Technical Report Three

Mechanical Systems Existing Conditions Evaluation

Father O'Connell Hall Renovation

The Catholic University of America
Washington, D.C

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Executive Summery

The purpose of this report is to analyze the mechanical system of Father O'Connell Hall located on The Catholic University of America in Washington, DC. The mechanical system first cost is $1.6 million about 13% of the total building costs. It was calculated that it costs approximately $44.67 per square foot. In addition to first cost, it was calculated that the average annual utility costs is $17,000. Father O'Connell Hall consumes about 289,522 kWh of electricity and 2,010 therms of natural gas.

An overall system evaluation was performed on the mechanical design system in order to determine potential improvements. Ventilation, design requirements, heating and cooling loads, energy consumption, mechanical costs, and a LEED analysis was done. The analysis did reveal some potential design changes that may increase energy savings. These changes will be analyzed in future reports.

Building Overview

Father O'Connell Hall is a 54,000 SF, $15 million exterior and interior renovation on the campus of The Catholic University of America in Washington, DC. Father O'Connell Hall has three conjoined structures: the four story main building constructed in 1914, the three story east wing constructed in 1958, and the west wing constructed in 1962. Figure 1 below shows the three conjoined structures as well as the site on The Catholic University of America's campus. The Hall is the third oldest building on campus; the renovation will preserve the historical Catholic culture which The Catholic University of America reflects in our nation's capital. Father O'Connell Hall will be used for administrative/Enrollment services, admissions, financial aid, and a banquet hall which will be used to hold special events. The design sells the school while still reflecting the rich historical tradition of The Catholic University of America and of the surrounding buildings.

The façade is primarily granite stone with Indiana limstone. The façade is broken up with a series of two story arched windows along the main building of the banquet hall, while the east and west wings use large rectangular one story windows. This closley represents a historic collegiate gothic style.

Figure 1: Father O'Connell Hall located on The Catholic University Campus.

Mechanical System

Design Objectives and Requirements

Father O'Connell Hall was previously serves as the history department building as well as student housing. The renovation will relocate both of these and will house the new Catholic University of America's financial aid, admissions, and administration offices. The building will also have a 200 person events/banquet hall. Father O'Connell Hall is the third oldest building on campus dating back to 1916. Strict historic preservation codes must be taken into account during the renovation. There are no current plans for future expansion.

Due to the requirements stated above the new mechanical system must take into account the new occupation of the building as well as obey all historical preservation codes. The design objectives clearly state that individually controlled spaces are desired to maximize occupant comfort. This may cause some challenges due to very tight existing structural conditions. In addition, the building has very poor insulation which creates extremely large heating and cooling loads in perimeter spaces. All systems will be designed in accordance to IBC 2006, as amended by the DC construction codes supplement of 2008 and ASHRAE Standards. Additional mechanical considerations include noise control, simple controls, and easy maintenance checks.

Design Conditions

Father O'Connell Hall is located in Washington, D.C which is in weather region 5A found in ASHRAE. ASHRAE Standard design conditions for Washington, D.C can be seen in figure 1 below.

Outdoor Design Temperature		
	Winter (°F)	Summer (°F)
Outdoor Design Conditions	14 db/11 wb	93 db/76 wb

Table 1: Outdoor Design Temperature

To provide a comfortable indoor environment the mechanical engineers require the following interior design conditions. The temperatures and relative humidity can be seen in Figure 2and Figure 3 below.

Indoor Design Temperature		
	Winter (°F)	Summer (°F)
Occupied	72	76
Unoccupied	55	85

Table 2: Indoor Design Temperature

Humidity		
	Winter (%RG)	Summer (%RH)
	25 ± (5)	50 ± 5

Table 3: Relative Humidity

Ventilation

Ventilation rates were calculated using the procedure from ASHRAE Standard 62.1-2010 Section 6. Air handling units 2,4,5,6 and 100% outside AHU (OAHU-1) were analyzed to estimate minimum outside air requirements for all spaces. Existing air handling units 1 and 3 were not able to be analyzed due to lack of information in the project documentation. AHU's 1 and 3 only provide ventilation for a small portion of the building which was not in the scope of this renovation. Table 4 below is a summary of all five air handlers that were analyzed. Design CFM and Minimum OA CFM were taken from the project documentation and compared to ASHRAE 62.1 Min. OA CFM calculated values. Detailed spreadsheets used for these calculations are available in Appendix A.

Minimum Ventilation Rates				
Unit	Design CFM	Minimum OA CFM	ASHRAE 62.1 Min. OA CFM	Compliant (Y/N)
OAHU-1	1800	1800	1400	Y
(E)AHU-2	7790	1861	1171	Y
AHU-4	4100	1480	613	Y
AHU-5	8000	1480	1479	Y
AHU-6	3500	500	381	Y

Table 4: Minimum Ventilation Rates

Heating and Cooling Loads

Father O'Connell Hall Renovation building load and energy modal was done using Trane Trace 700. This is an accepted program by many building industry professionals for load and energy consumption calculations. Trane was utilized to calculate ventilation loads, heating and cooling loads, and annual energy and operating costs at Father O'Connell Hall. Block loading was done since time was a sensitive issue. Restrooms and stairwells were neglected since these would not contribute to any cooling loads. Also existing zones that were not renovated were also neglected for these calculations. These block zones can be seen in the Figures 3-7 below. Specific parameters for Father O'Connell Hall were taken into account to calculate accurate loads. Some of the parameters include lighting, occupancy schedules, construction, and building orientation. Figures 8 and 9 below show the calculated data compared to the designed data. As you can see reasonably accurate loads were calculated compared with design documents.

Unit	Design (CFM)	Calculated (CFM)	Error (%)
AHU-2	7790	7446	4.4
AHU-4	4100	3537	13.7
AHU-5	8000	9090	-13.6
AHU-6	3500	3302	5.7
OAHU-1	1800	1697	5.7

Table 5: Ventilation Error

Design vs Calculated Energy Capacities			
Cooling		Heating	
Design (Tons)	97.7	Design (MBh)	1000
Calculated (Tons)	105.1	Calculated (MBh)	1122
Error (%)	7.6	Error (%)	12.2

Table 6: Design vs. Calculated Energy Capacities

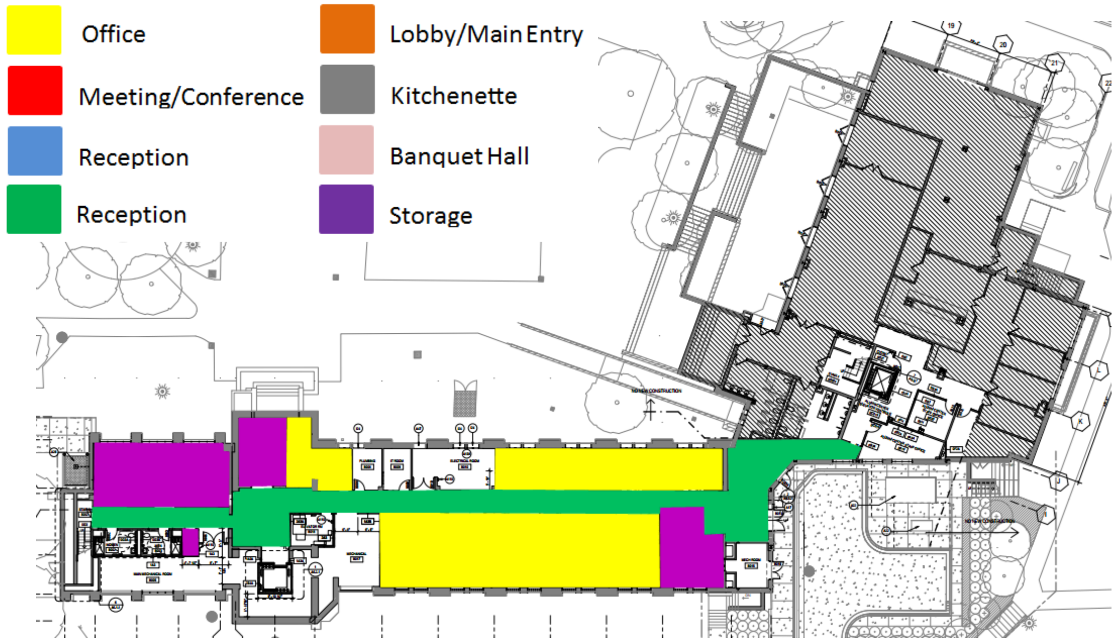

Figure 2: Basement Level Block Loads

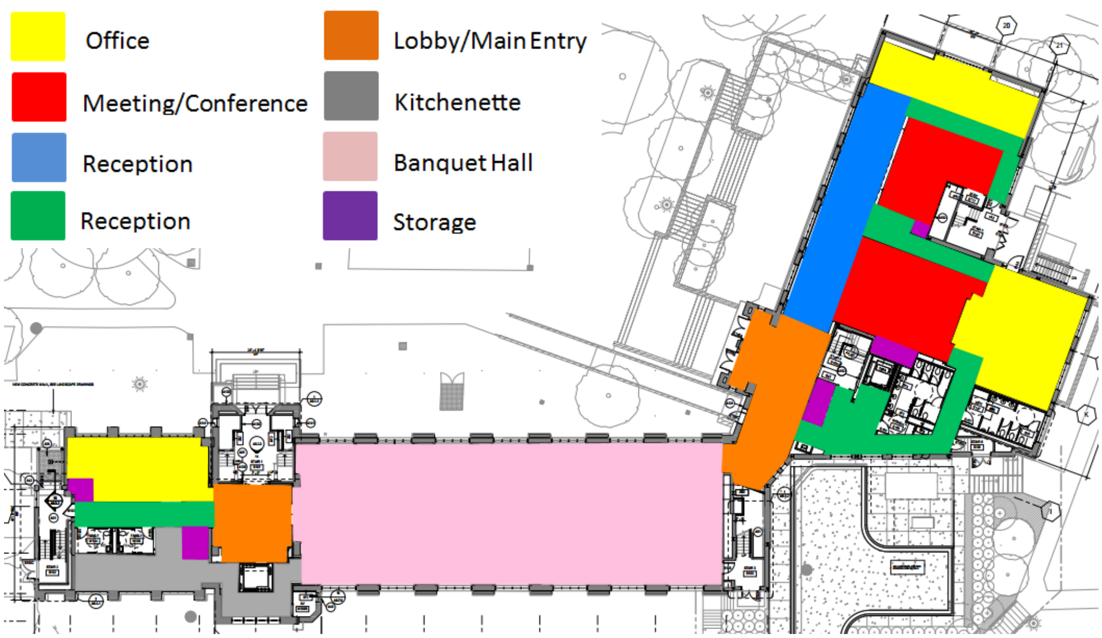

Figure 3: First Floor Block Loads

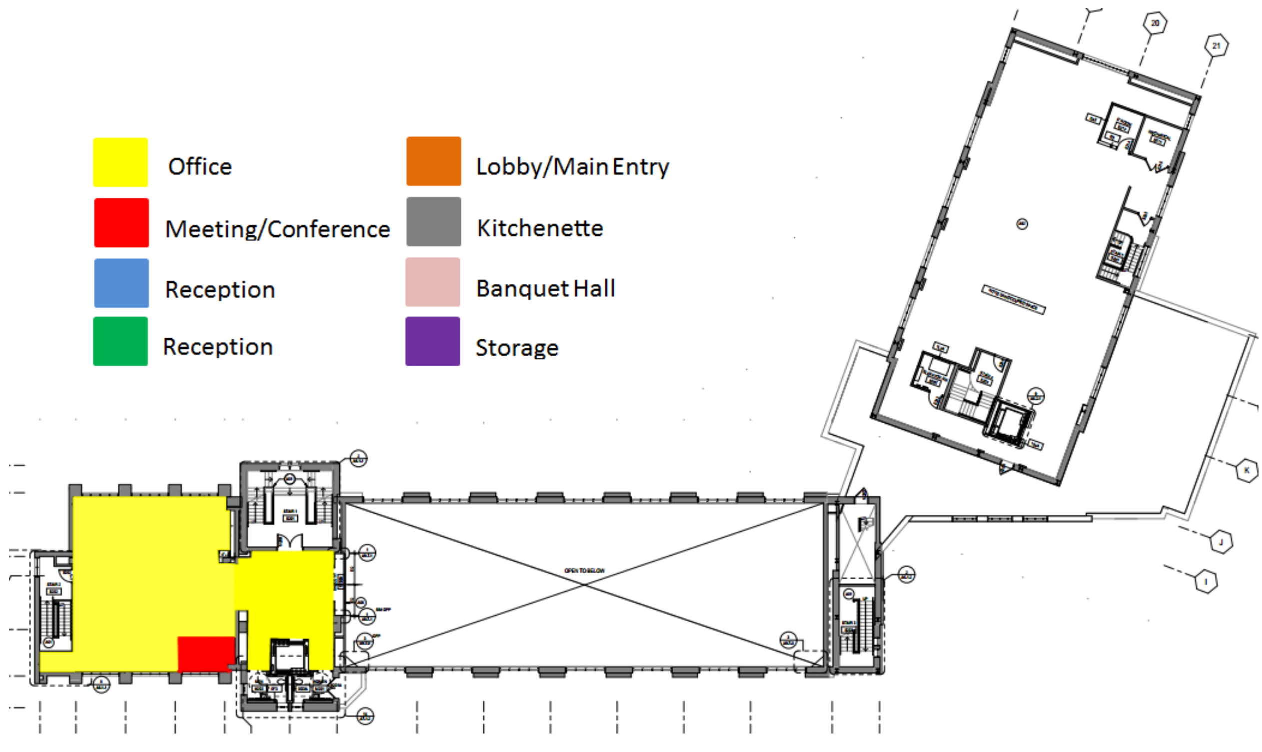

Figure 4: Second Floor Block Loads

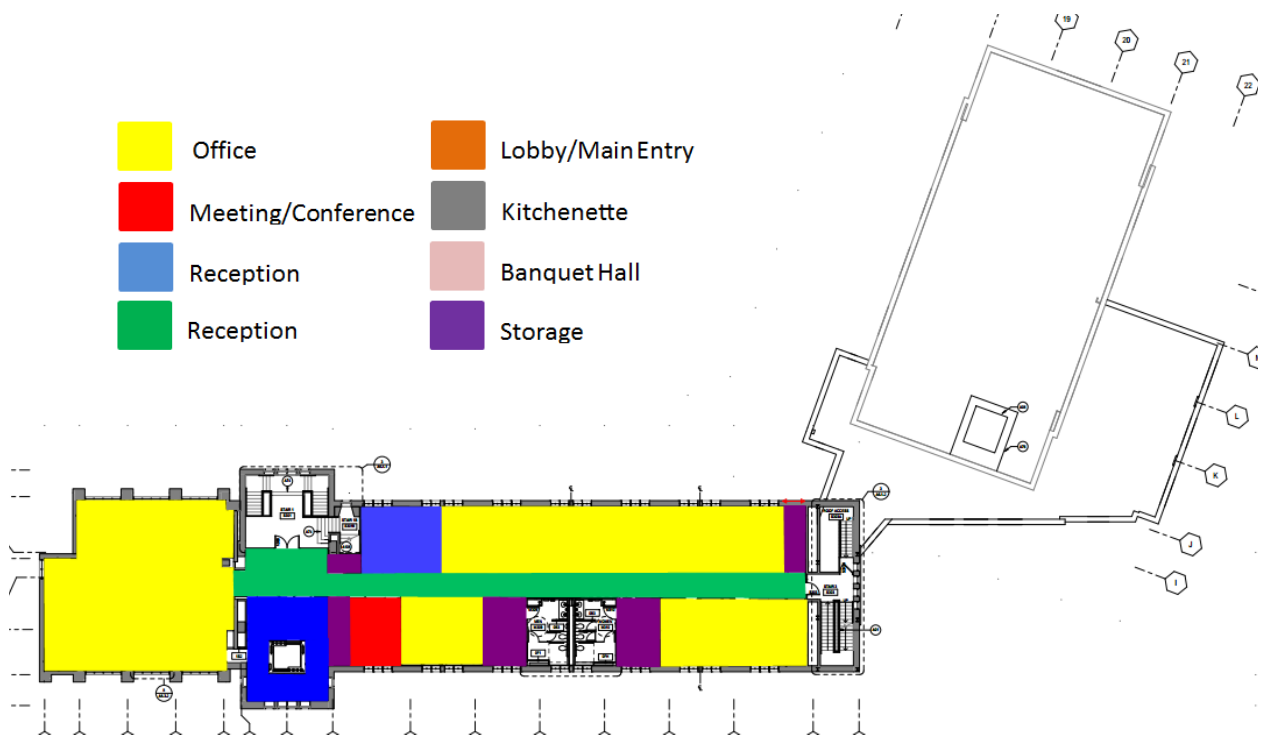

Figure 5: Third Floor Block Loads

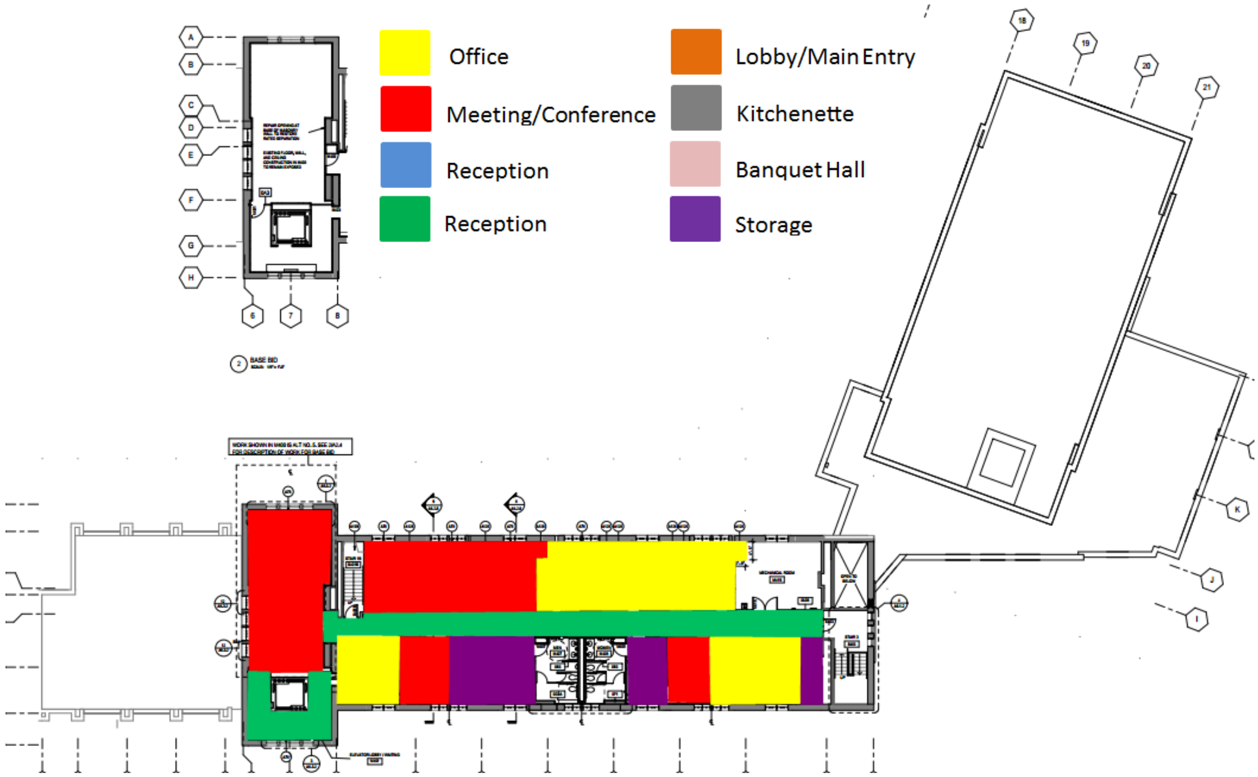

Figure 6: Fourth Floor Block Loads

Annual Energy Consumption and Cost

Trace was also used to calculate Father O'Connell's energy usage and cost. The Annual energy consumption and cost can be seen below in Table 10. No measured data is available for comparison.

Annual Energy Consumption and Cost				
Electricity (kWh)	Electricity Cost Per Year	Natural Gas (Therms)	Natural Gas Cost Per Year	Total Cost Per Year
289,522	14,955	$2,010	3,096	$16,965

Table 7: Annual Energy Consumption and Cost

Mechanical Equipment Summary

Father O'Connell Hall is ventilated using seven air handling units, with one being 100% outdoor air. *Figure 2* on the following page shows the zoning for each air handling units throughout the building. All New AHU's will be equipped with economizer cycle to maximize ventilation and reduce energy. The 100% outdoor air unit will also have an air-to-air heat plate exchanger as well as a wraparound pipe heat recovery exchanger to pre-condition supply air temperatures and further reduce energy consumption. Recirculation of this air is provided by fan powered boxes, VAV's, and air transfer ducts located in the plenum above the ceiling on the basement and first floors.

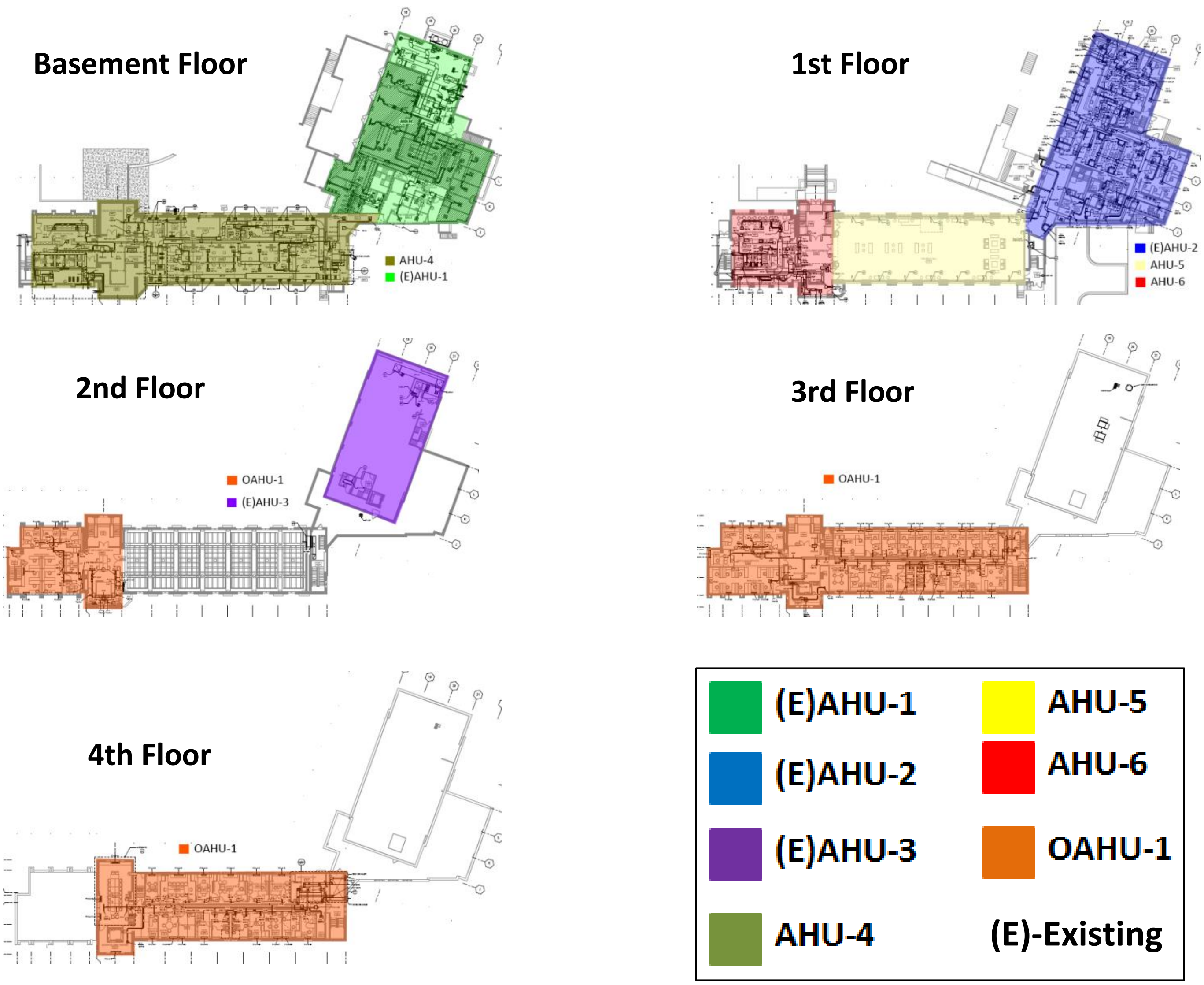

Figure 7: Air Handling Unit Zoning

Chilled Water System

Chilled water is provided from one 97.7 ton electric air-cooled chiller located on grade on the south side of east wing. Chilled water is provided directly to all AHU's and all FCU's located on floors 2 to 4. Chilled water flow delivered to all AHU's and FCU's is controlled by a proportional integral controller (PIC) control valve regulated by two chilled water pumps with VFD's. Additional cooling for two telecom rooms is provided by two ductless split system units.

Heating Hot Water System

Washington Gas Company provides a low pressure (2 psi), 2 inch gas pipe to two 500 MBH condensing pulse combustion boilers located on the basement level of the west wing. These boilers provide all hot water to the AHU's, FCU's, and reheat coils for the VAV's and Fan powered boxes. The hot water flow is controlled the same way as the chilled water system using three heat water pumps with VFD's. There are two additional existing boilers located in the east wing of the basement floor. These boilers provide heating to the small portion of the building that is not in the scope of this renovation. Information for this portion of the building is not available at this time.

Tables 11 to 15 below breakdown the major mechanical equipment used. In addition to the equipment listed below 62 fan coil units, 12 fan powered boxes, and 11 variable air volume boxes are used.

Air Handling Unit Schedule						
Tag	Supply Airflow (CFM)	Outside Airflow (CFM)	Cooling Coil LAT DB (°F)	Heating Coil LAT DB (°F)	Total Capacity (MBH)	VFD
AHU-4	4100	745	54	85	150	Y
AHU-5	8000	1480	54	85	274	Y
AHU-6	3500	500	54	85	113	Y
OAHU-1	1800	1800	55	70	88.5	Y

Table 8: Air Handling Unit Schedule

Chiller Schedule (Electric Air-Cooled)					
Tag	Tons	Electrical Volts	Evaporator		Condenser
			GPM	LWT (°F)	Ambient Temp (°F)
CH-1	97.7	208	195.3	42	95

Table 9: Chiller Schedule

Boiler Schedule (Hot Water)						
Tag	Type	Input (MBH)	Flowrate (GPM)	EWT (°F)	LWT (°F)	Electrical Volts
B-1	Condensing-Pulse Combustion	500	45	140	160	120
B-2	Condensing-Pulse Combustion	500	45	140	160	120

Table 10: Boiler Schedule

Pump Schedule							
Tag	Flowrate (GPM)	Discharge Head (FT WG)	Minimum Efficiency	Motor Data			VFD
				HP	LWT (°F)	Electrical Volts	
CHWP-1	180	85	72	7.5	1750	208	Yes
CHWP-2	180	85	72	7.5	1750	208	Yes
HHWP-1	45	50	57	1.5	1750	120	Yes
HHWP-2	45	50	57	1.5	1750	120	Yes
HHWP-3	45	50	57	1.5	1750	120	Yes

Table 11: Pump Schedule

Fan Schedule						
Tag	Design (CFM)	Type	External SP (In wg)	HP	Electrical Volts	VFD
EF-1-01	300	Centrifugal	0.25	0.167	120	Yes
EF-1-02	300	Centrifugal	0.25	0.167	120	Yes
EF-1-03	300	Centrifugal	0.25	0.167	120	Yes
EF-2-01	820	Centrifugal	0.3	0.25	120	Yes
EF-B-01	100	Centrifugal	0.25	0.167	120	Yes
EF-B-02	520	Centrifugal	0.4	0.25	120	Yes

Table 12: Fan Schedule

Mechanical First Costs

The mechanical system at Father O'Connell Hall has a first cost estimate of about 1.6 million dollars or $44.67 per square foot. Table 11 below shows all service first cost estimates. Graph 1 below breaks up the mechanical costs for detail estimates. Major miscellaneous costs in Graph 1 include sheet metal, piping, and insulation.

Service Costs	Cost
Mechanical	1,593,323
Demo	12,850
Central Plant	253,708
Distribution	949,165
Controls and BAS	256,875
Testing and Balancing	20,625
Miscellaneous	100,100
Electrical	1,091,650
Plumbing	447,595
Fireprotection	262,770
Elevators	348,015
Total	**3,743,353**

Table 13: Service Costs

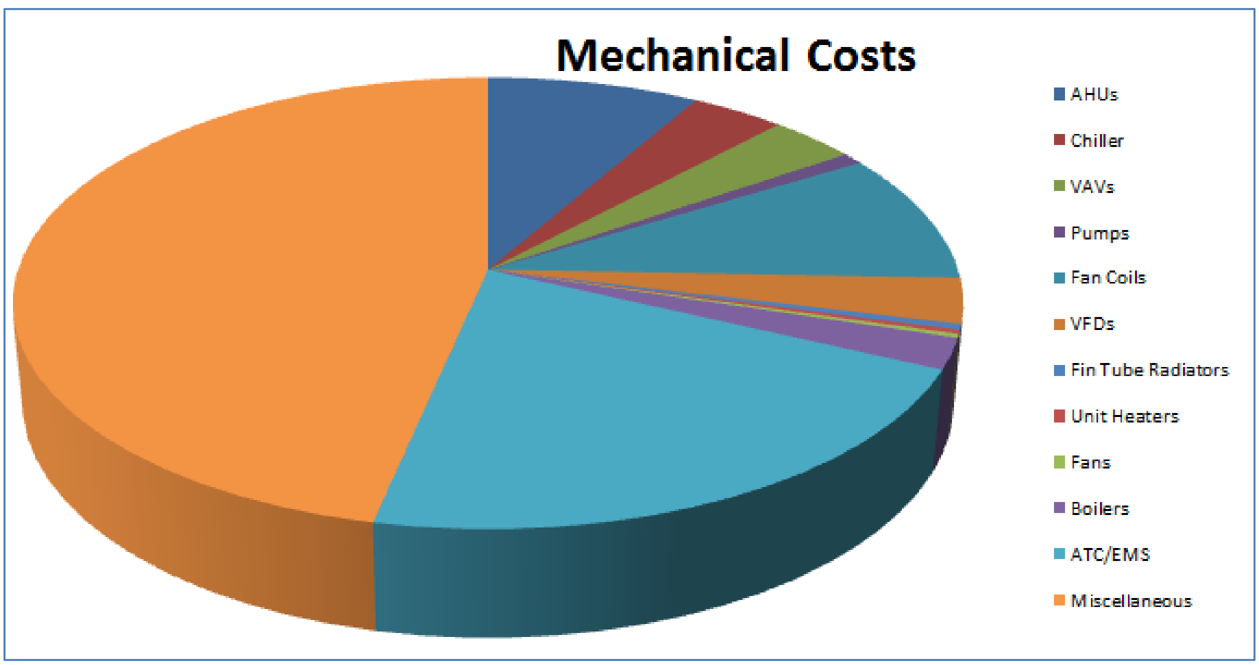

Figure 8: Mechanical Costs

Mechanical Operation and Schematics

Air-Side Operations

Air Handling Units 4, 5, and 6

Air handling units 4, 5, and 6 are controlled identically since they serve similar spaces in Father O'Connell Hall. These units serve floors one and two, while AHU-5 strictly serves the banquet hall. The air handling unit is initialized when the automatic outdoor damper is open. The supply fan is equipped with a VFD that is controlled by pressure sensors. The return air is controlled by an exhaust fan, also equipped with a VFD. A mixing box is placed in the plenum above the air handling unit and dampers control how much return air mixes with outdoor air. Most of the spaces are office spaces so the recirculation of air does not violate any of ASHRAE standards. The air handling units contain an economizer cycle utilize free cooling when the outdoor weather conditions permit.

Outdoor Air Handling Unit OAHU-1

Floors two, three, and four are ventilated from the 100% outdoor air handling unit (OAHU) located on the fourth floor. OAHU can be very beneficial and significant energy savers since it uses much less fan energy. The supply fan and return fan are both equipped with VFDs. Both the fans speed is controlled by the BMS. In addition, and Air-To-Plate heat exchanger is used between the exhaust air and the supply outdoor air. This is used to preheat the outdoor air before the coils. Furthermore, a wraparound heat pipe recovery exchanger is also used. These heat exchangers are important to preheat the outside air and used for humidity control. An economizer cycle is also used. This is dependent on the outdoor air wet bulb temperature. An optimal start is utilized to provide a comfortable environment when employees arrive in the morning. A sound silencer is used to isolate sound from the supply fan because adjacent to the mechanical room on the fourth floor is office space.

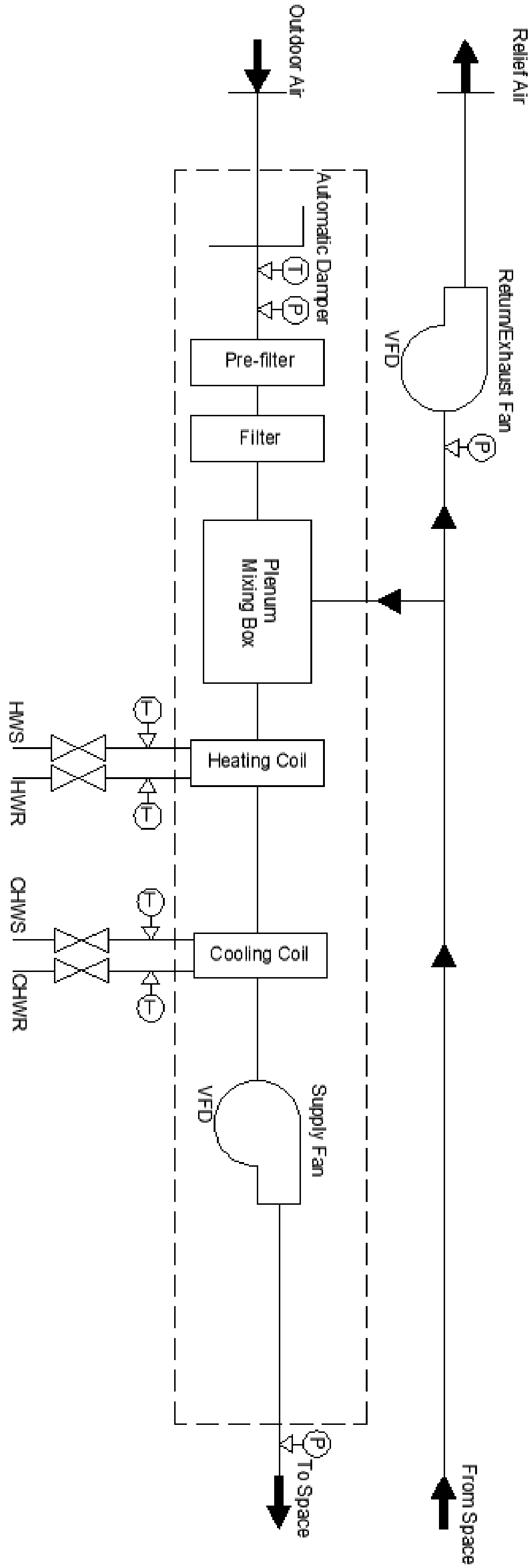

Figure 9 Typical Air handling Unit Schematic

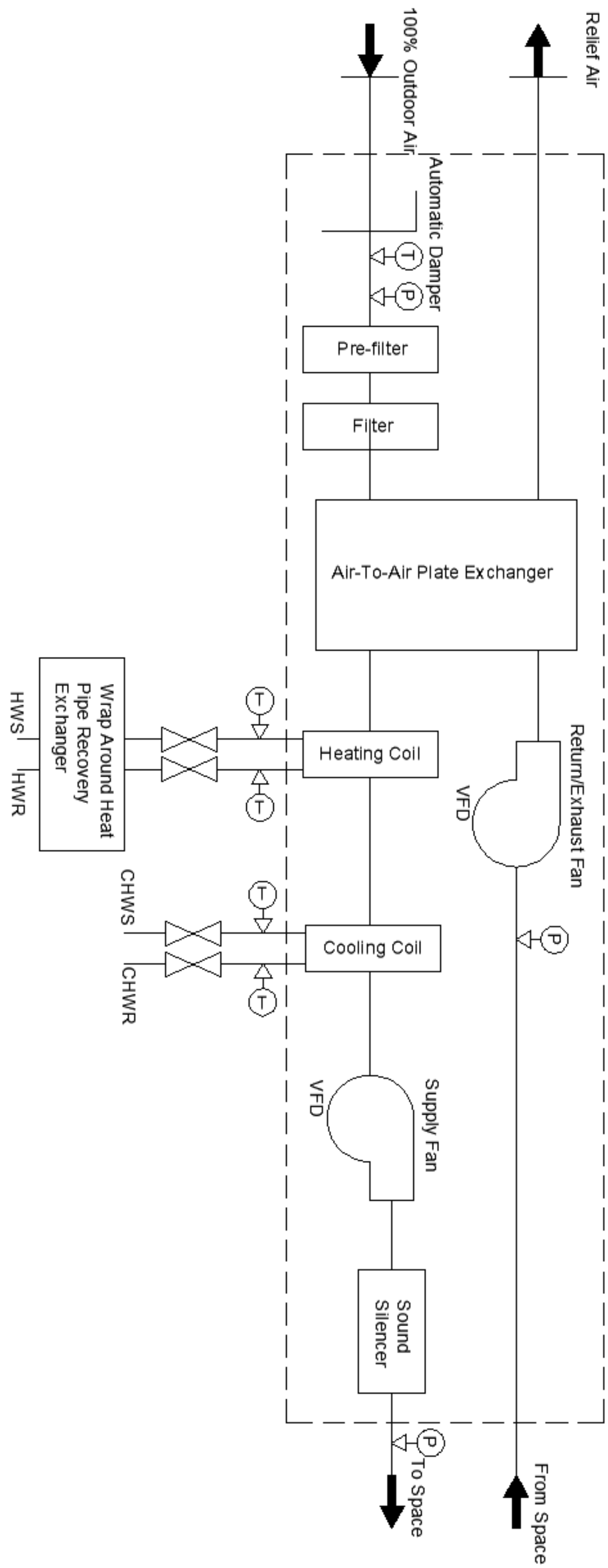

Figure 10: Outdoor Air Handling Unit Schematic

Water-Side Operations

Hot Water System

The hot water system consists of two lead/lag condensing boilers. Once the building management system (BMS) enables the heating hot water system controlled by the time and season schedules, the ModSync controller starts the lead boiler at the same time that it starts the lead primary hearing hot water pump. When the ModSync controller senses that the single boiler cannot meet heating loads a signal is sent to the BMS indicating the need for the lad primary hot water pump. Once the lag heating hot water pump is started the lag boiler is started. An additional heating hot water pump with a bypass valve is in the loop intended for backup. If a hot water pump shall fail, an alarm will set and the backup pump will automatically start. The boilers have been sized for an entering water temperature of 140 °F and leaving water temperature of 160 °F.

All three heating hot water pumps are equipped with Variable frequency Drive's (VFD's). The BMS monitors the differential pressure between the hot water supply and the hot water return piping in the building. If the differential pressure drops below an initial setpoint pressure of 15psi, the pump speed will increase. If the differential pressure exceeds the initial setpoint the pump speed will decrease. The initial setpoint is set at 15psi, but the actual setpoint will be set in the field. If both pumps are operating at the same time, they will be operating at the same speed. In addition, the pumps speed will be controlled to meet the minimum flow of 45 GPM to the boilers. Refer below to Figure 5 for a detailed heating hot water schematic.

Chilled Water System

The chilled water system consists of a single air cooled chiller, two primary chilled water pumps, and a bypass valve for building cooling. The two pumps are controlled using staging with a lead/lag system. Chilled water is distributed throughout the building to all air handling units and fan coil units. When the cooling load cannot be met with one pump, the BMS sends a signal to start the second pump. Like the heating hot water pumps, both chilled water pumps are equipped with VFD's and controlled the same way. Water is supplied from the chiller at a constant 42 °F.

The speed of the pumps are controlled by a differential pressure sensor between the chilled water supply and chilled water return piping. If the differential pressure drops below the initial set point of 20 psi, the pump speed will increase. If the differential pressure exceeds the set point the pump speed will decrease. The differential pressure is initially set at 20psi, but the actual pressure will be determined in the field. Refer below to Figure 6 for a detailed heating hot water schematic.

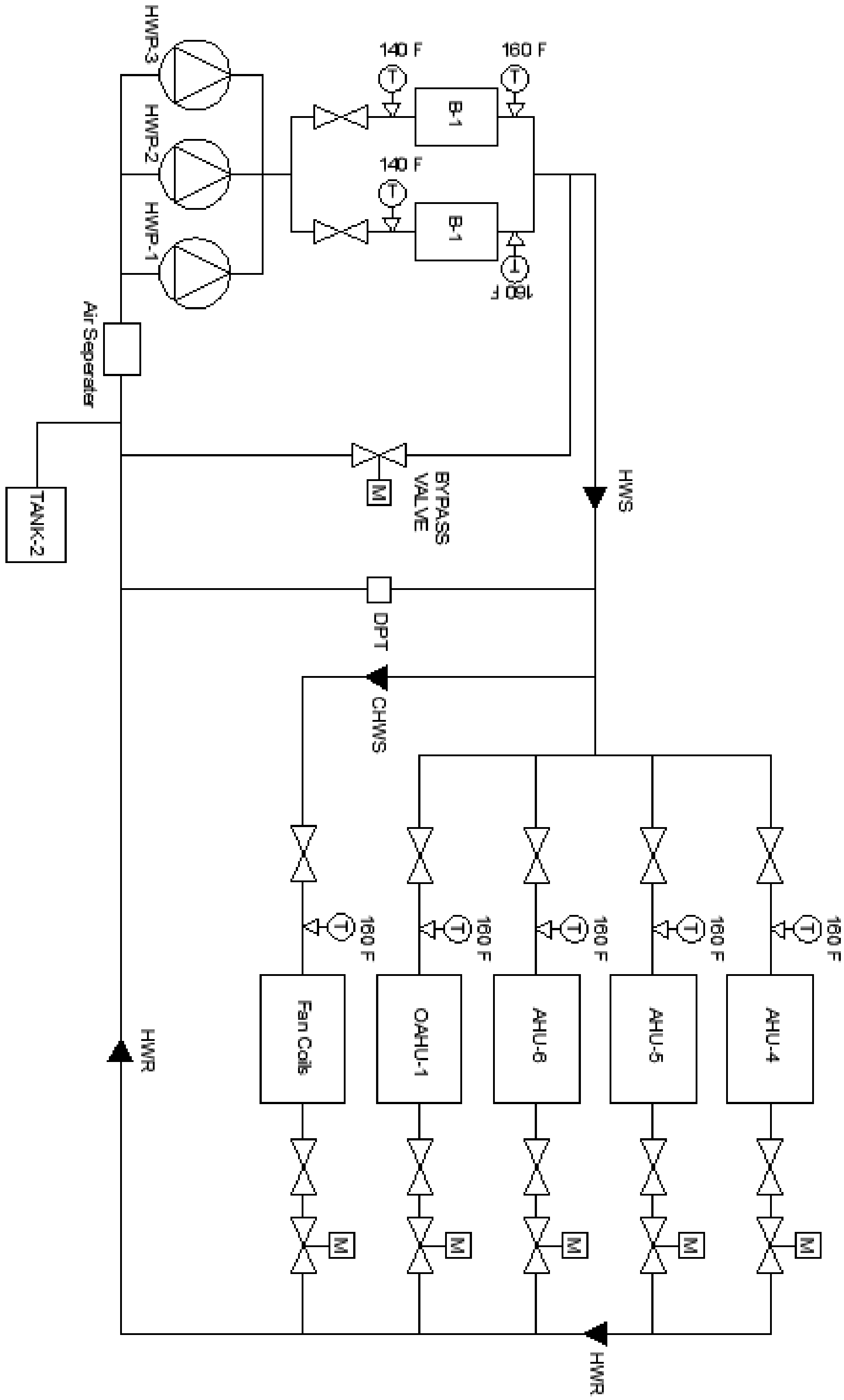

Figure 11: Heating Hot Water Schematic

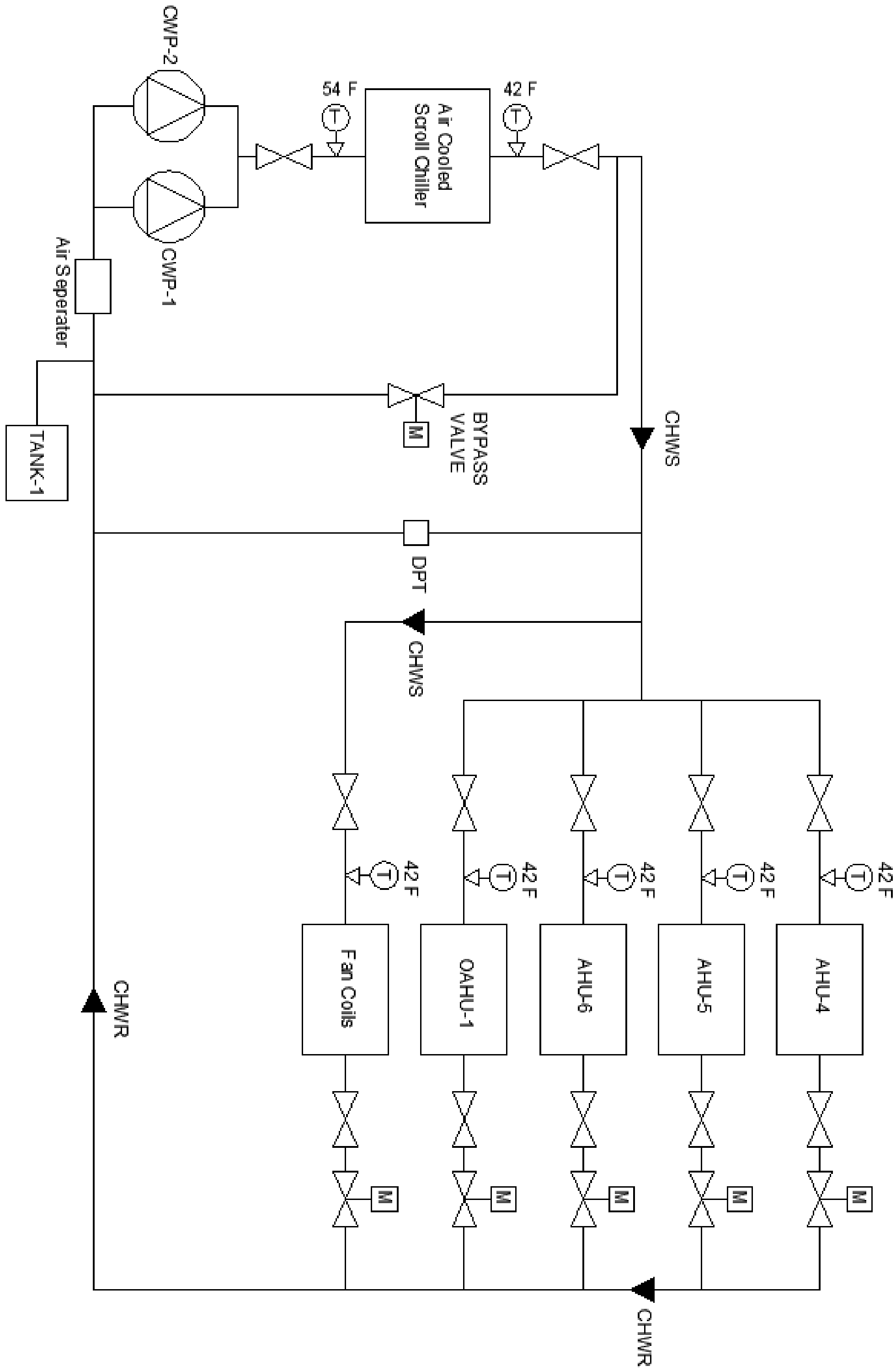

Figure 12: Chilled Water Schematic

Usable Space

Mechanical rooms and shafts take up valuable usable space in buildings. This space could be used to gain profit through tenants, however, mechanical equipment is extremely important for the building to function properly. Father O'Connell does a pretty good job limiting mechanical space throughout the building. Father O'Connell utilizes a dedicated outdoor air handling unit. This is important because it can significantly reduce duct sizes. Not only would that increase usable space from smaller shafts, but also could increase ceiling heights. Table 12 below shows the breakdown of usable space on each floor, however, this usable space does not include elevator rooms, electrical rooms, or piping shafts so the usable space is actually much lower. Although, compared with only mechanical systems it was found 94 % of the floor area is usable space.

Mechanical Space Requirements				
Level	**Floor Area**	**Mechanical Area**	**Usable Area**	**% Usable**
Basement	16,000	2,815	13,185	82
First	16,000	136	15,864	99
Second	12,913	123	12,790	99
Third	8,357	10	8,347	100
Fourth	6,245	546	5,699	91
Total	**59,515**	**3,630**	**55,885**	**94**

Table 14: Mechanical Space Requirements

LEED Analysis

Leadership in Energy and Environmental Design (LEED) is an internationally recognized program that rates the design, construction, and operation of high performance buildings. Certifications are achieved based on satisfying credits in 6 different categories. Below is an analysis of Father O'Connell Hall of two categories that deal with the mechanical system: Energy and Atmosphere and Indoor Environmental Quality.

Energy and Atmosphere

It was estimated that Father O'Connell Hall would achieve 5 credits in this category.

Prerequisite 1: Fundamental Commissioning of the Building Energy Systems

Commissioning processes were done by the project team to reduce energy usage and lower operating costs. The system is operating in accordance to the owner's project requirements.

Prerequisite 2: Minimum Energy Performance

Father O'Connell Hall is in complete accordance with ASHRAE Standard 90.1. An energy model could not be obtained from the design team, but my own energy model showed significant savings compared to ASHRAE baseline.

Prerequisite 3: Fundamental Refrigerant Management

Refrigerant R-410a is used in place of CFC refrigerants. R-410a has a lower ozone depletion and global warming potential than CFC's or HCFC's.

Credit 1: Optimize Energy Performance – 2 Points

The purpose of this credit it to further achieve higher levels of energy performance beyond the minimum required in prerequisite 2. It is estimated that Father O'Connell Hall will perform about 14% better.

Credit 2: On-Site Renewable Energy

This credit is awarded to projects that use on site renewable energy rather than burning fossil fuels at an off-site location. Father O'Connell Hall does not use any on site renewable energy.

Credit 3: Enhanced Commissioning – 1 Point

In house commissioning was done from the design team to achieve this credit.

Credit 4: Enhanced Refrigeration Management – 2 Point

This credit looks at refrigerant global warming potential (GWP) and ozone depletion potential (ODP). Table 15 below used from the United State Green Building Council website, shows that Father O'Connell is well below the 100 max of average refrigerant impact.

HVAC&R Equipment Type	N	Q (tons)	Refrig-erant	GWPr	ODPr	Rc (lb/ton)	Life (yrs)	Lr (%)	Mr (%)	LCGWP	LCODP x10^5	Impact per ton	Impact Total
Scroll Compressor	1	100	R-410A	1890	0.000	0.88	20	2	10	42	0	42	4,200
	Total	100	Average refrigerant impact per ton (must be less than or equal to 100)									42	4,200

Table 15: Refrigerant Management

Credit 5: Measurement and Verification

The intent of this credit is to provide ongoing accountability of the building energy consumption over time. No know plans were set to measure consumption in the future.

Credit 6: Green Power

To meet the criteria for this credit it is encouraged to develop renewable energy to create a net zero site. No renewable energy is used at Father O'Connell Hall.

Indoor Environmental Quality

It is estimated that 12 credits are obtainable for Father O'Connell Hall in this section.

Prerequisite 1: Minimum IAQ Performance

The purpose of this prerequisite is to establish a minimum indoor air quality. This prerequisite requires the compliance of ASHRAE Standard 62.1. Father O'Connell Hall complies with this standard as seen earlier in this report.

Prerequisite 2: Environmental Tobacco Smoke (ETS)

The purpose of this credit is to prevent the building from being exposed to environmental tobacco smoke. Father O'Connell Hall prohibits smoking inside the building and within 25 feet of all entries and outdoor air intakes.

Credit 1: Outdoor Air Delivery Monitoring – 1 Point

Credit 1 requires the monitoring of ventilation that is being supplied to occupants. The BMS controls ventilation to ensure minimum ventilation rates are being met. In addition, there is a 100% outdoor air handling unit providing ventilation for most of the building.

Credit 2: Increased Ventilation – 1 Point

Credit 2 is intended to improve occupant comfort by providing additional ventilation about the minimum requirements. This credit requires the ventilation to increase 30% above the minimum. Ventilation calculations were done and compared to the design minimum outdoor air rates and it was found that Father O'Connell does provide sufficient ventilation to achieve this credit.

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

Credit 3.1 intent is to reduce indoor air quality problems during construction. The building specifications of the air handling units specifically require compliance with credit 3.1.

Credit 3.2: Construction IAQ Management Plan, Before Occupancy

Credit 3.2 is similar to credit 3.1 in its intent to reduce indoor air quality problems during construction. This credit requires a building flush out before occupancy or using protocols from the EPA to determine the air pollutants indoors. No know tests are scheduled for Father O'Connell Hall.

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

Credit 4.1 intent is to reduce indoor air contaminants that are odorous or harmful to occupants due to adhesives and sealants. Father O'Connell uses low-emitting materials and adhesives and meets this credits requirements.

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

Credit 4.2 is similar to 4.1. Paints and coatings are not to exceed certain volatile organic compound (VOC) levels that can be potentially harmful to occupants. It is specified that materials do not exceed these limits in Father O'Connell Hall.

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

The purpose of credit 4.3 is to reduce indoor air quality problems due to carpet systems. Father O'Connell Hall's carpets have been specified to meet credit 4.3. In addition, the adhesives have been specified to meet credit 4.1.

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

The purpose of credit 4.3 is to improve indoor air quality by using composite wood systems that do not contain urea-formaldehyde resins. Wood floor systems are not used in Father O'Connell Hall so it meets this credits requirements.

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

The purpose of credit 5 is to limit occupant exposure to hazardous chemical pollutants. A minimum filter of MERV 13 is used for all occupied spaces. An entryway system is provided for all spaces. The only space with hazardous gases or chemicals is the kitchen area and the air is directly exhausted outside.

Credit 6.1: Controllability of Systems, Lighting – 1 Point

The purpose of credit 6.1 is to provide high level lighting system with individual control to promote productivity, comfort, and well-being. Individual lighting controls are provided in at least 90% of the building. In addition, many lighting controls are dimmable.

Credit 6.2: Thermal Comfort – 1 Point

The purpose of credit 6.2 is to create comfortable environment with individual controls. At least 50% of the building occupants have individual controls. Most office spaces are controlled by a single fan coil unit with a single programmable thermostat.

Credit 7.1: Thermal Comfort, Design – 1 Point

The purpose of credit 7.1 is to provide a comfortable environment to promote productivity, comfort, and well-being. HVAC systems are design to comply with ASHRAE Standard 55-Thermal Comfort Conditions for Human Occupancy.

Credit 7.2: Thermal Comfort Verification
The purpose of credit 7.2 is to provide an assessment of building occupant thermal comfort over time. One way this credit could be achieved is through the distribution of a survey. No know surveys are planned to be distributed in the future.

Credit 8.1: Daylight & Views, Daylight 75% of Spaces– 1 Point
The purpose of credit 8.1 is to provide building occupants with a connection between indoors and outdoors through the introduction of day lighting for 75% of spaces. A detailed calculation was not done but Father O'Connell Hall is a very long and narrow building with most rooms being exterior rooms. It seems that 75% of spaces will have a direct line of sight to the outdoor environment.

Credit 8.2: Daylight & Views, Views for 90% of Spaces
The purpose of credit 8.2 is to further encourage a connection between indoors and outdoors for at least 90% of the spaces. This credit could not be achieved.

Mechanical System Evaluation

Father O'Connell Hall mechanical system has been estimated to cost 1.6 million dollars about 13% of total project costs. The mechanical cost on a square foot basis is $44.67 per square foot. The average annual energy cost is $17,000.This annual cost is on the lower end. One reason could be due to the 100% outdoor air handling unit with heat recovery limiting the amount of airflow through much of the building.

Large mechanical rooms in the basement and fourth floor host most of the major equipment. These include the air handling units, boilers, pumps, and fans. Some exhaust fans are located on the rooftop. The chiller is also located outdoors, but everything else is located interior of the building. Even with these large mechanical equipment located indoors, 94% of the building is still usable space when compared with the mechanical equipment.

Father O'Connell Hall does a good job with its mechanical design in terms of LEED. Most points in the Energy and Atmosphere and Indoor Environmental Quality are obtained. Efforts in energy reduction could be looked into improving. On way of improving would be to look into on-site renewable energy. Currently, Father O'Connell Hall has uses no renewable energy sources.

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