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Executive Summary

The purpose of this report was to provide an evaluation of the existing conditions within North Pocono High School's HVAC system. The system consists of 16 Carrier rooftop units, with variable air volume terminal units. The cooling system is comprised of direct expansion coils within the unit; the heating system uses duct mounted hot water coils to heat the air supplied to the space. The system uses a direct digital control system to maintain the set points forth by the designer.

The systems design objectives were staying within the budget set by the owner and providing thermal comfort while adhering to design standards. It was found that North Pocono's system complies with the above conditions.

After evaluating the existing system a critique of the system is provided which showed two major areas of discrepancies, lower the cooling load supplied to the school to keep operation costs down, and improve equipment.

Design Objectives

North Pocono High School is approximately 230,000 with all of the spaces that are included in a typical high school: gymnasium, auditorium, woodshops, science labs, computer labs, communication labs, offices, and of course classrooms. The mechanical engineer for the job did not have any special requirements set forth by the owner of the new school; therefore the designer followed the building codes and standards that were in place during the design phase of the building.

The engineer's objectives were to design a system that would adequately condition the spaces, while staying within the budget set forth by the owner. The next section discusses the budget of North Pocono; while the thermal comfort requirements are discussed in the *Design Condition* section.

Cost Analysis

To the best of my knowledge there were no rebates, tax reliefs, special government funding, etc. that influenced North Pocono's design. **Table 1** has a breakdown of the engineering costs for North Pocono.

Table 1- Breakdown of Cost

Discipline	Cost ($)	Cost/ft^2 ($/ft^2)	Percentage
Construction Mngt.	19,519,000	84.87	65%
Plumbing Cost	2,400,000	10.43	9%
Mechanical Cost	**4,300,000**	**18.70**	**14%**
Electrical Cost	3,700,000	16.09	12%
Total	**29,919,000**	**130.08**	**100%**

Design Conditions

North Pocono's load calculation was determined by the Trane Trace 700 program. The outdoor design conditions were taken from the nearest location within the program, Wilkes-Barre, Pa., which is approximately 20 miles southwest of the high school's location. Table 2 shows the values given by the program that the designer followed.

Table 2 - Outdoor Design Conditions

The indoor design condition, however were set forth by the engineer and were relevant according to the specific use of the space. The interior temperature and humidity levels were the same for all the spaces in the building. They are 72 ^{o}F for the dry and wet bulb temperature while the humidity is to be maintained at 50%. Table 3 breaks down the loads generated within the various spaces.

Table 3 – Indoor Design Conditions

Space	Sensible Load (Btu/hr)	Latent Load (Btu/hr)	Lighting Heat Gain (W/ft^2)	Miscellaneous Loads (W)
Classroom	250	200	1.4	2050
Gymnasium	225	105	1.4	0
Auditorium	225	105	0.9	0
Office	250	200	1.1	0.5 (W/ft^2)
Computer Lab	250	200	1.4	4150
Library	250	250	1.7	4000
Cafeteria	275	275	0.9	0
LGI	250	200	1.4	0
Food Court	275	275	0.9	0
Kitchen	275	275	1.2	2.5
Lobby	250	200	1.3	0

Design Analysis

The information in the above section was then input into the Trace 700 Program to generate the cooling and heating loads for North Pocono. The school was broken into 11 zones; three classroom zones and 8 specific areas. Table 4 describes the zones.

Table 4 – Zone Description

Zone	Area (ft^2)	Occupancy (People)
Lower Level Classroom	35,685	425
Middle Level Classrooms	62,349	893
Upper Level Classrooms	51,375	945
Adminstrative Offices	10,000	121
Gymnasium	14,921	1500
Auditorium	10,720	890
Large Group Instruction	3,075	100
Cafeteria	15,362	480
Food Court	2,760	100
Kitchen	3,383	10
Lobby	2,245	0

The reason for breaking down the school this way was because as you previously read in the Design Condition section the 8 specific zones had slightly different design conditions.

After all the data was input into the program the results were generated. Table 5 compares this report's cooling load results with those generated by the design professional.

Table 5 – Computed Cooling Load vs. Design cooling Load

Zone	Computed Cooling Load (ft^2/ton)	Design Cooling Load (ft^2/ton)
Lower Level Classrooms	397	375
Middle Level Classrooms	396	395
Upper Level Classrooms	365	338
Administrative Area	335	314
Gymnasium	100	102
Auditorium	128	121
Large Group Instruction	224	112
Cafeteria	228	196
Food Court	50	34
Kitchen	149	48
Lobby	100	104
Building Average	**225**	**194**

Overall the model provided slightly less cooling than what the engineer used to base North Pocono's design. These discrepancies could be due to the difference between the breakdowns of the spaces used to generate the loads.

Table 6 is a comparison of the total amount of air supplied to the building between the Trace program and the engineer's design.

Table 6 - Computed Supply Air vs. Designed Supply Air

Zone	Computed Supply Air (cfm/ft^2)	Design Supply Air (cfm/ft^2)
Lower Level Classrooms	1.13	1.11
Middle Level Classrooms	1.07	1.04
Upper Level Classrooms	1.10	1.05
Administrative Area	.78	.97
Gymnasium	1.98	2.0
Auditorium	1.66	1.66
Large Group Instruction	1.83	1.83
Cafeteria	0.95	1.6
Food Court	0.14	1.14
Kitchen	3.32	3.32
Lobby	1.14	1.14
Building Average	**1.37**	**1.53**

Overall the Trace program supplied less air than what the designer supplied, again the differences could be attributed to the breakdown of the building's areas.

The comparison of ventilation air required for North Pocono was not generated using the Trace program. The comparison was made by comparing the ventilation air supplied by each air handler unit to the method for calculating the ventilation air set forth by ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. Table 7 has an overall comparison while Appendix A has a breakdown of the individual zones served by the air handlers.

Table 7 - Computed Ventilation Air vs. Design Ventilation Air

Label	ASHREA Standard (cfm)	Designer Value (cfm)
AHU-1	4,195	4,355
AHU-2	5,025	7,360
AHU-3	4,810	10,270
AHU-5	2,750	3,860
AHU-7	4,525	4,800
AHU-8	3,895	4,315
AHU-9	5,370	6,225

Table 7 - **Computed Ventilation Air vs. Design Ventilation Air (cont.)**

AHU-10	1,670	3,685
AHU-12	2,400	2,255
AHU-13	5,105	10,725
AHU-14	1,985	2,470
AHU-15	3,950	5,890
Total	**45,680**	**66,210**

The reason for excluding air handlers 4,6,11 and 16 from this analysis is because they are used for economizer only and supply 100% outdoor air to the space. This was done so that the exhaust or return fans that are in the zones served by those units were properly sized. Overall North Pocono is adequately ventilated; this was because the engineer wanted to ensure that the air quality was optimized.

System of Operations

The following is a description of the system used to maintain a comfortable work environment within the school.

The majority of the air distribution system for North Pocono High School is made up of 16 Carrier Rooftop air handlers. Twelve of the units are variable air volume (VAV) units; while the four units mentioned before (4, 6, 11, and 16) are constant volume (CV) units that are for economizer and serve the auditorium, the locker room areas, and the large group instruction room. The CV units are dampers are controlled by CO_2 a sensor located in the zone. The dampers position is proportional to the amount following CO_2 values:

CO_2 level = or > 800 ppm / min. OA intake = 5,400 cfm

CO_2 level = or > 400 ppm / min. OA intake = 2,100 cfm

The air handlers are equipped with direct expansion cooling coils (DX), while the heating system is comprised of duct mounted heating coils used to condition the supply air (SA). The SA is a mixture of return air (RA) and outdoor air (OA). The percentage of each type of air brought into the unit is determined by a Direct Digital Controlled thermostat (DDC). The thermostat is programmed to send a signal to the DDC dampers for the RA and OA to maintain a mixed air temperature of 55 ^{o}F. The air is then conditioned and supplied to the space. The different cooling and heating processes are described below.

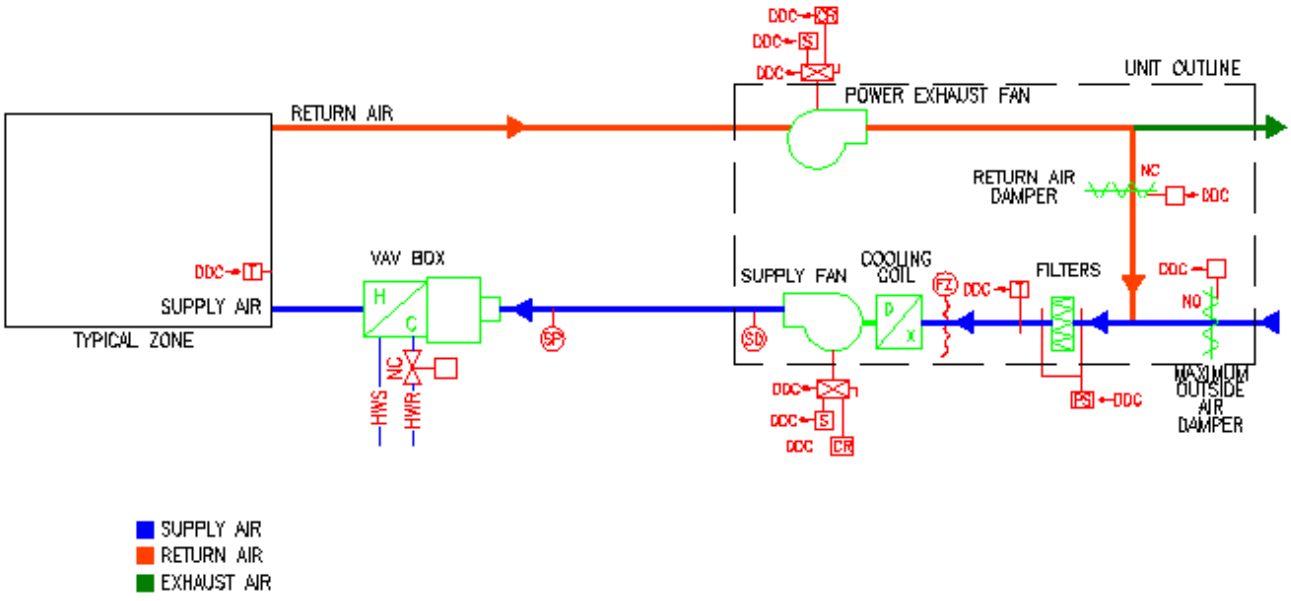
Cooling mode - VAV Units

The air handlers are programmed for 3 modes: morning cool down, occupied cycle, and unoccupied cycle. During the morning cool down cycle the DDC thermostat located in the zones sends a

signal to the unit when the space is above the cooling set point temperature of 75 °F. At this point the unit closes the OA damper, opens the RA damper, and the mechanical system energizes and cools the air until it reaches 55 °F. Then the unit switches over to occupied cycle, and the compressor/condensing units maintain a SA temperature of 55 °F. If the OA is above 55 °F during the cooling season the OA damper will remain at its minimum position, and the supply fan will run continuously. The supply fan speed is modulated by a variable frequency drive which is regulated by a static pressure sensor set to maintain a ¾" pressure. The supply fan is upstream of the DX coil therefore it pulls the air through the coil and then supplies it the terminal units. The VAV terminal unit is set to maintain a supply temperature of 75 °F. This is achieved by modulating the position of the damper in the unit. The damper is controlled by the DDC thermostat located in the zone.

The last mode is the unoccupied cycle. During this period the mechanical system cycles on and off to maintain a set point of 80 °F within the space. During this stage the VAV box's coil valve is closed and therefore does not heat the air. Figure 1 represents the air flow through the unit during the cooling mode.

Figure 1 – VAV Air Handler Schematic (Cooling Mode)



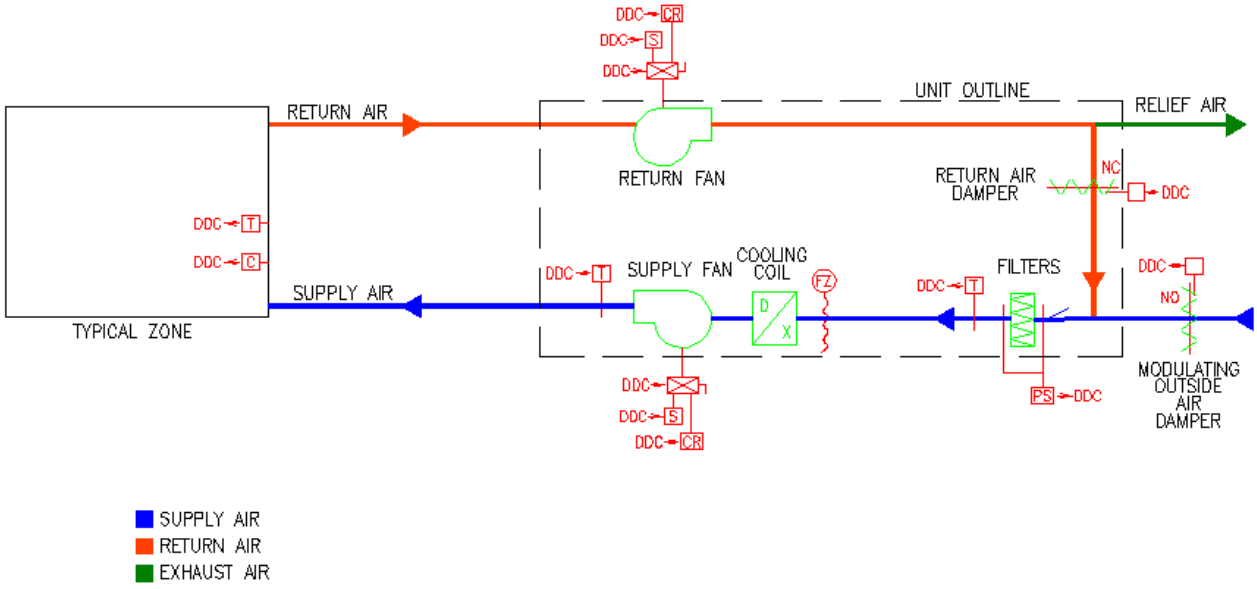
Cooling Mode – CV Units

The CV units have three modes of cooling: morning cool down, occupied, and unoccupied. The unit begins the morning cool down cycle when the zone temperature is above the set point of 75 °F, which is sensed by the DDC thermostat within the zone. At this point the OA damper will close, the RA damper will open, and mechanical cooling will begin. When the room reaches the set point of 75 °F the morning cool down cycle will end and the occupied mode will commence.

During the occupied mode the OA damper will open to provide economizer cooling and maintain a mixed air temperature of 55 °F. The temperature is registered by a DDC thermostat located after the RA and OA are mixed. As the outside air temperature continues to increase the DX cooling coil and condensing units will energize and condition the air.

When the unit is in the unoccupied mode the system shall maintain the night set point of 80 °F by the DX cooling coil. Figure 2 represents the air flow through the unit during the cooling mode.

Figure 2- CV Air Handler Schematic (Cooling Mode)



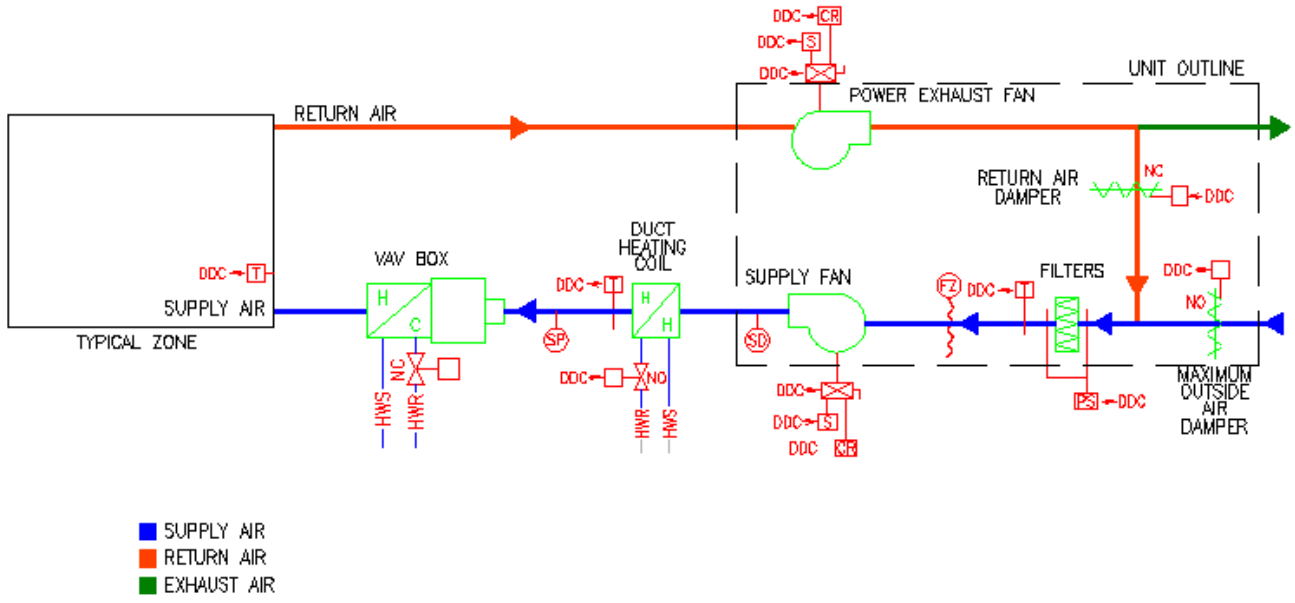
Heating mode – VAV Units

Similarly to the cooling mode the heating system also has three modes of operation: morning warm-up, occupied, and unoccupied cycle. During the warm-up the thermostat in the zone sends a signal to the unit when the space goes below the heating set-point of 72 °F. At this point the OA damper closes and the RA damper opens. The VAV box shall be set to heating mode and the heating coil shall modulate at open. Once the room reaches the set point the system switches over to occupied mode.

When in occupied mode the mixed air DDC thermostat regulates the position of the RA and OA dampers to maintain a SA temperature of 55 °F. The heating coil is turned on, and the VAV box is set to heating mode. The hot water reheat valve opens and the water flows through the coil to maintain the set point temperature of 72 °F, while the damper is set to the minimum heating position.

When the space is unoccupied the VAV box maintains the set point of 68 °F, by keeping the damper in maximum position and the reheat valve set to maintain the desired temperature. Figure 3 represents the air flow through the unit during the heating mode.

Figure 3 – VAV Air Handler Schematic (Heating Mode)



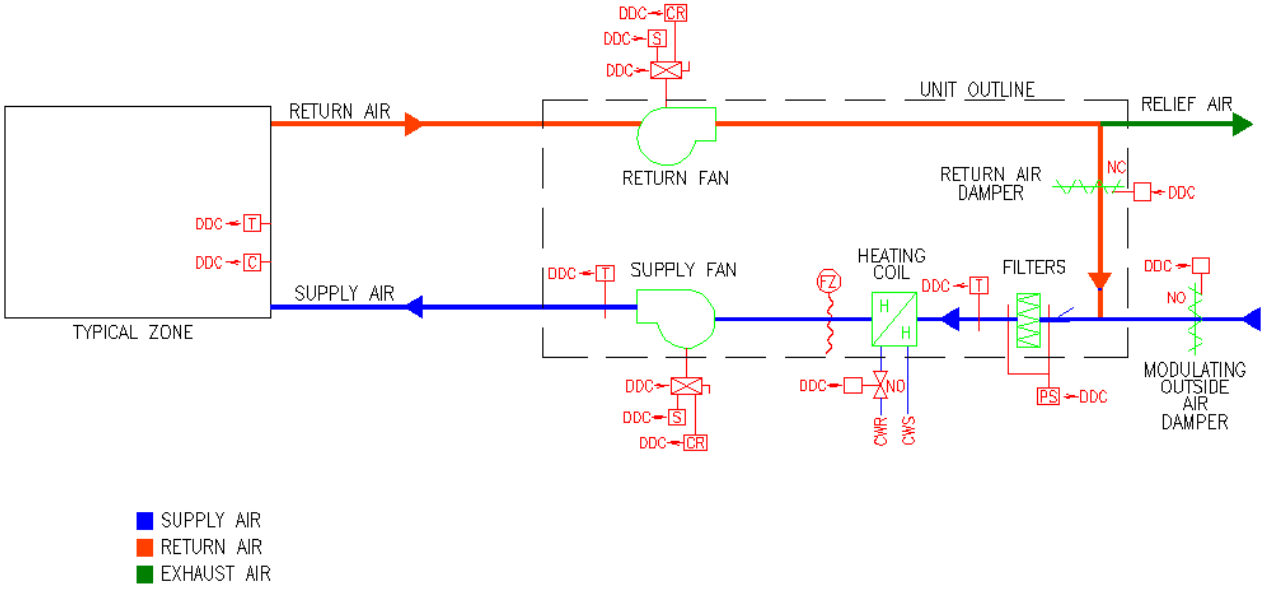
Heating mode – CV Units

The CV units have three modes of operation during the heating season: morning warm up, occupied, and unoccupied. In the morning warm up cycle the unit will begin heating the space until it reaches the set point temperature of 72 ^{o}F. This is achieved by having the OA damper closed, the RA damper open, and the heating coil will condition the air till it reaches the set point temperature of 72 ^{o}F.

Once the set point is reached the supply and return fan will run continuously and the OA damper will remain in minimum position. If the temperature falls below the set point, the hot water heating valve will open and modulate to maintain the set point.

During the unoccupied mode the supply fan will shut-down and the RA damper will open and the return fan will run intermittently maintaining the night set point (68 ^{o}F). Figure 4 represents the air flow through the unit during the heating mode.

Figure 4 - CV Air Handler Schematic (Heating Mode)

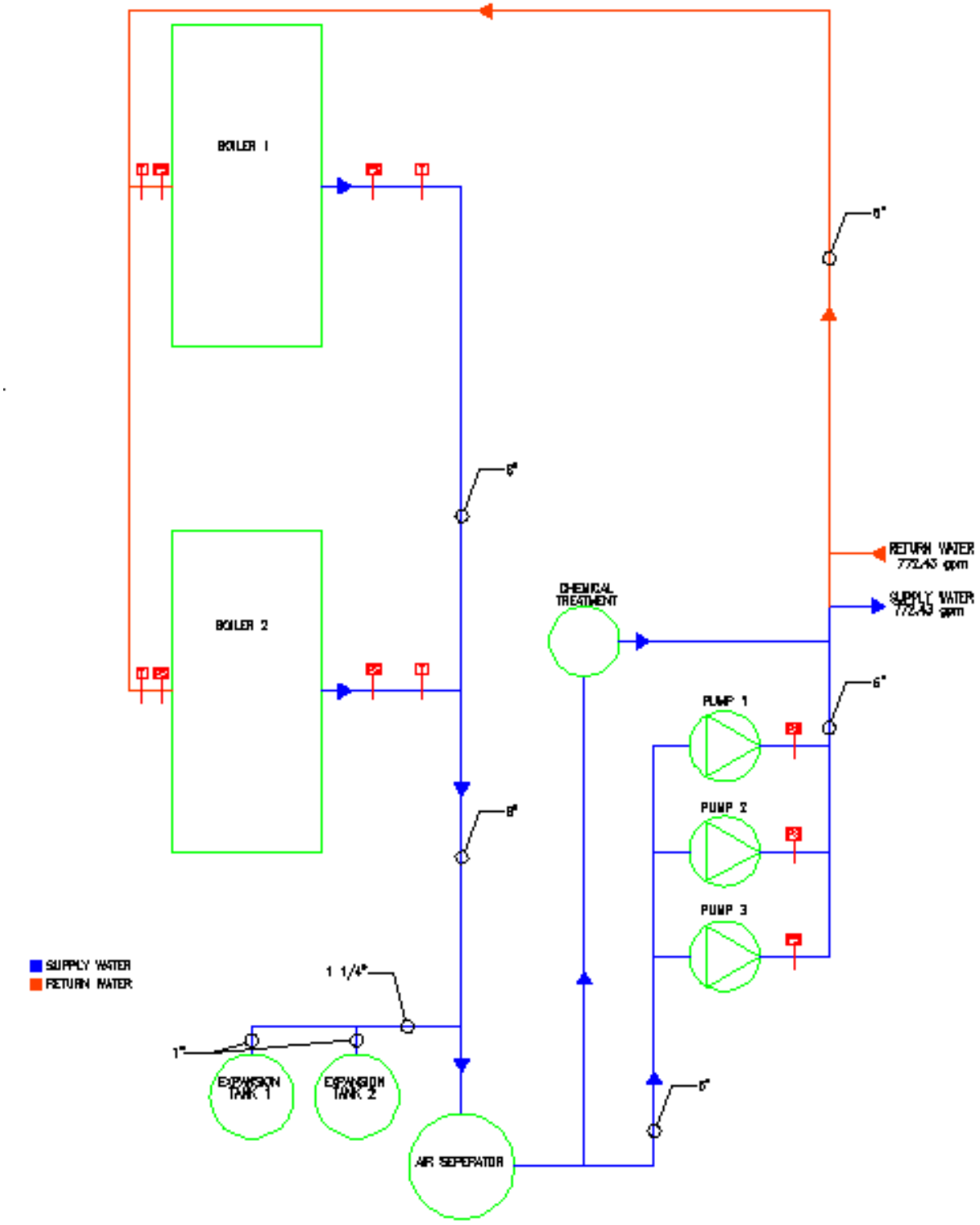


Hydronic System

The hydronic heating system for North Pocono is centralized in the mechanical room. It consists of two oil fired boilers, three centrifugal water pumps, the duct mounted heating coils, and the reheat coils contained in the VAV terminal units.

The water is supplied to the boilers heated to temperature of 180 ^{o}F and then pumped throughout the building to the heating coils and terminal units. They are programmed so that there is a lead boiler and when more heating is called for the second boiler is enabled. The boilers are set to alternate as being the lead boiler every week. The three pumps shall also trade off being the lead pump. The hot water is monitored by the DDC system. Figure 5 is a flow diagram representing the path the water follows.

Figure 5 – Hot Water Schematic



Since North Pocono is not served by a central cooling the amount of space lost to mechanical system is minimal. Table 8 is a comparison of the lost usable space due to the mechanical system.

Table 8 – Lost Useable Space

	AREA (ft^2)	PERCENTAGE
Mechanical Space	2,357	1%
Remaining Spaces	234,075	99%
Total	236,432	100%

Energy Analysis

An energy analysis using the Trace program was also performed to project how much energy North Pocono would consume annually. However, one was not performed by the design engineer because it was not requested by the owner.

North Pocono's energy rates and sources are listed in Table 9.

Table 9 – Utilities and Rates

Utility	Source		Rate
Electricity	PP&L	On-Pk. Cons.	$10.00/kW
		On-PK. Demand	$0.05/KWh
		Off-Pk. Cons.	$5.00/kW
		Off-Pk. Demand	$0.03/kWh
Oil	-	Consumption	$0.80/therm

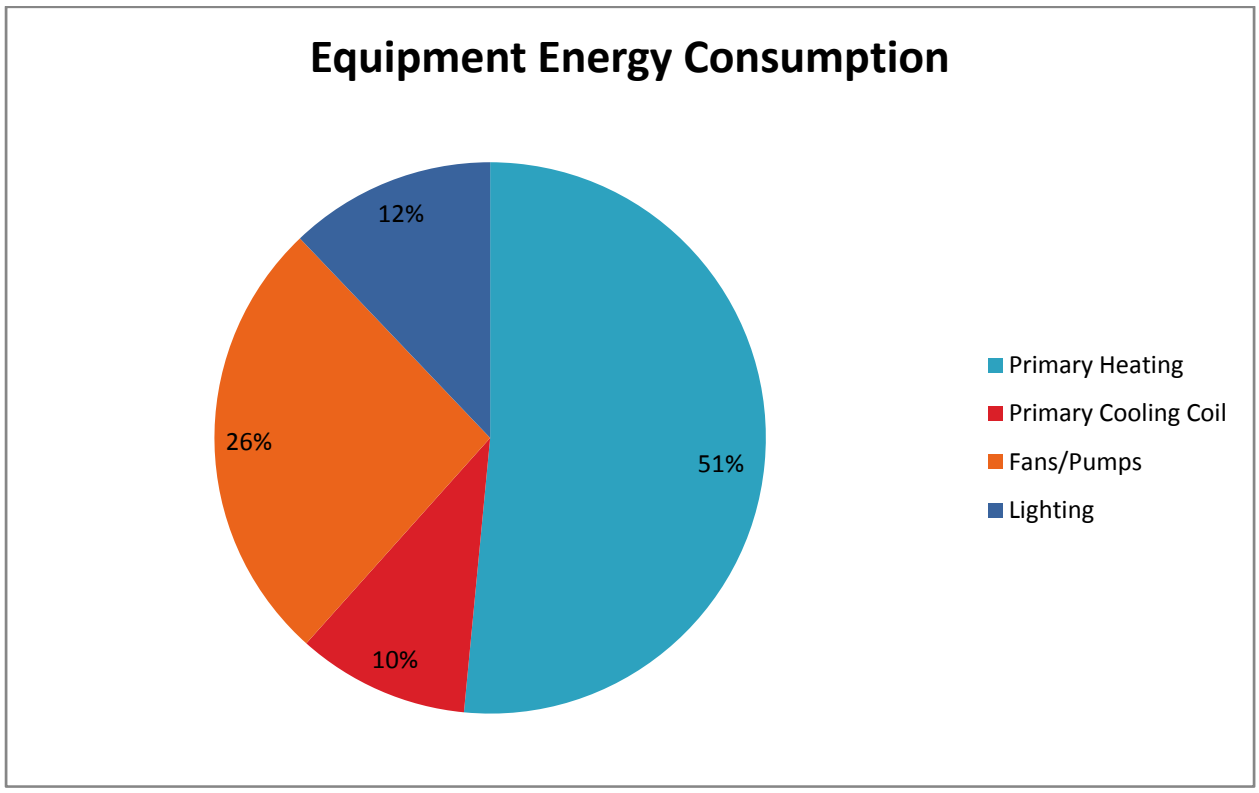
North Pocono is still looking for an oil provider therefore the value used to generate the oil cost was taken from the Trace programs economic library.

The results from the analysis showed the North Pocono will consume approximately 2,122,698 kWh a year, and 71,682 therms of oil year. This works out to be a total of 138,204 Btu/(ft^2-yr). The owner will spend approximately $230,474/yr; this includes $201,801/yr for electricity and $28,673/yr for oil. The projected cost/ ft^2 for the building's energy use is $1.09/yr.

The energy breakdown is as follows: the heating of the building accounts for 51% of the energy, cooling 10%, fans and pumps 26%, and lighting 12% of the energy. Table 10 shows the energy consumed by each category for the year.

Table 10 – Equipment Energy Consumption

Source	Energy (kBtu/yr)	Percent of Total Energy
Primary Heating	7,323.8	51%
Primary Cooling	1,456.1	10%
Fans/Pumps	3,752.4	26%
Lighting	1,770.5	12%



Operating History

The building is currently under construction therefore there is no data available for this section.

LEED Analysis

LEED, Leadership in Energy and Environmental Design, is a rating system set forth by the USGBC, United States Green Building Council. The LEED program rates a building according to six different categories: Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and

Innovation and Design Process. The six categories are broken down into a point system; the number of points received determines the building level of certification. The levels are:

1. Certified 26-32 points
2. Silver 33-38 points
3. Gold 39-51 points
4. Platinum 52-69 points

North Pocono did not apply for LEED rating, therefore the data used to verify certification was not recorded. However through discussion with several professional working on the project some of the points were able to be verified. A complete LEED rating checklist can be found in Appendix E. Overall, if the building complied with the necessary points it could have received 13 points.

Overall Evaluation

As shown throughout the research compiled for this project North Pocono's HVAC system adequately condition the school. Its cost is consistent with the budget that was provided by the school district. The DX cooling system does provide more cooling than called for therefore that is an area where the system could be improved so that operational costs stay down. Although the system does comply with the standards comparisons made during this project the equipment used within in the system can be improved. As shown in Appendix F the efficiencies of most of the air handlers do not comply with ASHRAE Standard 90.1, Energy Standards for Buildings…, which explains how to "provide minimum requirements for the energy efficient design of buildings…"

Appendix A – Ventilation Analysis

Air Handler 1	SA cfm = 15,850	Min OA cfm = 4,335									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Corridor-D001	Corridor	NA	NA	3,524	0.06	210	1.0	210	55	100	0.55
FCS Lab-D014	Classroom	25	10	1,273	0.12	405	1.0	405	460	1,400	0.33
Storage-D016	Storage	NA	NA	305	0.12	40	1.0	40	50	300	0.17
Classroom-D017	Classroom	25	10	805	0.12	350	1.0	350	350	1,280	0.27
Classroom-D018	Classroom	25	10	807	0.12	350	1.0	350	350	1,280	0.27
Electrical-D025	Electrical	NA	NA	120	0.06	10	1.0	10	15	225	0.07
Business Room-D113	Classroom	25	10	789	0.12	345	1.0	345	350	1,140	0.31
Business Lab-D114	Computer Lab	29	10	783	0.12	385	1.0	345	480	2,480	0.19
Classroom-D117	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Corridor-D118	Corridor	NA	NA	1,490	0.06	90	1.0	90	85	100	0.85
Room D120		9	10	380	0.12	135	1.0	135	170	645	0.26
Classroom-D121	Classroom	25	10	798	0.12	345	1.0	345	350	1,280	0.27
Classroom-D122	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-D123	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Electrical-D133	Electrical	NA	NA	119	0.06	10	1.0	10	15	225	0.07
Corridor-A101	Corridor	NA	NA	1,006	0.06	60	1.0	60	75	150	0.50
Training-A105	Classroom	7	10	551	0.12	70	0.8	90	70	500	0.14
Office-A106	Office	3	5	253	0.06	30	1.0	30	40	300	0.13
Classroom-A107	Classroom	25	10	800	0.12	345	1.0	345	390	1,220	0.32
							Total	4,195			

Air Handler 3	SA cfm = 36,000	Min OA cfm = 10,270									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Tickets-D226	Office	2	5	162	0.06	20	1.0	20	100	250	0.40
Gymnasium-D125	Gymnasium	NA	NA	14,921	0.3	4,475	1.0	4,475	9,005	30,000	0.30
Lobby - A202	Lobby	NA	NA	5,240	0.06	315	1.0	315	1,165	2,560	0.45
							Total	4,810			

Air Handler 2	SA cfm = 16,415	Min OA cfm = 7,675									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Faculty Room-D027	Office	20	5	1,750	0.06	205	1.0	310	375	1,640	0.23
Classroom-D010	Classroom	25	10	802	0.12	345	1.0	345	550	1,280	0.43
Classroom-D011	Classroom	25	10	890	0.12	360	1.0	360	570	1,280	0.45
Faculty Room-D135	Office	20	5	1,744	0.06	205	1.0	310	375	1,740	0.22
SGI-D136	Classroom	6	10	219	0.12	85	0.8	105	205	335	0.61
Classroom-D137	Classroom	25	10	835	0.12	350	1.0	350	560	880	0.64
Classroom-D138	Classroom	25	10	835	0.12	350	1.0	350	560	880	0.64
SGI-D139	Classroom	6	10	219	0.12	85	0.8	105	205	335	0.61
Aerobics-D140	Aerobics	30	20	1,178	0.06	670	1.0	670	810	810	1.00
Corridor-D001	Corridor	NA	NA	3,524	0.06	210	1.0	210	50	100	0.50
General Science-D106	Classroom	25	10	1,278	0.12	405	1.0	405	625	1,110	0.56
Storage-D107	Storage	NA	NA	133	0.12	15	1.0	15	20	125	0.16
Classroom-D109	Classroom	25	10	1,278	0.12	405	1.0	405	625	1,280	0.49
Classroom-D110	Classroom	25	10	802	0.12	345	1.0	345	550	1,280	0.43
Business Lab-D111	Computer Lab	25	10	789	0.12	345	1.0	345	550	2,440	0.23
Electrical Room-D250	Storage	NA	NA	415	0.12	50	1.0	50	180	225	0.80
Classroom-D206	Classroom	25	10	802	0.12	345	1.0	345	550	1,115	0.49
							Total	5,025			

North Pocono High School

Air Handler 5	SA cfm = 6,800	Min OA cfm = 3,945									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Control Room-D232	Media Center	2	10	122	0.12	35	1.0	35	85	180	0.47
Studio-D233	Office	4	5	186	0.06	30	1.0	30	80	100	0.80
Corridor-D237	Corridor	NA	NA	1,565	0.06	95	1.0	95	80	150	0.53
Choral Room-D238	Music	100	10	1,677	0.06	1,100	1.0	1,100	1,225	2,100	0.58
Health-D240	Classroom	26	10	759	0.12	350	1.0	350	550	1,410	0.39
Music Classroom-D242	Music	22	10	594	0.06	255	1.0	255	375	880	0.43
Practice-D243	Music	5	10	133	0.06	60	1.0	60	100	100	1.00
Practice-D244	Music	5	10	133	0.06	60	1.0	60	100	100	1.00
Practice-D245	Music	5	10	156	0.06	60	1.0	60	100	100	1.00
Music Classroom-D246	Music	22	10	594	0.06	255	1.0	255	340	880	0.39
Music Office-D247	Office	3	5	560	0.06	50	0.8	65	275	550	0.50
Musice Lab-D248	Music	33	10	911	0.06	385	1.0	385	550	920	0.60
							Total	2,750			

Dan Hanley

Air Handler 7	SA cfm = 13,500	Min OA cfm = 4,355									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Corridor-C201	Corridor	NA	NA	2,221	0.06	135	1.0	135	175	580	0.30
Corridor-C202	Corridor	NA	NA	1,557	0.06	95	1.0	95	90	290	0.31
Corridor-C203	Corridor	NA	NA	1,173	0.06	70	1.0	70	90	290	0.31
Classroom-C210	Classroom	25	10	814	0.12	350	1.0	350	350	1,280	0.27
Classroom-C211	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-C212	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-C213	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-C214	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-C215	Classroom	25	10	802	0.12	345	1.0	345	350	1,280	0.27
Classroom-C216	Classroom	25	10	814	0.12	345	1.0	345	350	1,280	0.27
Classroom-C217	Classroom	25	10	802	0.12	345	1.0	345	390	1,280	0.30
Classroom-C218	Classroom	25	10	802	0.12	345	1.0	345	390	1,280	0.30
Classroom-C219	Classroom	25	10	802	0.12	345	1.0	345	390	1,280	0.30
Classroom-C220	Classroom	25	10	802	0.12	345	1.0	345	390	1,280	0.30
Classroom-C221	Classroom	25	10	802	0.12	345	1.0	345	390	1,280	0.30
Dressing Room-C225	Office	4	5	200	0.06	30	0.8	40	20	200	0.10
Dressing Room C230	Office	4	5	200	0.06	30	0.8	40	25	200	0.13
							Total	4,525			

Air Handler 8	SA cfm = 13,500	Min OA cfm = 4,355									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Corridor-C101	Corridor	NA	NA	1,387	0.06	85	1.0	85	70	200	0.35
Classroom-C103	Classroom	25	10	802	0.12	345	1.0	345	410	1,280	0.32
Classroom-C104	Classroom	25	10	802	0.12	345	1.0	345	410	1,280	0.32
Classroom-C105	Classroom	25	10	802	0.12	345	1.0	345	410	1,280	0.32
Classroom-C106	Classroom	25	10	802	0.12	345	1.0	345	410	1,280	0.32
Electrical-C115	Electrical	NA	NA	129	0.06	10	1.0	10	15	225	0.07
Classroom-C118	Classroom	25	10	815	0.12	350	1.0	350	370	1,280	0.29
Classroom-C119	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
Classroom C120	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
Classroom-C121	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
Classroom-C122	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
Classroom-C123	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
Classroom-C124	Classroom	25	10	802	0.12	345	1.0	345	370	1,280	0.29
							Total	3,895			

Air Handler 9	SA cfm = 14,195	Min OA cfm = 6,245									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Chemistry-C222	Science Lab	25	10	1,280	0.18	480	1.0	710	500	1,180	0.42
Science Prep-C223	Classroom	3	10	279	0.12	65	1.0	65	135	400	0.34
Chemistry-C224	Science Lab	25	10	1,282	0.18	480	1.0	480	550	1,180	0.47
Earth Science C107	Science Lab	25	10	1,280	0.18	480	1.0	710	500	1,180	0.42
Science Prep-C108	Science Lab	3	10	279	0.18	80	1.0	130	80	400	0.20
Earth Science-C109	Science Lab	25	10	1,273	0.18	480	1.0	480	605	1,180	0.51
Corridor-C001	Corridor	NA	NA	1,390	0.06	85	1.0	85	85	200	0.43
Classroom-C003	Classroom	25	10	802	0.12	345	1.0	345	550	1,280	0.44
Classroom-C004	Classroom	25	10	802	0.12	345	1.0	345	550	1,280	0.44
Art Classroom-C005	Art Class	25	10	1,254	0.18	475	0.8	595	840	1,830	0.46
Storage-C006	Storage	NA	NA	247	0.12	30	0.8	40	100	295	0.34
Art Classroom-C008	Art Class	25	10	1,280	0.18	480	0.8	600	750	1,635	0.46
Corridor-C011	Corridor	NA	NA	980	0.06	60	1.0	60	60	100	0.60
Corridor-C018	Corridor	NA	NA	459	0.06	30	1.0	30	30	100	0.30
Classroom-C020	Classroom	25	10	811	0.12	350	1.0	350	435	1,280	0.34
Classroom-C021	Classroom	25	10	802	0.12	345	1.0	345	435	1,280	0.34
							Total	5,370			

Air Handler 15	SA cfm = 15,300	Min OA cfm = 6,120									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Physics-D203	Classroom	25	10	1,282	0.12	405	1.0	405	630	1,350	0.47
Science Prep-D204	Classroom	3	10	279	0.12	65	1.0	65	145	400	0.36
Physics-D205	Classroom	25	10	1,282	0.12	405	1.0	405	585	1,340	0.44
Corridor-D101	Corridor	NA	NA	3,558	0.06	215	1.0	215	270	350	0.77
Biology Classroom-D103	Classroom	25	10	1,281	0.12	405	1.0	405	630	1,340	0.47
Science Prep-D104	Classroom	3	10	279	0.12	65	1.0	65	245	400	0.61
Biology Classroom-D105	Classroom	25	10	1,281	0.12	405	1.0	405	585	1,340	0.44
Electrical-C016	Electrical	NA	NA	109	0.06	10	1.0	10	90	225	0.40
Corridor-D001	Corridor	NA	NA	3,524	0.06	210	1.0	210	80	150	0.53
Communication Lab-D003	Computer	25	10	1,380	0.12	415	0.8	520	705	1,700	0.41
Press Room-D004	Office	4	5	336	0.06	40	0.8	50	330	770	0.43
Dark Room-D005	Classroom	3	10	269	0.12	60	0.8	75	75	130	0.58
CADD Lab-D007	Computer	21	10	869	0.12	315	0.8	395	570	1,190	0.48
Wood Shop-D008	Wood Shop	20	10	1,850	0.18	535	0.8	670	750	1,600	0.47
Custodial BreakRoom	BreakRoom	7	5	355	0.06	55	1.0	55	200	360	0.56
							Total	3,950			

Air Handler 10	SA cfm = 8,565	Min OA cfm = 3,770									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Corridor - A203	Corridor	NA	NA	578	0.06	35	0.8	45	45	100	0.45
Police - A205	Office	3	5	152	0.06	25	0.8	30	75	145	0.52
Waiting - A206	Reception	6	5	378	0.06	55	0.8	70	220	495	0.44
Adminstrative Area - A207	Reception	2	5	610	0.06	50	0.8	65	215	480	0.45
Work/Break Room - A208	Break	5	5	320	0.06	45	0.8	55	210	480	0.44
Storage - A209	Storage	NA	NA	91	0.12	10	0.8	15	75	140	0.54
Corridor - A210	Corridor	NA	NA	295	0.06	20	0.8	25	240	540	0.44
Adminstrative Area - A211	Reception	2	5	380	0.06	35	0.8	45	255	550	0.46
Vice Priniciple -A214	Office	3	5	261	0.06	30	0.8	40	95	450	0.21
Office - A215	Office	3	5	268	0.06	30	0.8	40	150	380	0.39
Principal's Office- A216	Office	7	5	284	0.06	50	0.8	65	190	420	0.45
Conference Room-A217	Conference	14	5	370	0.06	90	0.8	115	380	820	0.46
Waiting - A218	Reception	8	5	182	0.06	50	0.8	65	65	100	0.65
Nurses Office-A219	Office	3	5	544	0.06	50	0.8	65	165	480	0.34
Cot-A220	Classroom	3	10	174	0.12	50	0.8	65	65	120	0.54
Exam Room - A222	Office	2	5	132	0.06	20	0.8	25	95	200	0.48
Storage - A224	Storage	NA	NA	133	0.12	15	0.8	20	20	45	0.44
Hearing-A225	Office	4	5	108	0.12	35	0.8	45	100	200	0.50
Cot-A226	Classroom	3	10	201	0.06	40	0.8	50	65	120	0.54
Corridor-D211	Corridor	NA	NA	1,975	0.06	120	0.8	150	60	120	0.50
Corridor-D216	Corridor	NA	NA	306	0.6	20	0.8	25	25	100	0.25
Conference Room-D217	Conference	8	5	171	0.06	50	0.8	65	220	550	0.40
Office-D218	Office	4	5	208	0.06	30	0.8	40	75	200	0.38
Office-D219	Office	3	5	170	0.06	25	0.8	30	70	180	0.39
Office-D220	Office	4	5	171	0.06	30	0.8	40	75	180	0.42
Conference Room-D221	Conference	14	5	400	0.06	95	0.8	120	120	820	0.15
File Room-D222	Storage	NA	NA	165	0.12	20	0.8	25	25	40	0.63
Office-D223	Office	4	5	171	0.06	30	0.8	40	70	180	0.39
Office-D224	Office	4	5	149	0.06	30	0.8	40	70	180	0.39
Adminstrative Wating-D225	Reception	9	5	690	0.06	85	0.8	105	105	320	0.33
Kitchenette-D271	Coffee Station	2	5	75	0.3	35	0.8	45	45	80	0.56
							Total	1,670			

Air Handler 12	SA cfm = 3,800	Min OA cfm = 2,250									
Space	Use	P_z	R_p	A_z	R_a	V_{bz}	E_z	V_{oz}	OA_{sup}	V_{pz}	Z_p
Corridor-D249	Corridor	NA	NA	1,654	0.12	200	1.0	200	230	300	0.77
Band Room-D254	Music	150	10	3,249	0.06	1,695	1.0	1,890	2,000	3,300	0.61
Corridor-D274	Corridor	NA	NA	395	0.06	25	1.0	25	25	100	0.25
							Total	2400			

Air Handler 13	SA cfm = 18,200	Min OA cfm = 10,800									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Corridor-B202	Corridor	NA	NA	629	0.06	40	1.0	40	160	375	0.43
Cafeteria-B203	Cafeteria	360	7.5	9,295	0.18	4,375	0.8	4,375	8,640	14,800	0.58
Faculty Dining	Cafeteria	20	7.5	650	0.18	270	0.8	270	540	1,120	0.48
Food Court-B208	Cafeteria	NA	NA	1,989	0.18	360	0.8	360	1,250	2,280	0.55
Office-B214	Office	3	5	114	0.06	20	0.8	20	25	145	0.17
School Store	Store	NA	NA	325	0.12	40	0.8	40	110	300	0.37
							Total	5,105			

Air Handler 14	SA cfm = 10,300	Min OA cfm = 2,575									
Space	Use	P_z (# of Occupants)	R_p cfm/person	A_z Area (sq. ft.)	R_a cfm/sq.ft.	V_{bz} (cfm)	E_z	V_{oz} (cfm)	OA_{sup} (cfm)	V_{pz} (cfm)	Z_p
Storage-D207	Storage	NA	NA	393	0.12	50	1.0	50	105	430	0.24
Computer Lab-D208	Computer Lab	30	10	1,184	0.12	440	1.0	440	720	2,900	0.25
Library-D209	Library	70	5	3,490	0.12	770	0.8	965	1,120	4,955	0.23
Office-D210	Office	3	5	485	0.06	45	0.8	55	130	565	0.23
Corridor-D211	Corridor	NA	NA	1,975	0.06	120	1.0	120	60	180	0.33
Classroom-D212	Classroom	25	10	800	0.12	345	1.0	345	285	1,280	0.22
Electrical Room-D235	Electrical	NA	NA	119	0.06	10	1.0	10	50	225	0.22
							Total	1,985			

Appendix B – Equipment Summary

Table B1 – Air Handlers and DX Cooling

TAG	SUPPLY AIR (cfm)	MIN O.A. (cfm)	L.A.T (°F)	FAN HP	MIN. MBH
AHU-1	15,850	4,335	54	25	596
AHU-2	16,415	7,675	52	25	792
AHU-3	36,000	10,270	55	25	2,000
AHU-4	3,700	3,700	55	5	220
AHU-5	6,800	3,945	53	15	392
AHU-6	19,500	19,500	55	20	1.061
AHU-7	13,500	4,355	53	20	558
AHU-8	12,650	4,355	55	20	453
AHU-9	14,195	6,245	52	25	651
AHU-10	8,565	3,770	52	15	383
AHU-11	3,000	3,000	55	5	164
AHU-12	3,800	2,250	54	-	225
AHU-13	18,200	10,800	52	30	943
AHU-14	10,300	2,575	55	10	338
AHU-15	15,300	6,120	53	25	662
AHU-16	3,000	3,000	54	5	164

Table B2 – Heating Coils

TAG	AIR FLOW (cfm)	WATER FLOW (gpm)	MIN. MBH
HC-1	6,115	24.1	481.71
HC-2	7,840	30.2	604.22
HC-3	36,000	160	3,150.45
HC-4	3,700	26.7	535.67
HC-5	3,795	20.5	410.35
HC-6	19,500	80.7	1,613.3
HC-7	6,026	23.9	477.50
HC-8	5,990	22.5	450.81
HC-9	6,495	26.0	519.60
HC-10	3,440	14.5	290.38
HC-11	3,000	12.4	249.07
HC-12	3,700	17.5	350.82
HC-13	5,830	31.5	629.69
HC-14	4,100	15.8	316.38
HC-15	4,915	19.3	386.42
HC-16	3,000	12.4	249.07

Table B3 – Condensing Units

TAG	CAPACITY (TONS)
CU-1	2.0
CU-2a	80.0
CU-2b	80.0
CU-3	124
CU-4	12.5
CU-5	10.0
CU-6	6.5
CU-7	4.5
CU-8	10

Table B4 – Boiler Schedule

TAG	HP	MBH INPUT	MBH OUTPUT	OIL FLOW RATE (gph)
B-1	167	7,000	5,880	50
B-2	167	7,000	5,880	50

Table B5 – Hot Water Pump Schedule

TAG	WATER FLOW RATE (gpm)	HEAD (ft.)	HP
P-1	395	120	20
P-2	396	120	20
P-3	396	120	20

Table B6 – VAV Box Ranges

Minimum MBH	Maximum MBH
4.14	60.88

Appendix C – Monthly Energy Consumption

Utility		Jan.	Feb.	Mar.	Apr.	May	June
Electric	On-Pk. Cons. (kWh)	242	228	202	131	174	242
	On-PK. Dem. (kW)	608	608	1,306	1,566	2,203	2,247
Oil	On-Pk Cons. (therms)	14,909	18,447	9,239	4,221	1,149	617

Utility		July	Aug.	Sept.	Oct.	Nov.	Dec.
Electric	On-Pk. Cons. (kWh)	192	10	173	140	156	233
	On-PK. Dem. (kW)	2,170	649	1,914	1,428	1,185	608
Oil	On-Pk Cons. (therms)	215	0	1,903	4,367	5,999	11,427

Appendix D – Monthly Energy Cost

Utility		Jan.	Feb.	Mar.	Apr.	May	June
Electric	On-Pk. Cons. ($)	7,277	7,268	6,432	4,167	7,714	6,117
	On-PK. Dem. ($)	4.945	4.945	10.616	12.735	17.907	18.271
Oil	On-Pk Cons. ($)	5,964	7,379	3,696	1,688	460	247
	Monthly Total ($)	18,636	19,592	20,743	18,590	23,934	26,232

Utility		July	Aug.	Sept.	Oct.	Nov.	Dec.
Electric	On-Pk. Cons. ($)	6,117	330	5,508	4,478	4,976	7,430
	On-PK. Dem. ($)	17.642	5.280	15.561	11.608	9.630	4.945
Oil	On-Pk Cons. ($)	86	0	437	1,747	2,399	4,571
	Monthly Total ($)	23,846	5,610	21,506	17,833	17,005	16,946

Appendix E – LEED CHECKLIST

LEED-NC

LEED-NC Version 2.2 Registered Project Checklist

<< enter project name >>
<< enter city, state, other details >>

Yes	?	No			
4		10	**Sustainable Sites**		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
		x	Credit 1	**Site Selection**	1
		x	Credit 2	**Development Density & Community Connectivity**	1
		x	Credit 3	**Brownfield Redevelopment**	1
x			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
		x	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
		x	Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	1
x			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
		x	Credit 5.1	**Site Development,** Protect of Restore Habitat	1
		x	Credit 5.2	**Site Development,** Maximize Open Space	1
x			Credit 6.1	**Stormwater Design,** Quantity Control	1
x			Credit 6.2	**Stormwater Design,** Quality Control	1
		x	Credit 7.1	**Heat Island Effect,** Non-Roof	1
		x	Credit 7.2	**Heat Island Effect,** Roof	1
		x	Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
1		4	**Water Efficiency**		5 Points
		x	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
		x	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		x	Credit 2	**Innovative Wastewater Technologies**	1
x			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
		x	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Yes	?	No			
		17	**Energy & Atmosphere**		17 Points

Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
		x	Credit 1	**Optimize Energy Performance**	1 to 10
		x	Credit 2	**On-Site Renewable Energy**	1 to 3
		x	Credit 3	**Enhanced Commissioning**	1
		x	Credit 4	**Enhanced Refrigerant Management**	1
		x	Credit 5	**Measurement & Verification**	1
		x	Credit 6	**Green Power**	1

continued…

Yes	?	No			
2		11		**Materials & Resources**	**13** Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		x	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		x	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		x	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
x			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
		x	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		x	Credit 3.1	**Materials Reuse**, 5%	1
		x	Credit 3.2	**Materials Reuse**,10%	1
		x	Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
		x	Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
x			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
		x	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
		x	Credit 6	**Rapidly Renewable Materials**	1
		x	Credit 7	**Certified Wood**	1

Yes	?	No			
6		9		**Indoor Environmental Quality**	**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
		x	Credit 1	**Outdoor Air Delivery Monitoring**	1
		x	Credit 2	**Increased Ventilation**	1
x			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
x			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1

Yes	?	No			
x			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
x			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
x			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
x			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
		x	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
		x	Credit 6.1	**Controllability of Systems**, Lighting	1
		x	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
		x	Credit 7.1	**Thermal Comfort**, Design	1
		x	Credit 7.2	**Thermal Comfort**, Verification	1
		x	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		x	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No			
		5	**Innovation & Design Process**		**5** Points
		x	Credit 1.1	**Innovation in Design**: Provide Specific Title	1
		x	Credit 1.2	**Innovation in Design**: Provide Specific Title	1
		x	Credit 1.3	**Innovation in Design**: Provide Specific Title	1
		x	Credit 1.4	**Innovation in Design**: Provide Specific Title	1
		x	Credit 2	**LEED® Accredited Professional**	1

Yes	?	No		
13		56	**Project Totals** (pre-certification estimates)	**69** Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

Appendix F – Air Handler Efficiency

Air Handler	Air Flow (cfm)	CFM*0.0015	Fan HP	Complaint
AHU-1	15,850	23.8	25	No
AHU-2	16,415	24.6	25	No
AHU-3	36,000	54.0	25	Yes
AHU-4	3,700	5.6	5	Yes
AHU-5	6,800	10.2	15	No
AHU-6	19,500	29.3	20	Yes
AHU-7	13,500	20.3	20	Yes
AHU-8	12,650	19.0	20	No
AHU-9	14,195	21.3	25	No
AHU-10	8,565	12.8	15	No
AHU-11	3,000	4.5	5	No
AHU-12	3,800	5.7	NA	NA
AHU-13	18,200	27.3	30	No
AHU-14	10,300	15.5	10	Yes
AHU-15	15,300	23.0	25	No
AHU-16	3,000	4.5	5	No