. Therefore a reasonable estimate for the distribution of the cost between the two contracts was acquired from the design engineer. The results are summarized in Table 4.

Table 4 – Mechanical and Plumbing First Cost

	Mechanical	Plumbing	Total
Cost	$1,600,000	$400,000	$2,000,000
Cost per Sq. Ft.	$33	$8	$42
% of Total Budget	13.33%	3.33%	16.67%

10.0 LEED-NC 2.2 Evaluation

LEED-NC 2.2 has two main categories where the mechanical system influences the accumulation of LEED credits. They are Energy and Atmosphere, and Indoor Environmental Quality. Energy and Atmosphere has three prerequisites and six credits that are influenced by the mechanical system. Indoor Environmental Quality has two prerequisites and seven credits that are influenced by the mechanical system. A description of each of these prerequisites and credits is included below. Please refer to the LEED-NC 2.2 rating system for detailed information on the requirements of each prerequisite and credit.

10.1 Energy and Atmosphere

EA Prerequisite #1: Fundamental Commissioning of the Building Energy Systems

The Alumni Center will have a commissioning agent verify that each energy related system is installed, calibrated and performing as specified by the construction documents. Since the project is less than 50, 000 gross square feet the commissioning agent may be part of the design or construction teams. As such, the Alumni Center project meets the requirements of Prerequisite #1.

EA Prerequisite #2: Minimum Energy Performance

As described in Technical Report I, the Alumni Center complies with all mandatory provisions of ASHRAE/IESNA Standard 90.1-2004 including equipment efficiencies, wall constructions, and lighting densities. The Alumni Center project meets the requirements of Prerequisite #2.

EA Prerequisite #3: Fundamental Refrigerant Management

Each AHU for the Alumni Center uses R-22 refrigerant, which is HCFC-based refrigerant. Since the project does not use any CFC-based refrigerant the requirements for EA Prerequisite #3 have been met.

EA Credit 1: Optimize Energy Performance

A baseline energy model was built in compliance with Appendix G of ASHRAE Standard 90.1 to compare to the energy model that was built to match the existing design. The baseline energy model uses direct expansion cooling and natural gas fired boilers to provide hot water to the heating coils. A detailed summary of the energy model of the current design is available in Section 4 of Technical Report II. The results of the comparative study of energy models are shown in Table 5. No credits are available for optimizing energy performance until the actual design saves 10.5% from the baseline annual energy cost.

Table 5 – Energy Model Comparative Study

	Annual Energy Cost
ASHRAE 90.1 Baseline	$71,418
Actual Design	$68,714
% Savings	3.79%

EA Credit 2: On-Site Renewable Energy
The project is not equipped with any non-polluting or renewable energy sources such as solar, wind, geothermal, hydro, etc. Therefore, no credit is given for EA Credit 2.

EA Credit 3: Enhanced Commissioning
No provisions have been made for the enhanced commissioning of the new Alumni Center. The budget set forth by the Alumni Association does not include funds for this service. Therefore, no credit is awarded for EA Credit 3.

EA Credit 4: Enhanced Refrigerant Management
To earn EA Credit 4 the result to the calculations described in LEED NC-2.2 must show that the refrigerant impact per ton of cooling is below 100. Because R-22 refrigerant is not a favorable refrigerant its impact per ton for this project is 770.9 as shown in Appendix 5.

EA Credit 5: Measurement & Verification
No provisions have been made for the measurement and verification of the new Alumni Center's energy performance. The budget set forth by the Alumni Association does not include funds for this service. Therefore, no credit is awarded for EA Credit 5.

EA Credit 6: Green Power
To receive this credit the Alumni Center would have to provide at least 35% of their electricity from renewable sources through a 2-year renewable energy contract. No such contract has been established and thus no credit can be awarded for EA Credit 6.

10.2 Indoor Environmental Quality

EQ Prerequisite 1: Minimum IAQ Performance
The ventilation rates and other IAQ factors for the Alumni Center meet the minimum required values as established in Sections 4 through 7 of ASHRAE Standard 62.1. Details on the Alumni Center's compliance with this Standard are available in Technical Report I. The project meets the requirements of EQ Prerequisite 1.

EQ Prerequisite 2: Environmental Tobacco Smoke Control
As a university building, The Alumni Center is a smoke-free facility and all designated smoking areas are a minimum of 25 feet from entries, outdoor air intakes and operable windows. As such the project meets the requirements of EQ Prerequisite 2.

EQ Credit 1: Outdoor Air Delivery Monitoring
Densely occupied spaces such as the Banquet Hall and conference rooms do not have CO_2 monitoring devices as required to gain this credit. The AHU sequence of operations dictates that when the AHU's are in occupied mode they will provide the minimum ventilation rate as described on the mechanical equipment schedules. Therefore, no credit is given for EQ Credit 1.

EQ Credit 2: Increased Ventilation
To receive this credit the designer would have to design the system to provide ventilation rates that are 30% above those required by ASHRAE Standard 62.1. The AHU's are designed to provide the minimum ventilation rates are require by Standard 62.1 and therefore no credit can be awarded for EQ Credit 2.

EQ Credit 3.1: Construction IAQ Management Plan: During Construction
In-depth information on the compliance with the requirements of this credit was not available from the general contractor. However, it is suspected that there is not an indoor air quality management plan for the construction and pre-occupancy phases of the building. General guidelines were used for storing materials with offensive or dangerous odors and minimum filtering was used on all air distribution equipment that was utilized during construction phases. Without more information, no credit could be awarded for EQ Credit 3.1.

EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy
The Alumni Center is currently under construction and has not reached the point of the project where this credit could be earned. If prior to occupancy the building is flushed out according to Option 1 of this credit or by testing for air pollutants as stated in Option 2 of this credit the point may be earned. However, there is no current plan to provide either of these services. Therefore, the requirements for this credit have not been meet.

EQ Credit 6.2: Controllability of Systems: Thermal Comfort
In order to receive this credit there must be individual comfort control for 50% of building occupants and also comfort control to meet the needs of multi-occupant spaces. Many of the variable volume boxes for the building serve more than two individual offices. As such, the system does not meet the requirement of have individual comfort control for 50% of the building occupants. This credit cannot be awarded with the current system layout.

EQ Credit 7.1: Thermal Comfort: Design
The Alumni Center project meets the requirement of this credit by having the indoor design conditions within the envelope of human comfort as established in ASHRAE Standard 55-2004.

EQ Credit 7.2: Thermal Comfort: Verification
To receive this credit the Alumni Association must distribute a survey to building occupants within six to 18 months after occupancy. If more than 20% of occupants are dissatisfied with the thermal comfort of

the building the Alumni Association must provide corrective action. There is currently no plan for the distribution of a thermal comfort survey, so no credit can be awarded in this category.

10.3 Gaining Addition Credits

Under the current design and specifications there are many LEED credits that cannot be achieved. However, many of these credits can be gained by planning ahead and creating plans for things such as IAQ during construction, placing CO_2 monitors in transiently occupied spaces, and design, verification and controllability of thermal comfort. There may be significant added cost for supplying these services and design changes and the Alumni Association would need to carefully weigh the capital cost against the benefits and payback of each option.

11.0 Overall System Evaluation

11.1 Original Design

The minimal capital budget for this project dictated the complexity and performance of the designed system. The original design for the project included a central plant that included several air-cooled chillers with a water/glycol mix for the chilled water coils of each AHU and a central boiler system that provided hot water to the heating coils of each AHU and the reheat coils in each VAV box. The bids for this system came in over budget and the design had to be modified. The design engineers provided the Alumni Association with information that showed that the central plant design would decrease annual energy cost by $19,000 per year when compared to the packaged rooftop design. However, this project was first cost driven and the annual energy cost was not a major factor in system selection.

11.2 Value Engineered Design-Packaged Rooftop System

Construction Cost

The construction cost of 13.33% of the overall project cost is low compared to similar buildings in the same market. Owners typically budget 15-25% of the overall project cost of office buildings for mechanical systems. Because this design is simple and designed to provide a low first cost, it is reasonable that the construction cost would be below average.

Space Requirements

Inherent with a packaged rooftop system is a minimal space requirement. Since all of the mechanical equipment is located on the roof, only a small mechanical room is necessary for the domestic hot water heaters and emergency generator. The only additional space required for this system is the vertical shaft space, which is a very small percentage of the overall area of the building. The implementation of any other mechanical system will most likely require the use of more building area.

Maintainability

The packaged rooftop system is very simple to maintain. There is little maintenance required as there are no pumps, chillers, or boilers to maintain. On the AHU's the coils must be cleaned, filters replaced and the fan must be maintained. All aspects that must be maintained are easily accessible as they are either on the roof or above drop ceilings. Overall, the annual maintenance costs are very low compared to other systems that could be implemented.

Final Thoughts

While the low construction cost, minimal space requirements and low maintenance cost create a positive feeling for the design that was implemented, these factors alone do not provide the entire picture of the system. The AHU's that were specified by the design engineer are available in both R-22 and R-410a models. To reduce the first cost, the mechanical contractor chose to install the R-22 version of the AHU's. Starting in 2020, R-22 will no longer be produced or imported in accordance with the Montreal Protocol because it is harmful to the ozone layer and may cause global warming. That deadline is only 12 years away, and the expected life of a rooftop AHU is approximately 15-20 years. This means that in 12 years the equipment will need to be replaced with equipment that uses a non-phase out refrigerant. The cost of new equipment should be included in a 20 year lifecycle cost comparison of multiple systems, along with their relative annual energy costs, to determine the system that has the lowest lifecycle cost. Systems that may be evaluated may be the packaged rooftop system, central plant with air-cooled chillers and hot water boilers, and a ground loop heat pump system.

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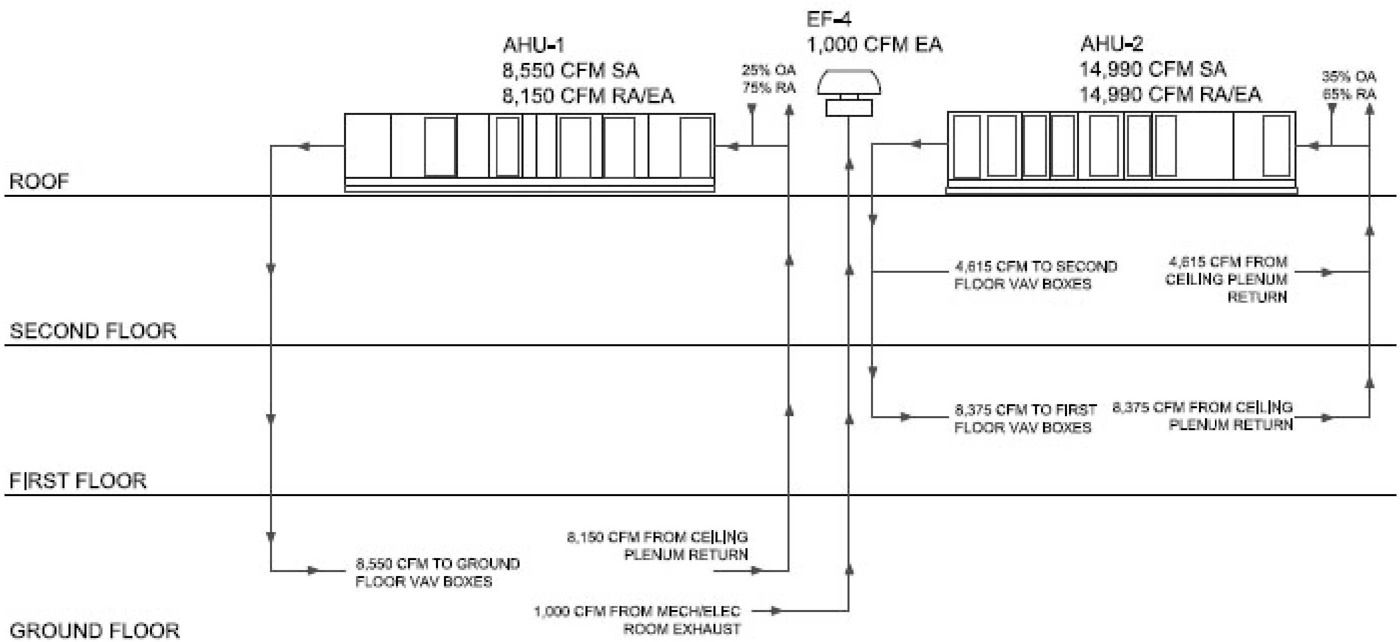
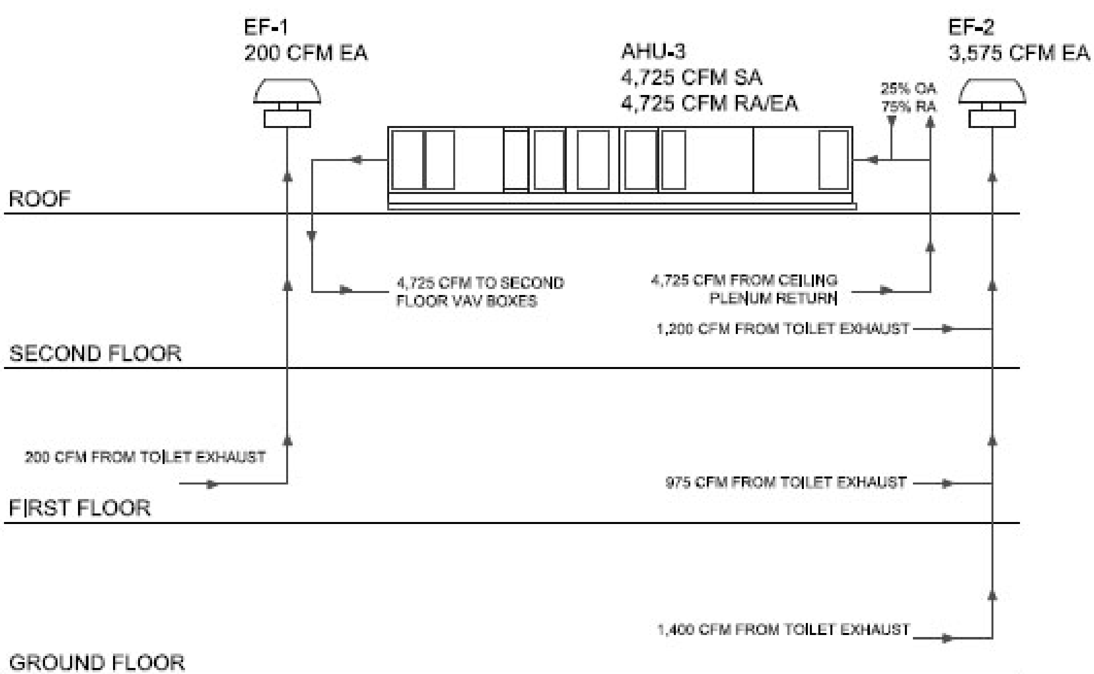
Appendix 1 – Major Equipment Summary

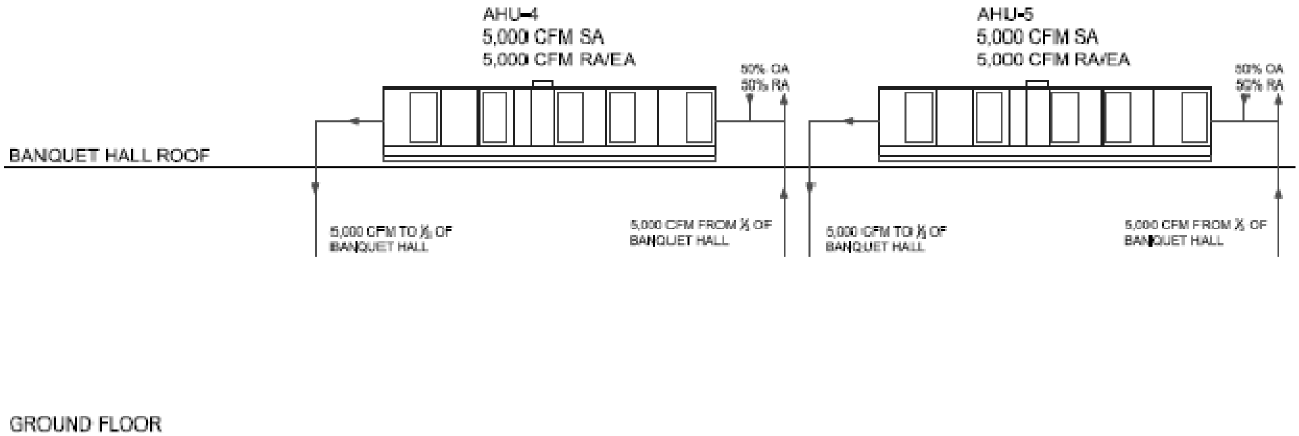
	Total CFM	% OA	Supply Fan Data			Cooling Coil		Condenser Fans		Gas Furnace		Exhaust/Return			Phase/Volt
			Total SP	Fan HP	Fan VFD	TOT MBH	SENS MBH	QTY	Fan HP	Input MBH	Output MBH	CFM	HP	VFD	
AHU-1	8550	25	3.97	15	Yes	306	235	3	0.75	270	218.7	8150	7.5	Yes	3/480V
AHU-2	14990	35	4.28	2(15)	Yes	624	453	4	0.75	780	632	14990	15	Yes	3/480V
AHU-3	4725	25	3.24	7.5	Yes	171	130	2	0.75	270	218.7	4725	2(5)	Yes	3/480V
AHU-4	5000	50	2.85	7.5	No	224	157	2	0.75	390	315.9	5000	3	No	3/480V
AHU-5	5000	50	2.85	7.5	No	224	157	2	0.75	390	315.9	5000	3	No	3/480V
AHU-6	5000	50	2.85	7.5	No	224	157	2	0.75	390	315.9	5000	3	No	3/480V
AHU-7	5455	100	3.16	7.5	No	305	197	4	0.75	780	631.8	5455	5	Yes	3/480V
AHU-8	8620	100	2.5	15	No					940	750			No	3/480V
AHU-9	10000	20	3.53	15	No	347	269	4	0.75	540	437	10000	7.5	No	3/480V

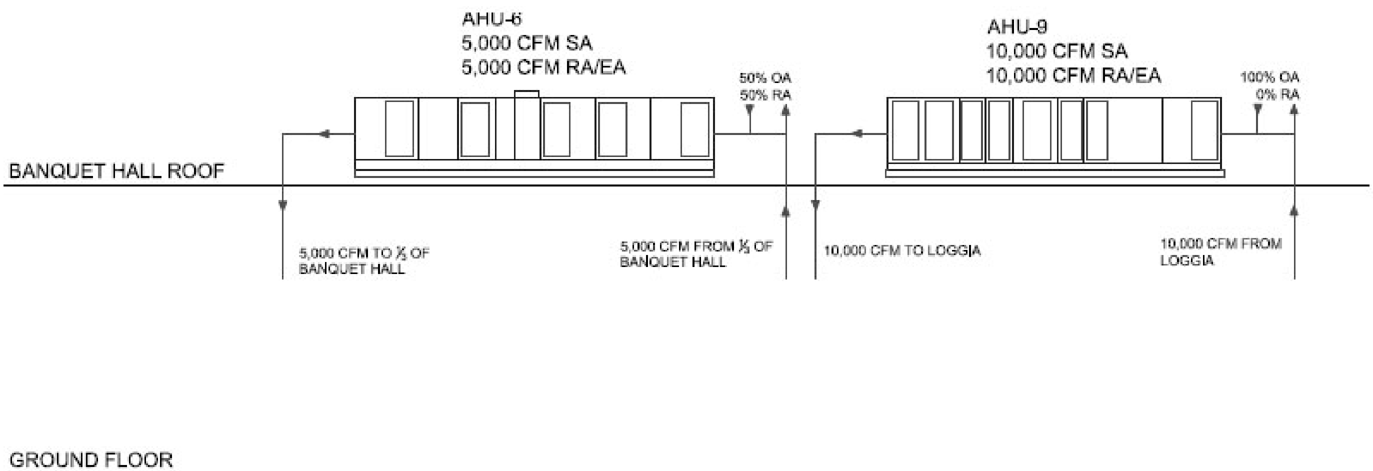
Appendix 2 – Main Building Air Distribution Schematics



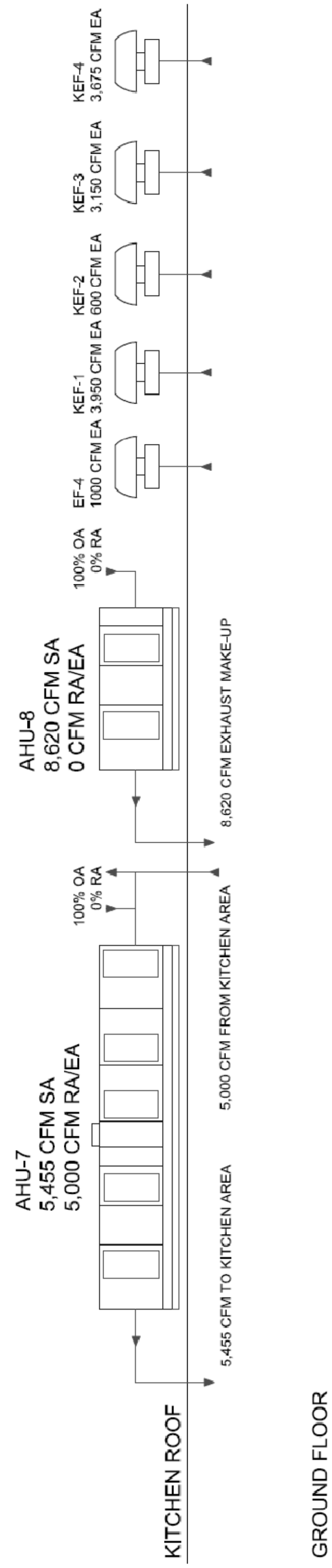


Appendix 3 – Banquet Hall/Loggia Air Distribution Schematics





Appendix 4 – Kitchen Air Distribution Schematic



Appendix 5 – Enhanced Refrigerant Management

HVAC&R Equipment Type	N	Q (tons)	Refrig-erant	GWPr	ODPr	Rc (lb/ton)	Life (yrs)	Lr (%)	Mr (%)	LCGWP	LCODP x10^5	Refrigerant Impact per ton	Refrigerant Impact Total	
Packaged AC or Heat Pump	1	25.5	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	19,652	Clear
Packaged AC or Heat Pump	1	48	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	36,992	Clear
Packaged AC or Heat Pump	1	14.3	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	10,982	Clear
Packaged AC or Heat Pump	3	18.7	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	43,165	Clear
Packaged AC or Heat Pump	1	25.4	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	19,575	Clear
Packaged AC or Heat Pump	1	28.9	R-22	1,780	0.04	5.00	15	2	10	237.3	533.3	770.7	22,272	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
								2	10	0	0	0	0	Clear
Total Tons:	**198**										**Total:**	**770.9**	**152,638**	

Total Refrigerant impact per ton must be less than or equal to 100 to achieve points for this credit.