Technical Report 3:

(Mechanical Systems Existing Conditions Evaluation)

Due Date: November 29, 2010

The Mirenda Center for Sports, Spirituality, and Character Development

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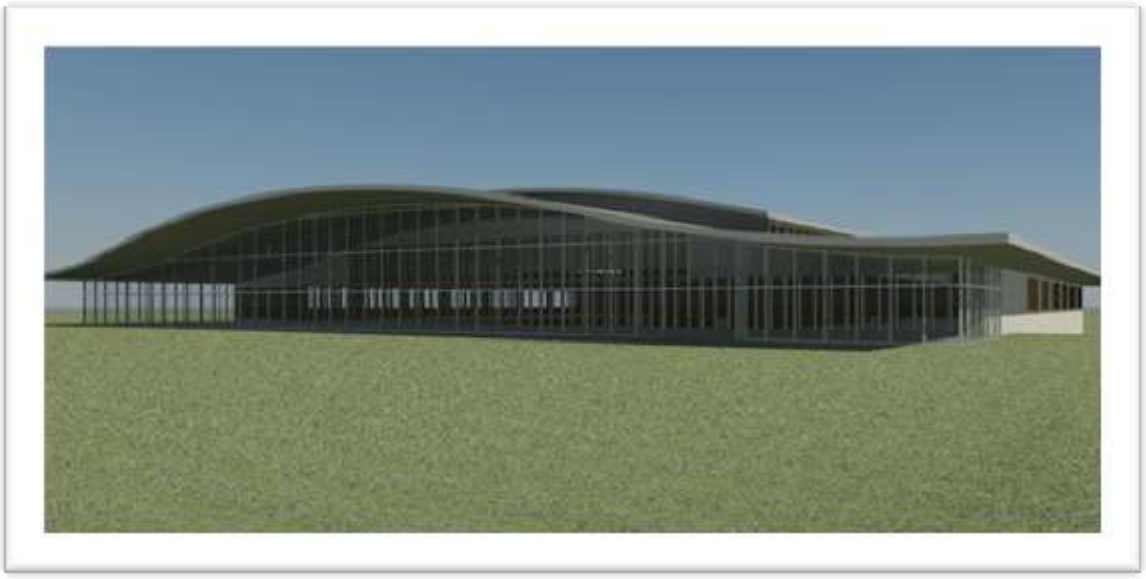
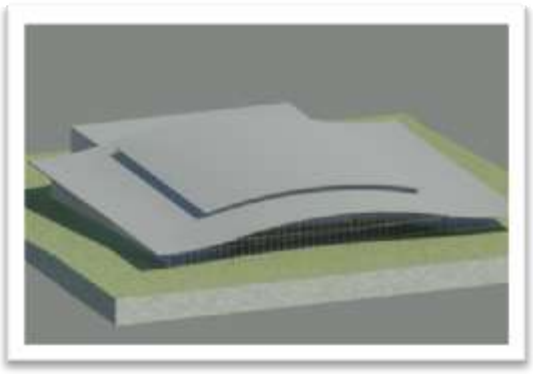
Executive Summary

General Building Overview

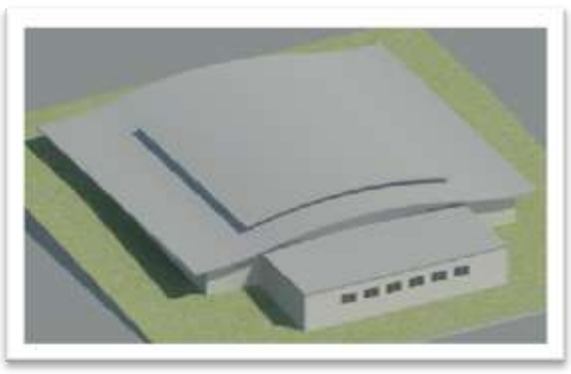
The Mirenda Center for Sports, Spirituality, and Character Development (CSSCD) is a two story building. The ground floor entrance is at the second level in the front of the building, while the lower level is underground at the front of the building while the sloping topography brings the lower level to exit at ground level in the rear of the building. See Exploded View on following page.



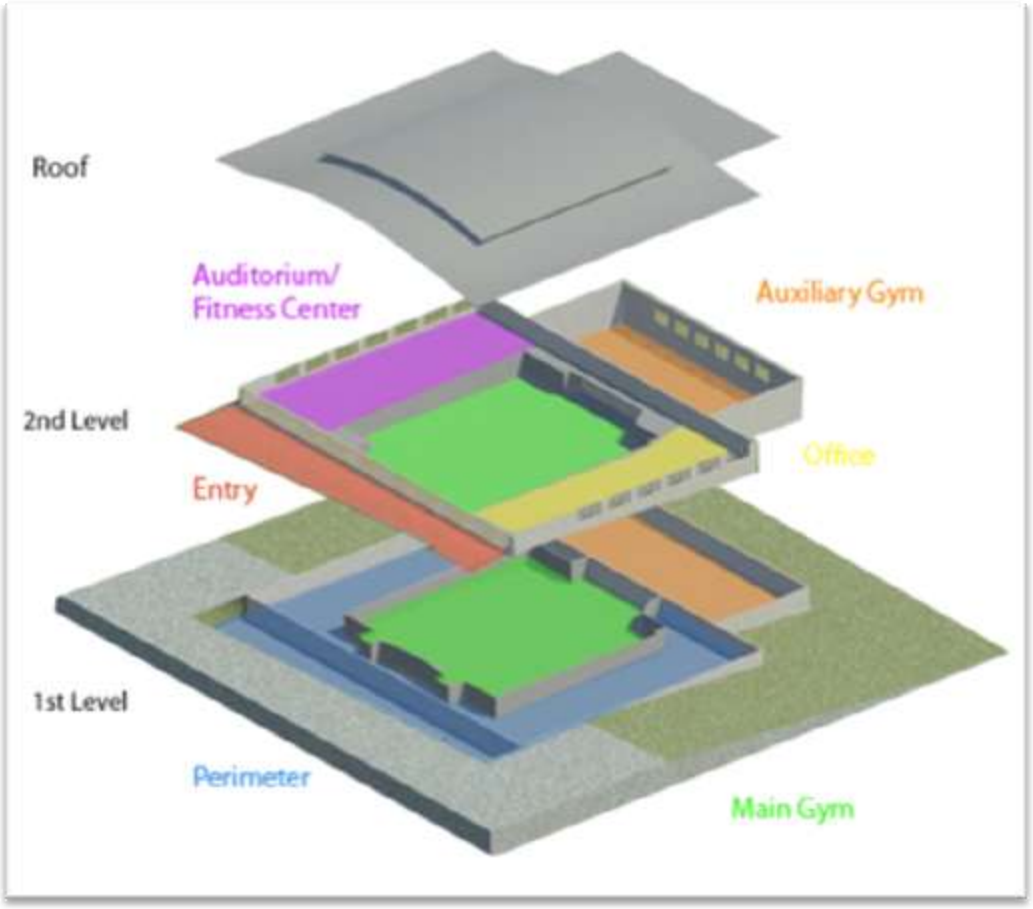
The core of the building is the main gymnasium that seats up to 1450 spectators at the lower level. Wrapped around the main gym at the second level is an indoor running track. The outer most perimeter is as follows: Offices on the east side, Auxiliary gym on the north side, multipurpose and fitness center on the west side, and open glazed atrium on the south side. See Exploded View on following page.



Front View



Rear View



Exploded View

Mechanical System Overview

The Mirenda Center is primarily heated and cooled by 6 roof top air handling units; their location is above the auxiliary gym. RTU-5&6 serve the main gymnasium and the indoor running track in unison. RTU-3 & 4 serve only the auxiliary gym. RTU-1 and 2 serve the remaining perimeter spaces: the auditorium and fitness center, the offices, and entry. There is natural gas burners for heating of the RTU's and reheats for each zone in the constant air volume boxes. There is also electric resistant strip heat around the perimeter of the building. This electric resistance heat is primarily to keep condensation from forming on the glazing.

Design Objectives and Requirements

The program of The Mirenda Center is quite voluminous. The key features of the building that stand out in the foreground of the architecture are the 1450 seat main gymnasium and the Indoor running track. The Mirenda Center is for Sports Spirituality and Character Development. The Sports consist of the main gymnasium, the auxiliary gymnasium, the running track, and the fitness center with weight and cardio equipment. These features are the attractive features of the building that attract student activity. The Spirituality consists of Offices for the Institute for Sport, Spirituality and Character Development. The Character Development is integrated with Spirituality and built upon by providing a multipurpose room, a student lounge, dance studio, and a general classroom. All of this must be administrated, thus there is a President's hospitality suite, a catering kitchen, and so much more that brings The Mirenda Center together.

1. Energy Sources and Rates

The energy sources for The Mirenda Center are electricity and natural gas. Natural Gas is consumed primarily for heating in the Roof Top Air Conditioning Units. The rate structure is fixed $25.00 per month, and varies from $3.78 per Mcf for the first 200 Mcf to $2.64 per Mcf for all additional consumption. All but the heating load for the air system is fueled by electricity. These loads are primarily cooling, including the fans and compressors, and lighting both interior and exterior. The electric rate structure consists as follows: for peak demand $6.65 per kW, for off-peak demand $3.25 per kW, for peak consumption $0.07 per kWh, and $0.06 per kWh. The ratchet clause does apply. There for monthly maximum consumption of energy will have a huge effect on the yearly dollar amount. This point goes to show that even though in the winter less electric energy is used, The Mirenda Center will be charged for 10 months of it maximum consumption during the Month of July and/or August. The ratchet clause is detrimental to The Mirenda Center and could be offset by onsite electric generation.

2. Outdoor and Indoor Design Conditions

The Mirenda Center is located in Philadelphia, Pennsylvania. The location information is defined by ASHREA Handbook of Fundamentals for 4% for heating and 99.6% for cooling. This information was used for the Student Energy Model. Indoor conditions were determined by the designer with the acceptable range of the ASHRAE 55 Thermal Comfort. The values set for winter heating 72 °F and the summer cooling are 74 °F. Outdoor conditions as referenced in the Design Load Estimation of this section are from the ASHRAE Handbook of Fundamentals for 2008. The locality is Philadelphia, Pennsylvania. The outdoor dry bulb temperatures minimum and maximum temperatures are 12 °F dB for the heating season and 93 °F dB/76 °F wB for the cooling season.

3. Design Ventilation Requirements

ASHRAE Standard 62.1 was used to determine whether the design met the required amount of outdoor air. This procedure is known as the "Ventilation Rate Procedure". Outdoor Ventilation rates were taken from the mechanical drawings of the construction documents. RTU 1 is 8800 cfm, RTU 2 is 8500 cfm, RTU 3&4 combined are 7200 cfm, and RTU 5&6 are 242000 cfm.

	From Docs.	Calculated	Percent	Design Supply	ASHRAE 62.1
	Outdoor Air	Outdoor Air	Exceeded	Air Flow	Compliance
RTU_1	8800	3812	43%	22000	yes
RTU_2	8500	5054	59%	17000	yes
RTU_3	3600	1123	31%	8000	yes
RTU_4	3600	1249	35%	8000	yes
RTU_5	12100	4750	39%	20100	yes
RTU_6	12100	4193	35%	20100	yes

4. Design Heating and Cooling Loads

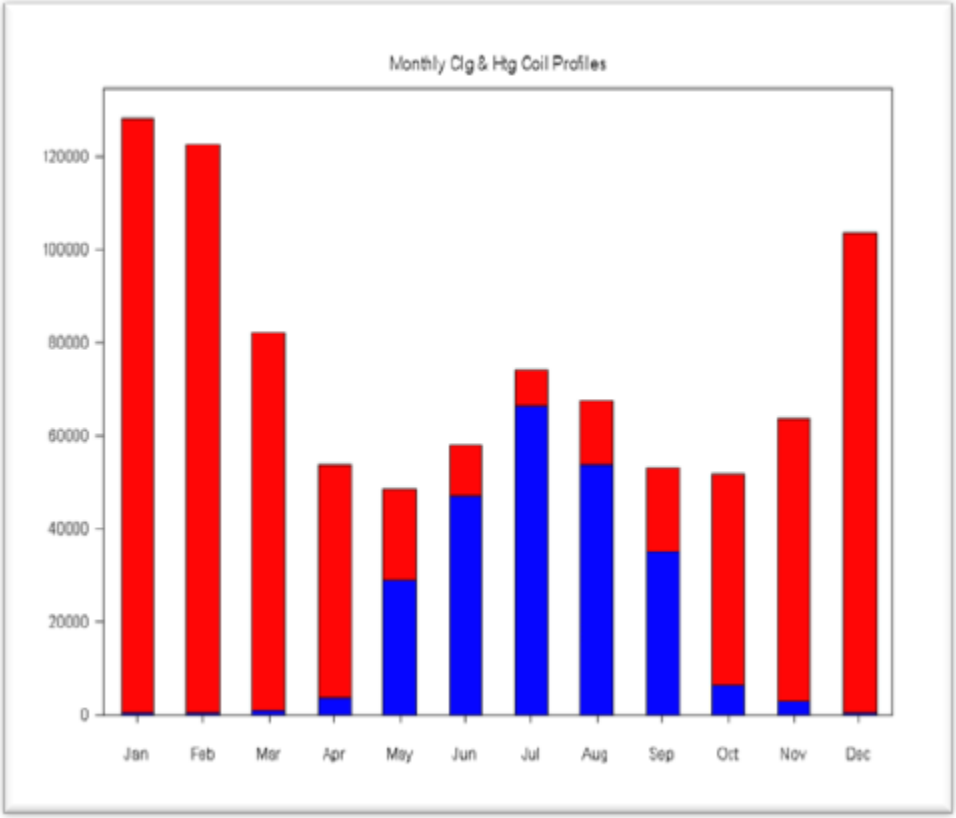
Heating Load

The heating load for the building is met by the combination of gas burners in the RTU units and the electric resistance heat both within the spaces, and reheat coils per system description. *(one or the other, or the combination of the two)* The heating load is found from the coldest day and the coldest hour prior to the sun rise. Typically this day is mid-winter. Max heating data for each system is as follows: Auxiliary Gym requires 571.0MBh of heating, Main gymnasium requires 575.9 MBh of heating, and the perimeter system requires 580.9MBh of heating.

Cooling Load

The max cooling load for The Mirenda Center is interesting, it is not necessary in the summer time. There are two possible scenarios that could happen in order to find the max cooling load. The first is the standard hottest day of the hot month at the hottest hour, which is July 16th.The second more interesting possibility is the basketball season. The Mirenda Center holds 1450 people with both the players and spectators includes. The human body load is so significant that the building is required to cool during the debt of winter. 1450 people is approximately 760,000 Btu/h. This load does not quiet trump the total load found in July. Thus equipment size shall be determined from the max monthly

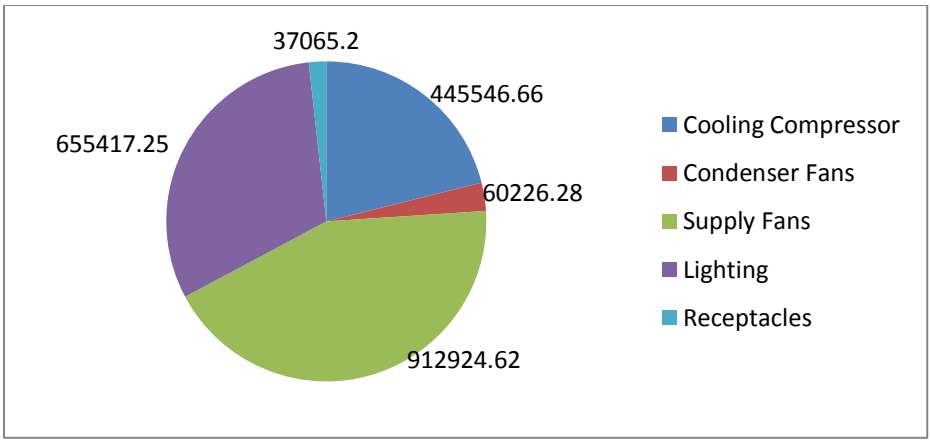
cooling load rules. July 16th data for each system is as follows: Auxiliary Gym requires 41 tons of cooling, Main gymnasium requires 152.4 tons of cooling, and the perimeter system requires 125.1 tons of cooling.

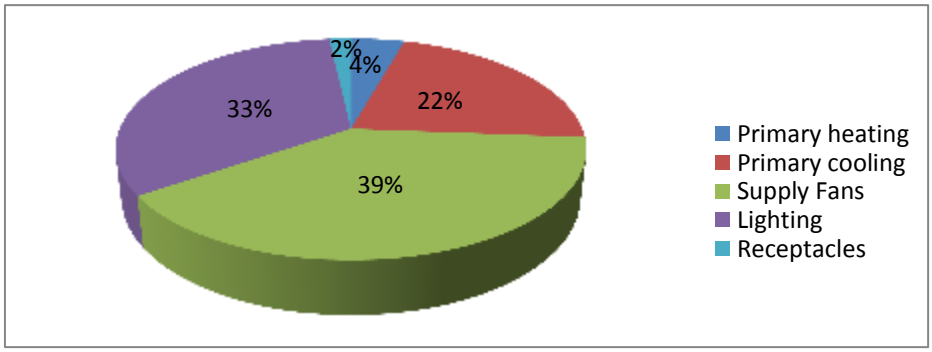


Cooling*(Tons)*
Heating*(Btu/hr)*

5. Annual Energy Use

The energy consumption of The Mirenda Center follows the standard cycle of the weather patterns. There is a higher heating rate in the winter months which convert to gas bills for the natural gas burners in the roof top units in conjunction with the electric bills for resistance heat for both space heat and reheat in ducts. The highest energy consumed due to electrically ran equipment, such as fans, lights, and majority of the cooling equipment.

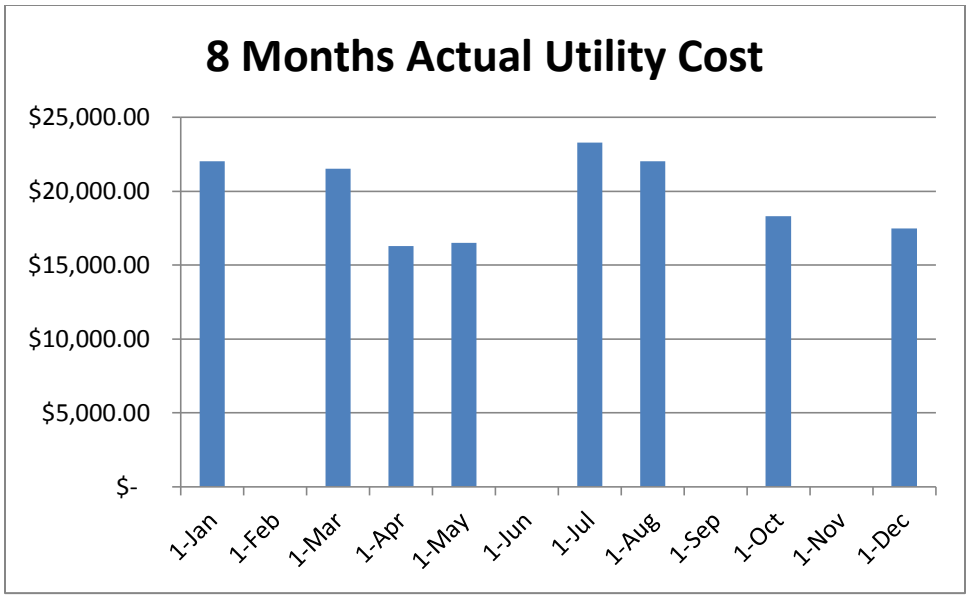


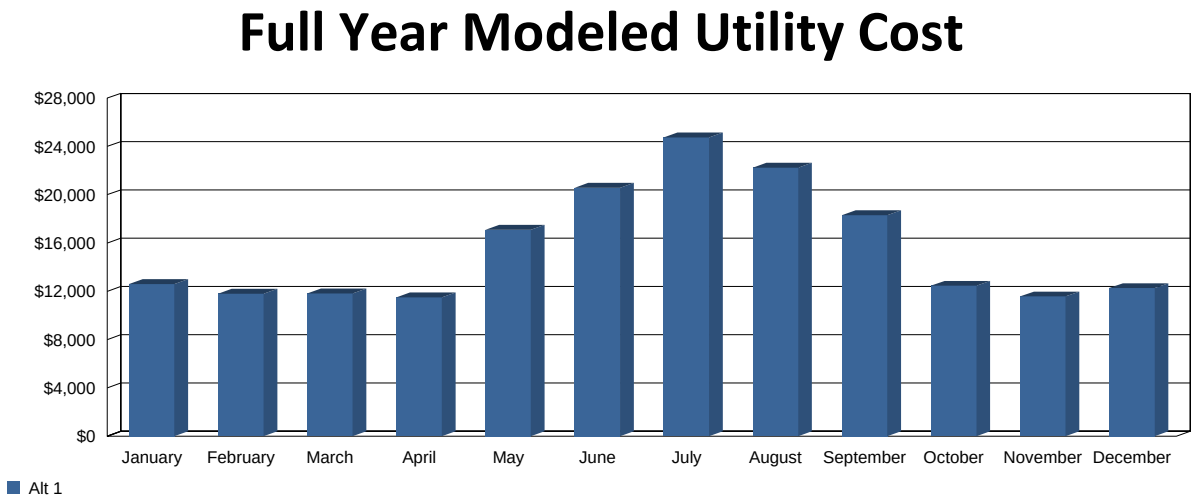


Total Source Energy	*(kBtu/yr)*
Primary heating	902839
Primary cooling	4478760
Supply Fans	8040356
Lighting	6711488
Receptacles	367432

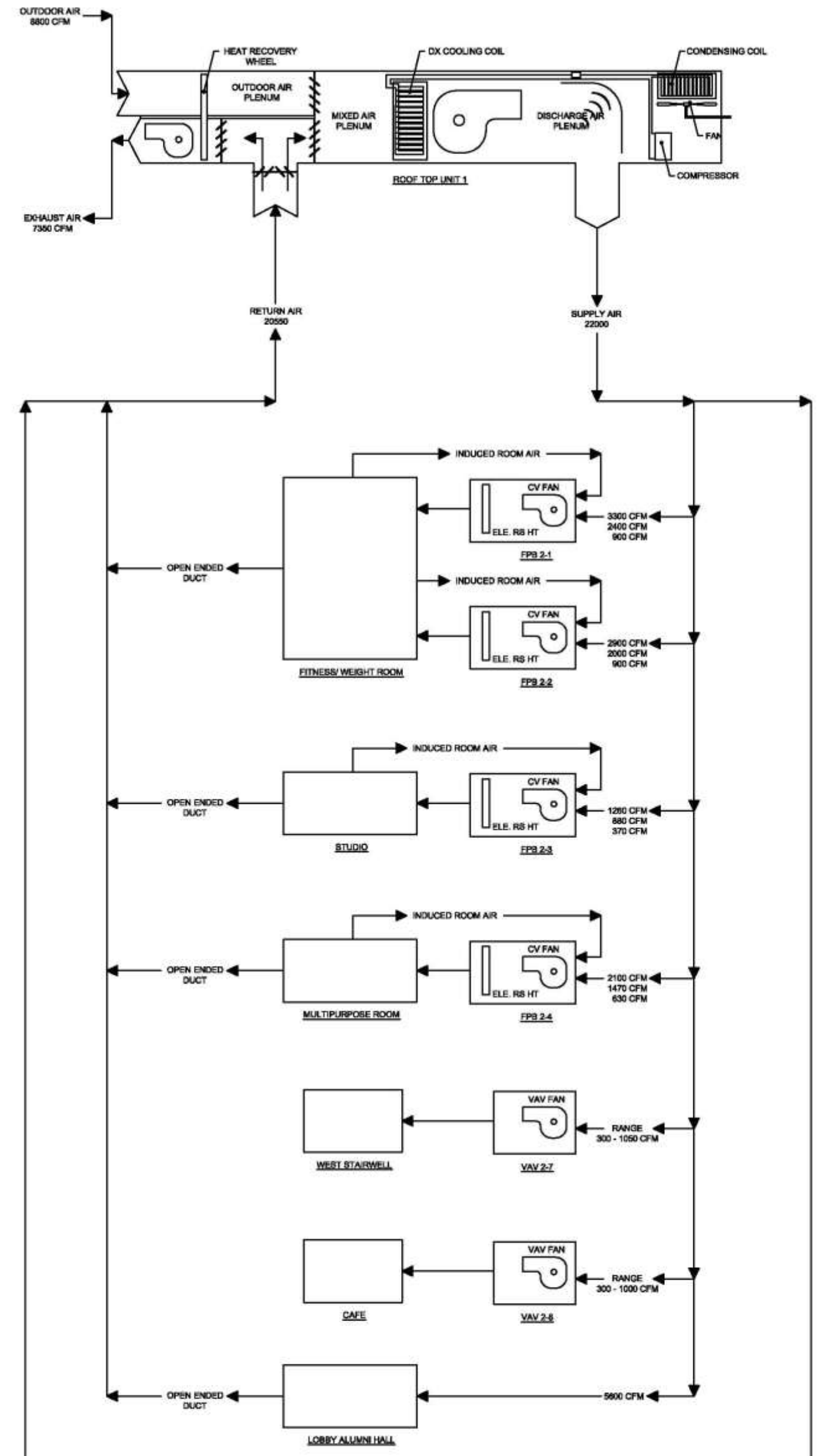
Fairly high assumptions were made for the lighting values. Particularly in the main gymnasium, there was an allowance for 2.26 *W/sq ft*. The rate structures for electricity are defined by peco electric.

- http://www.peco.com/pecobiz/energy_rates/our_rates_and_prices.htm

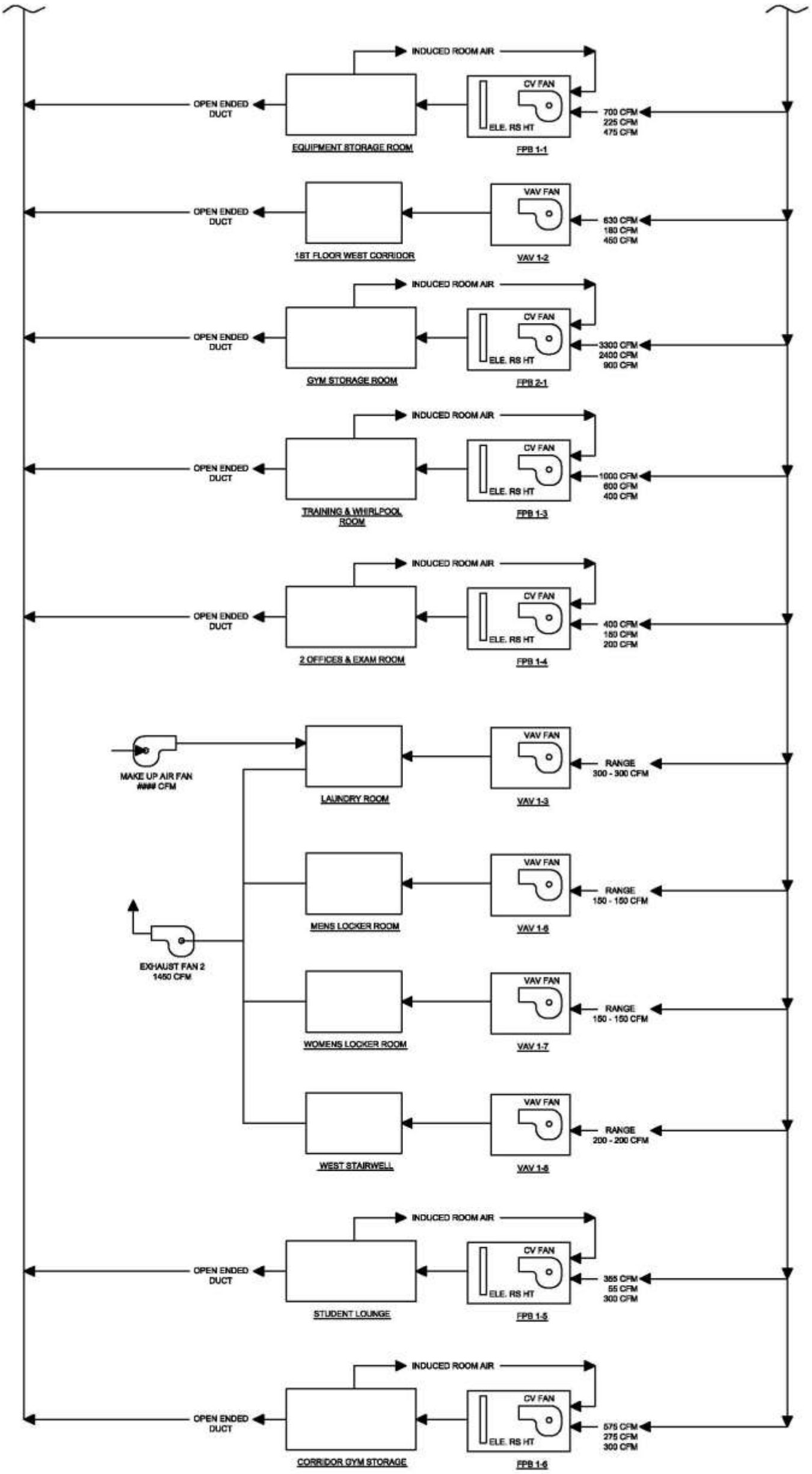




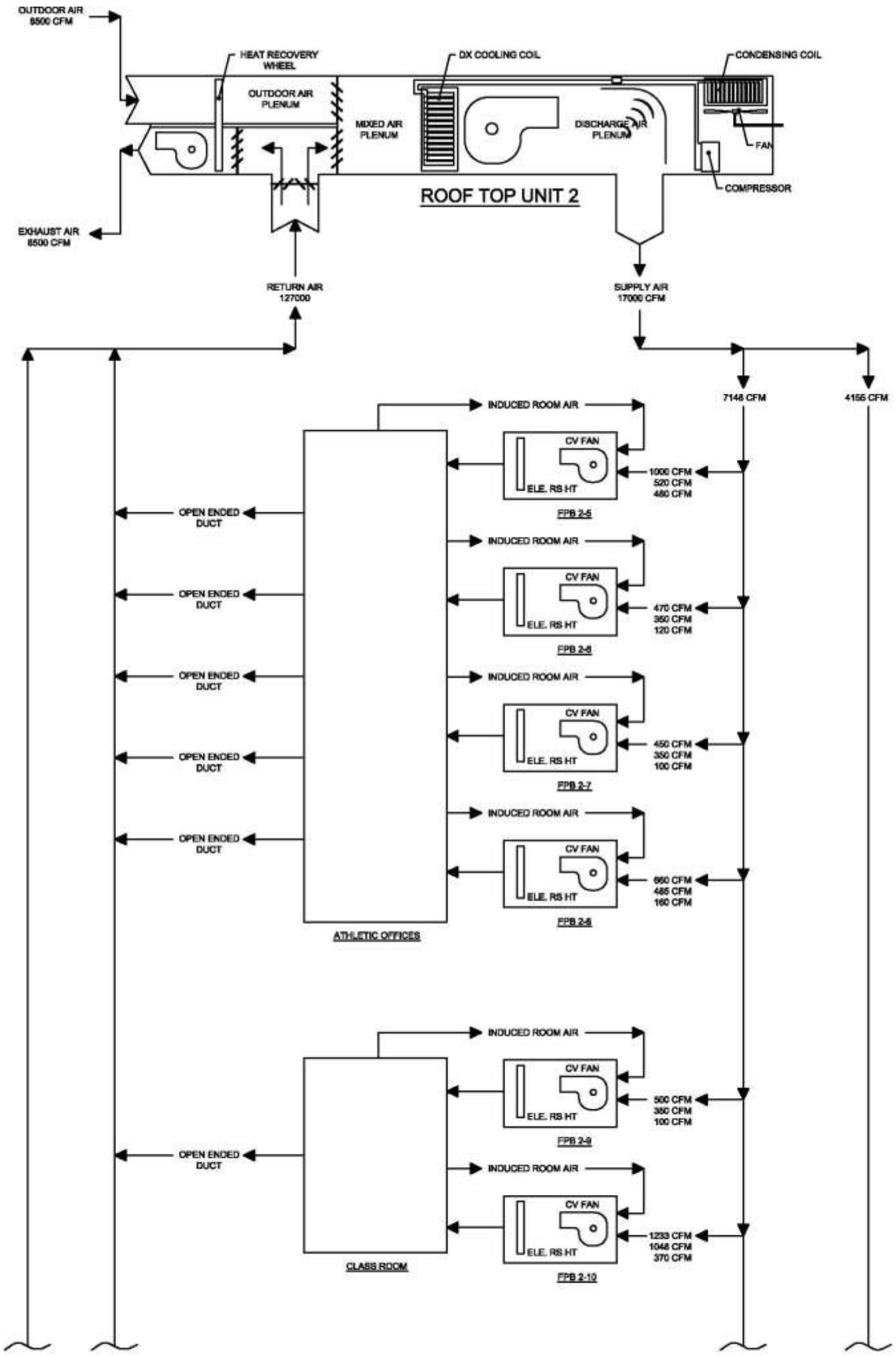
6. Schematic Drawings of Existing Mechanical System



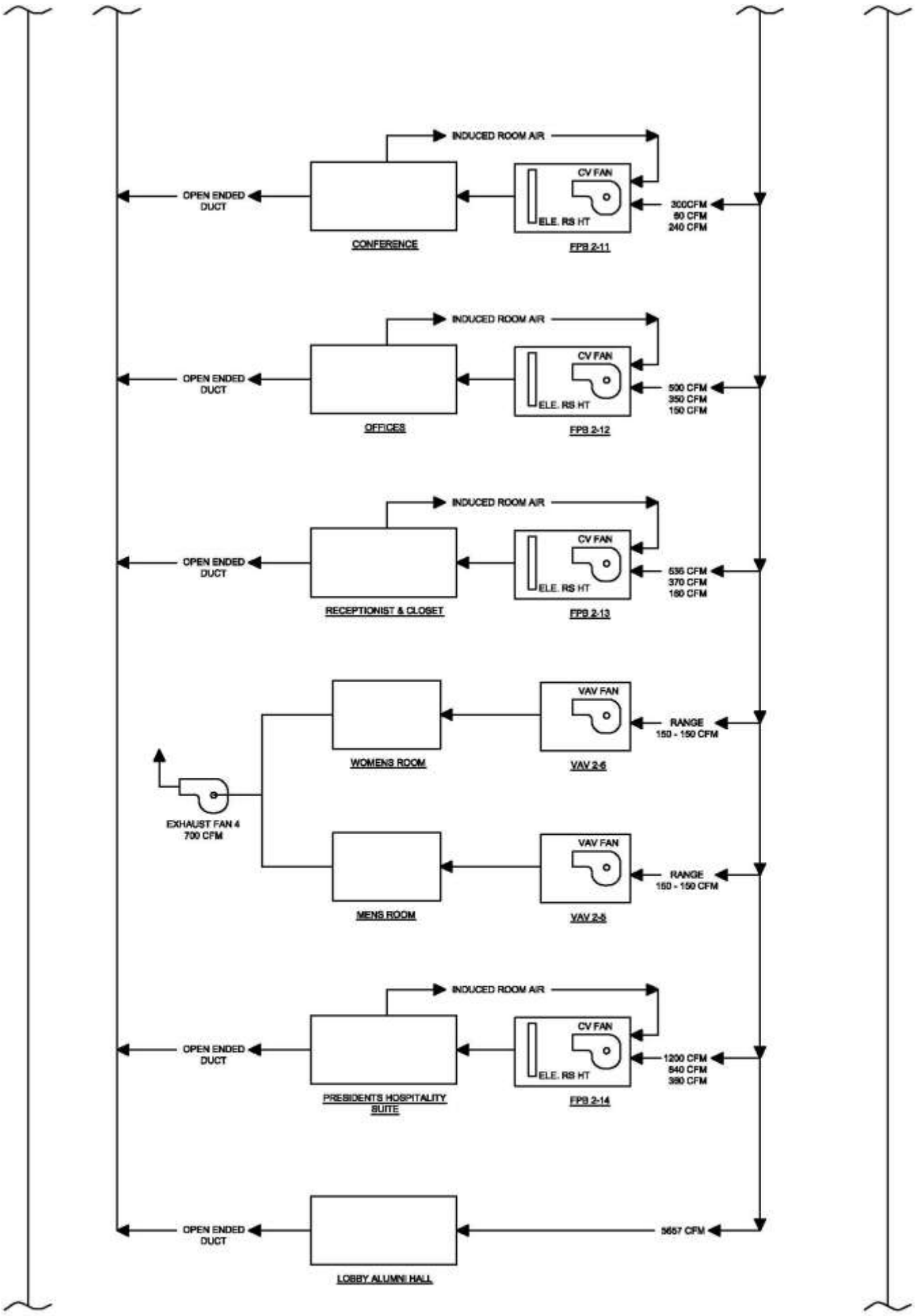
AIR-SIDE SCHEMATIC
ROOF TOP UNIT 1



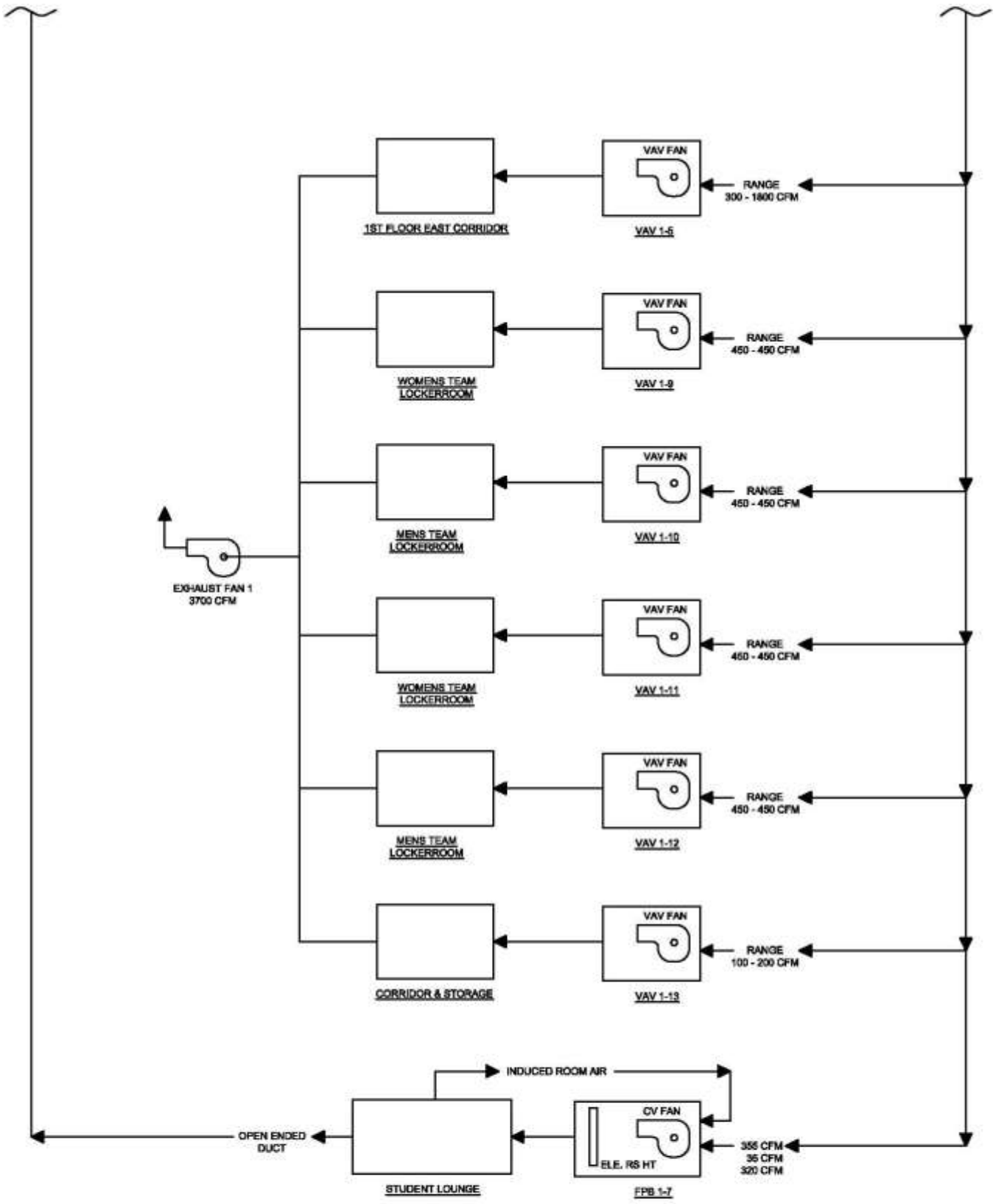
AIR-SIDE SCHEMATIC
ROOF TOP UNIT 1



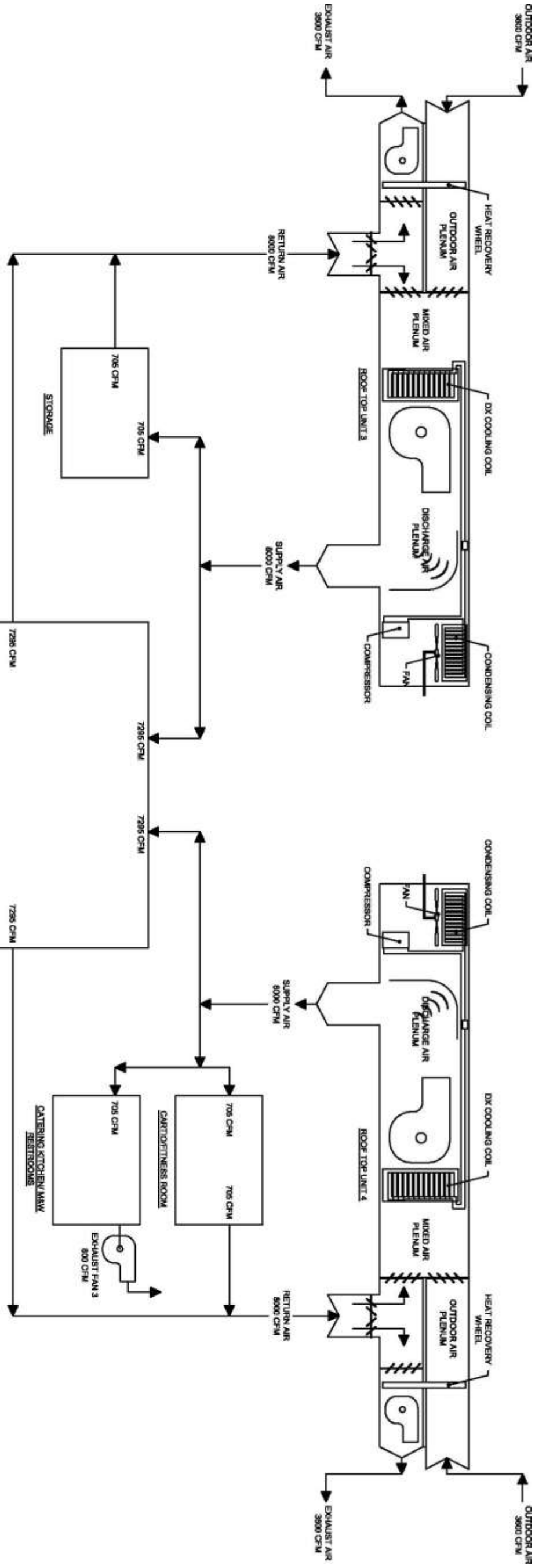
AIR-SIDE SCHEMATIC
ROOF TOP UNIT 2



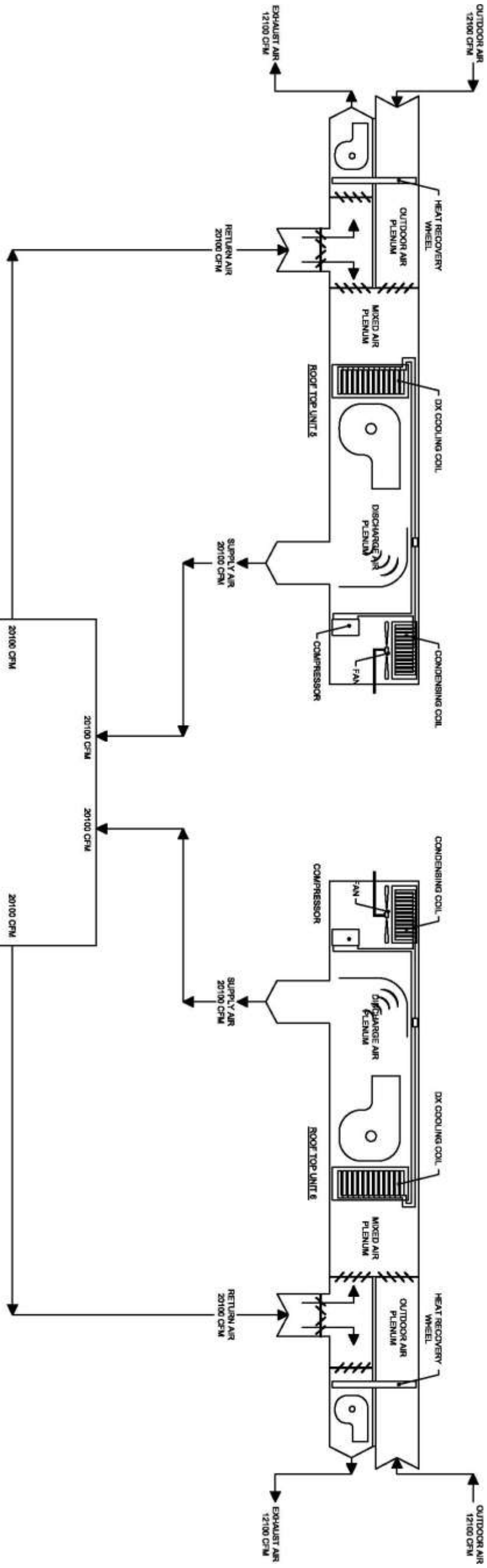
AIR-SIDE SCHEMATIC
ROOF TOP UNIT 2



AIR-SIDE SCHEMATIC
ROOF TOP UNIT 2



AIR-SIDE SCHEMATIC
ROOF TOP UNITS 3 & 4



AIR-SIDE SCHEMATIC
ROOF TOP UNITS 5 & 6

7. Table Summaries of Major Equipment

	TOTAL MBH	CFM	ENT. DB	LVG. DB	KW	MHP
RTU-1	941.2	22000	78.16	53.5	15.6	20X2
RTU-2	811.05	17000	81.4	53.1	10.78	15X2
RTU-3	340.9	8000	78.6	54.5	6.21	7.5
RTU-4	340.9	8000	78.6	54.5	6.21	7.5
RTU-5	1108.93	20100	79.18	52.26	14.74	20X2
RTU-6	1108.93	20100	79.18	52.26	14.74	20X2
CUH-1	10240	250	-	-	3	-
CUH-2	17065	250	-	-	5	-
EF-1	-	3700	-	-	-	2
EF-2	-	1450	-	-	-	3/4
EF-3	-	800	-	-	-	1/4
EF-4	-	700	-	-	-	1/6
FPB-1-1	19250	700	-	-	5.6	1/3
FPB-1-2	17325	630	-	-	5	1/3
FPB-1-3	19800	1000	-	-	5.8	1/3
FPB-1-4	13640	400	-	-	4	1/3
FPB-1-5	10934	355	-	-	3.2	1/3
FPB-1-6	14550	575	-	-	4.5	1/3
FPB-1-7	11300	355	-	-	3.3	1/3
FPB-2-1	72600	3300	-	-	21	(2) 1/2
FPB-2-2	31900	2900	-	-	10	(2) 1/2
FPB-2-3	41580	1260	-	-	12	1/2
FPB-2-4	69300	2100	-	-	20	1
FPB-2-5	24200	1000	-	-	7	1/2
FPB-2-6	9800	470	-	-	3	1/3
FPB-2-7	8910	450	-	-	2.6	1/3
FPB-2-8	14520	660	-	-	4.3	1/3
FPB-2-9	30250	500	-	-	9	1/3
FPB-2-10	40689	1233	-	-	12	1/2
FPB-2-11	8900	300	-	-	2.6	1/3
FPB-2-12	11000	500	-	-	3.2	1/3
FPB-2-13	11770	535	-	-	3.5	1/3
FPB-2-14	36300	1200	-	-	10	1/2
VAV-1-1	-	300	55	85	-	-

VAV-1-2	-	550	55	85	-	-
VAV-1-3	-	300	55	85	-	-
VAV-1-4	-	200	55	85	-	-
VAV-1-5	59400	1800	55	85	17	-
VAV-1-6	4950	150	55	85	1.5	-
VAV-1-7	4950	1500	55	85	1.5	-
VAV-1-8	6600	200	55	85	2.0	-
VAV-1-9	14850	450	55	85	4.4	-
VAV-1-10	14850	450	55	85	4.4	-
VAV-1-11	14850	450	55	85	4.4	-
VAV-1-12	14850	450	55	85	4.4	-
VAV-1-13	3300	200	55	85	1.0	-
VAV-2-1	-	100	55	85	-	-
VAV-2-2	-	300	55	85	-	-
VAV-2-3	100000	4500	55	85	30	-
VAV-2-4	100000	4500	55	85	30	-
VAV-2-5	4950	150	55	85	1.5	-
VAV-2-6	4950	150	55	85	1.5	-
VAV-2-7	9900	1050	55	85	3.0	-
VAV-2-8	9900	1000	55	85	3.0	-

8. Conceptual Description of System Operation

The schedule of operation is from 7 a.m. until 12:00 a.m. for weekdays, from 10 a.m. until 11 p.m. on weekends, and 8 a.m. until 10 p.m. during the summer. The Mirenda Center is mostly an all air system. There are six roof top direct expansion, air cooled units at that bring in and condition outdoor air.

Units 1 and 2 are variable volume that cool 941.2 MBH and 811.05 MBH total load. Units 1 and 2 also provide a heating load of 648 and 650 MBH respectively. Units 1 and 2 run at 2.25 in wg, and supply 22000 and 17000 cfm, where the outdoor quantities are 8800 and 8500 respectively. Roof top unit 1 and 2 conditions the west and east perimeter portions of the building respectively. All roof top units are turned on one hour prior to, and off one hour after the building schedule/time of day. As Units 1 and 2 come up to operating conditions, there fan powered boxes and variable air volume boxes take a space temperature reading and will begin to supply the necessary cfm to achieve the design space temperature condition of 72°F in the winter and 74°F in the summer. The fan powered boxes and variable air volume boxes are located in or near the room/rooms they serve. Their operation will not begin until one hour after the roof top units are up to running condition. The outdoor air intake amount is overridden if the carbon dioxide levels exceed 1000 parts per million parts of air. When the rooms are unoccupied that are served

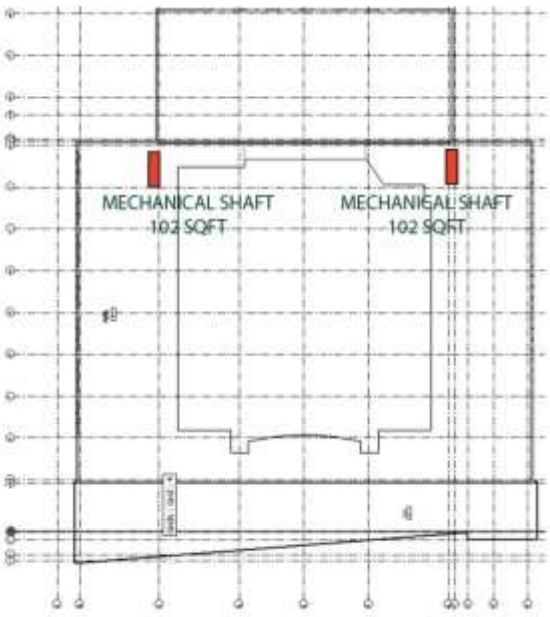
by units 1 and 2, the supply and return fans are to remain off until the space temperatures exceed 64°F or fall below 60°F depending upon the season. These rooms are in occupied mode during the building operation schedule.

Roof Top Units 3 and 4 maintain an operational pressure of 1.25 in wg, provide a total cooling load of 340.9 MBH, and heating load of 218.7 MBH. Units 3 and 4 work together to cool the Auxiliary Gymnasium, which is on the north end of the building.

Roof top units 5 and 6 also work in unison to cool the Main Gymnasium. Units 5 and 6 maintain an operational pressure of 2.25 in wg. This is achieved by bringing in 20100 cfm by each unit. There are four supply headers that are exposed in the ceiling of the main gymnasium. These supply 55°F air to the space while mixing with the room air to bring the total room air temperature down to the previously list design setpoints. Units 5 and 6 both have a cooling capacity of 1108.9 MBH, and a heating capacity of 648 MBH. There is high, medium, and low operation for units 5 and 6. The high setting is for high load situations, specifically sporting events with 1540 spectators. The medium setting is for events that don't involve a high load, such as an art show or career fair. The low setting is for when the building is in use but the main gymnasium is not occupied.
There is a small split system that provides cooling to computer rooms and other support spaces.

9. Space Associated with Mechanical System

All of the large heating and cooling plants are located on the roof of the auxiliary gym. The auxiliary gym roof is approximately 8400 feet square. This roof is not enclosed thus it is not usable. There are two small mechanical duct shafts on either side of the main gymnasium. Each of the vertical mechanical shafts are 102 square feet, thus totaling to 204 square of usable space taken by the mechanical equipment.



Space Lost Due Mechanical Shafts

10. Mechanical System First Cost

First cost for the mechanical systems would not be disclosed by the owner. This information is still being considered. Once any information is disclosed this document will be updated.

11. Operation History of System

According to the 8 months of utility data The Mirenda Center costs approximately $2.42 per eight months. Remembering that the utilities considered were only gas and electric. The modeled cost data can be seen the Annual Energy Consumption section of this report. Comparing $2.42 per square foot per eight months to $2.85 per square foot per year is fairly accurate data. The total actual data versus modeled data are gas $6,968 to $6,048 and for electric $150,429 to $180,930 respectively. The annual cost to run the cooling plant is $38,220. The annual cost to run the heating plant is $6048. The values are defined by the rate structure of the electrics and gas. The annual cost per square foot for the utilities is $2.85. The utilities include gas and electric consumption.

Actual Building Utility Bills				
Dates -Period		Gas	Elect	Total
Begin	End			
9-Oct	9-Nov			$ -
9-Nov	9-Dec	$ 1,243.05	$ 16,233.99	$ 17,477.04
9-Dec	10-Jan	$ 2,689.61	$ 19,324.49	$ 22,014.10
10-Jan	10-Feb			$ -
10-Feb	10-Mar	$ 1,604.17	$ 19,914.08	$ 21,518.25
10-Mar	10-Apr	$ 496.22	$ 15,785.64	$ 16,281.86
10-Apr	10-May	$ 381.76	$ 16,102.70	$ 16,484.46
10-May	10-Jun			$ -
10-Jun	10-Jul	$ 135.66	$ 23,146.23	$ 23,281.89
10-Jul	10-Aug	$ 137.94	$ 21,885.70	$ 22,023.64
10-Aug	10-Sep			$ -
10-Sep	10-Oct	$ 279.69	$ 18,036.99	$ 18,316.68
	Totals	$ 6,968.10	$ 150,429.82	$ 157,397.92

12. LEED Assessment of Mechanical System

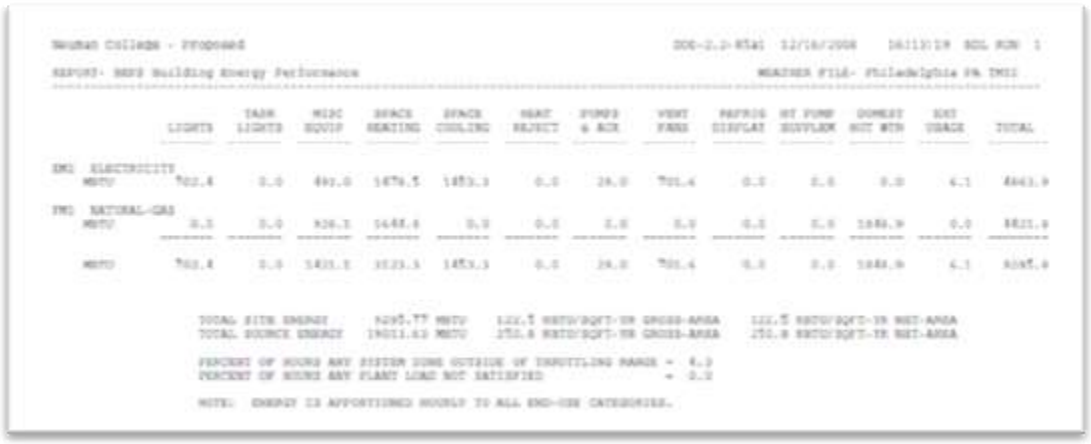
The Leadership in Energy and Environmental Design (LEED) is an organization created by the United States Green Building Council. The goal of LEED is to provide building owners and operators with the framework to implement practical and measurable solutions in the design. There is however issues with LEED because it only considers the design of the building. Some have argued how to rate a building on its operation, and actual annual energy costs.

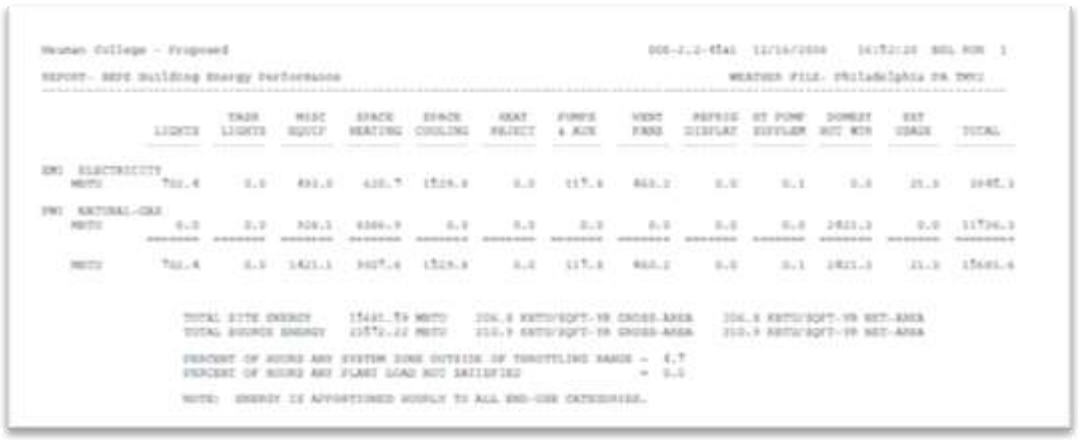
EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems - YES
The purpose of the is section is to ensure that the buildings systems are installed, calibrated, and performing to owner's project requirements, basis of design, and construction documents. The Mirenda Center was commissioned by Aramark's Technical Services Division. According to the commission report there was a total of 148 issues found during construction.

EA Prerequisite 2: Minimum Energy Performance - YES
The purpose of this section is to establish a baseline design for the energy goal of the building, and use the baseline to develop a more efficient building better that the baseline. The baseline model was established by ASHREA Standard 90.1-2004, and then was improved via an EQuest computer simulated model.

EA Prerequisite 3: Fundamental Refrigerant Management - YES
The purpose of this section is to reduce stratospheric ozone depletion. This can achieved by not using chlorofluorocarbon based refrigerants in the mechanical system. There are not CFC's used in the Mirenda Center, thus the building complies with the three perquisites.

EA Credit 1: Optimize Energy Performance - YES
The purpose of this section is increase levels of energy performance beyond the prerequisite standard to decrease negative effects on the environment associated with excessive energy use.



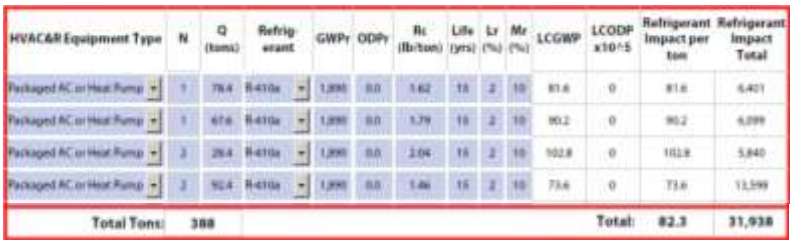


The preceding data shows the Baseline vs the Proposed annual cost for electricity and gas.

EA Credit 2: On-site Renewable Energy - NO
The purpose of this section is to encourage on site renewable energy. These points were not attempted.

EA Credit 3: Enhanced Commissioning - YES
The purpose of this section is to have commission services begin early in the design process, and also have the building commissioned after it is up and running. These 2 credits were met by having Aramark's Technical Services division assess and provide tools such operation and maintenance manuals for the building owner to use to increase and maintain optimal building performance.

EA Credit 4: Enhanced Refrigerant Management- YES
The purpose of this section is to ensure compliance with the Montreal Protocol Act, while minimizing direct contribution to climate change. The Mirenda Center does comply with the requirements of this section.



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	78.4	R-410a	1,890	0.0	1.62	15	2	10	81.6	0	81.6	6,401
Packaged AC or Heat Pump	1	67.6	R-410a	1,890	0.0	1.79	15	2	10	90.2	0	90.2	6,099
Packaged AC or Heat Pump	2	28.4	R-410a	1,890	0.0	2.04	15	2	10	102.8	0	102.8	5,840
Packaged AC or Heat Pump	2	92.4	R-410a	1,890	0.0	1.46	15	2	10	73.6	0	73.6	13,599
Total Tons:	388										Total:	82.3	31,938

EA Credit 5: Measurement and Verification - NO
The purpose of this section is to ensure that The Mirenda Center will have an ongoing accountability for energy consumption overtime. There is no program in place thus no credits were given.

EA Credit 6: Green Power – NO
The purpose of this section is to encourage the development and use of grid-source, renewable technologies on a net zero pollution basis. The Mirenda Center did not comply with this section, thus no credits were given.

13. Overall Evaluation of System

The Mirenda Center's mechanical system has room for improvement; however it does achieve the needs of The Center. It has increased functionality with the utilization of fan powered boxes and variable air volume boxes for the perimeter zones.

The Center is primarily heated and cooled by a set of air systems, 6 roof top air handling units. RTU-5&6 and RTU-3 & 4 operate in unison operated due to time of day or schedule. RTU-1 and 2 serve the perimeter spaces. The roof top units consume large amounts of electricity. This is a major concern where efficiency can be improved. The cost to operate the mechanical system per year is approximately $2.85.

Conclusion:

The Trane Trace 700 program allows to model baseline energy consumption. This baseline is a great tool to understand whether or not The Mirenda Center is performing operatively. The overall performance of The Mirenda Center is higher than the baseline presently. The reasons maybe due to underestimating schedule of use. The newness of the building may attract many unforeseen events that were unaccounted for in the design, such as commencement.