Contents

Executive Summary

The North Pocono High School is a 230,000 ft^2, $29 million dollar new facility located in Northeast Pennsylvania. The building is three levels which include: classrooms, offices, a gymnasium, an auditorium, a cafeteria, woodshops, computer labs, and a library. The construction for the school began in July 2007 and is scheduled to end in September of 2009.

The mechanical system for North Pocono is comprised of 16 Rooftop Air Handling Units (AHU), 12 are Variable Air Volume units (VAV), while 4 units are Constant Air Volume (CAV). The CAV units serve the auditorium, the large group instruction room, and the locker rooms. This was to ensure the return fan was properly sized for those spaces. All of the AHU are equipped with Direct Expansion (DX) cooling coils, and a duct mounted heating coil located downstream of the AHU. The AHU supply VAV terminal units with hot water reheat coils. The hot water is supplied by two boilers which heats the water to 180 ^{o}F and supplies to the heating coils and VAV boxes.

The purpose of this report is to propose an alternate system for North Pocono and compare it to the existing system. Several different options were considered for this proposal but the one that will be explored is a geothermal heating and cooling pump system with dedicated outdoor air system providing ventilation. The other options considered for the project were radiant flooring or radiant ceiling panels.

The rationalization for selecting the geothermal system is to: reduce the life cycle cost, reduce energy use, and gain valuable knowledge of how this system operates. With the industry moving towards more energy efficient systems; geothermal technology lends itself to becoming more common place.

Also, two breadth studies will be prepared as a part of the final report. One will be a structural breadth and will explore a new roof system due to the change of equipment that will be placed on the structure. The second study will analyze the electrical system in North Pocono, specifically the panels that serve the mechanical equipment.

Existing Systems Summary

North Pocono's air supply is conditioned by 12 VAV AHU units and 4 CV units, which are used for economizer only so that the equipment can be properly sized, with DX cooling coils and duct mounted heating coils that serve VAV terminal units with reheat capabilities. The AHU take return air and mix it with outdoor air within in the unit and then supply it to the VAV boxes which heat the air up to the set point determined by the occupant. The control system is direct digital control with thermostats in each zone and sensors within the units to adjust the dampers for proper mixture of the outdoor air and return air. According to ANSI/ASHRAE Standard 62.1 – 2007, Ventilation for Acceptable Indoor Air Quality, the VAV units supply too much ventilation air to the school. Table 1 breaks down what the standard calls for and what the ventilation the unit provides.

Table 1 – Standard 62.1 Ventilation vs. Supplied Ventilation

Tag	62.1	OA_{sup}
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
AHU-10	1,670	3,685
AHU-12	2,400	2,255
AHU-13	5,105	10,275
AHU-14	1,985	2,470
AHU-15	3,950	5,890

This puts unnecessary strain on the mechanical system because the AHU are conditioning too much OA.

Also the majority of the AHU efficiencies do not meet ANSI/ASHRAE Standard 90.1 – 2007, Energy Standard for Buildings…, which explains how to "provide minimum requirements for the energy efficient design of buildings…." Specifically Section 6 of the standard establishes the requirements for the buildings mechanical system to comply so that it can perform efficiently. Table 2 shows how the AHU do not comply with the standard.

Table 2 – Air Handler Efficiency

Air Handler	Air Flow (cfm)	CFM*0.0015	Fan HP	Compliant
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

The hydronic system is made up of 2 boilers and 3 water pumps located in the mechanical room of the school. All of the heating coils within the system use hot water. The water is heated to 180 ^{o}F by two 7,000 BTU oil fired boilers which are programmed to be two stage boilers and alternate each week as the lead boiler. The water is then pumped through the system by three water pumps, which are also programmed to alternate between the primary pump and so forth.

Alternate Design Considerations

Three options were explored for this report; two of which do not seem feasible or do not seem logical to put in place when the design of the school was considered.

Radiant Flooring

The first option was to replace the system with radiant heating and cooling in the floor system. All of the floors are poured concrete slab therefore embedding the necessary equipment during the construction phase would not have been an issue. Also since the heat would be radiating from the floor there would not be a need to put so much energy into conditioning the air; however the life cycle cost of the system seems to be greater problem. In order for the system to work properly the floor cannot fall below a certain temperature, therefore the pumps have to run continuously throughout the winter since the school is located in a region of the country that experiences cold temperatures during those months.

Radiant Ceiling Panels

The second option considered was to place radiant panels in the ceiling of the school. This would cool the warm air at the top of the room which would cause a natural circulation of the cold air around the room. But with the drop ceiling in the classrooms and offices being 11 feet high it would seem during the heating months the warm air would not reach the occupants resulting in thermal discomfort.

Proposed Redesign

Geothermal System

The purpose for applying geothermal technology to North Pocono High school is to reduce the school's life cycle, save energy, and gain a knowledge base with the technology offered by the system. On average it takes 5 to 10 years for a geothermal system to payback the systems first cost expenses, and will save the school board between 25% to 50% percent on energy consumption. This new technology takes advantage of the earth's stable core temperature; which is warmer than the air in the winter and cooler than the air in the summer.

In addition to the economic compensation the system would generate there are other advantages for applying this system to the school. For example, the school already fitted for VAV terminal units and have ample amount of plenum space which will be easy to retrofit for the heat pumps within the system. Also, this system could reduce the size of the boilers or eliminate the need for central boilers, thus reducing the size of the mechanical room and creating more useable space in the school.

Dedicated Outdoor Air System (DOAS)

Separating the ventilation air from the primary mechanical system will ensure that the proper amount of outdoor air will be supplied to the space. Also, this system generally reduces the need to condition outdoor air by 20% to 30% than a system with an integrated delivery system. The DOAS would meet all of the latent loads and a portion of the sensible. This system paralleled with a geothermal system will provide the necessary amount of thermal conditioning and comfort within the school.

Breadth Topics

Structural Breadth

Due to the change of equipment that would be placed on the school's roof a new structural system will be developed to accommodate the new loads. The current system will be analyzed and any modifications or changes in design will be further researched.

Electrical Breadth

Along with structural changes, electrical demand will be altered. With the addition of new pumps and equipment being eliminated from the schedule a new electrical system to serve the mechanical system will be explored.

Tools and Methods

In order to complete the redesign North Pocono's mechanical system a schedule will be generated, which is seen in Appendix A. The schedule will layout how much time will be spent on each task. First research will be conducted; this will include studying related topics and case studies of existing buildings. Following the research, equipment and system selection will take place. Next, the redesign of ductwork and piping systems will be completed as necessary.

Once the mechanical depth has been concluded the structural and electrical breadths will be reviewed. For the structural breadth faculty members, peers, and computer software will assist in the redesign of the school's roof system. The electrical breadth will be conducted with the assistance of faculty. Hand calculations will be used to calculate the new loads, and then new equipment will be designed.

Once those tasks are completed a Trace 700 model will be produced to analyze the proposed redesign. A comparison between the old model, which was created for the second report in this series, and the new model outputs will then be compared and a conclusion on which system is optimal for North Pocono High School will be made.

Throughout the mechanical depth a faculty consultation will occur to ensure the design analysis is accurate and to provide feedback on the new system.

References

http://doas.psu.edu/

Geothermal Heat Pumps. 2007. HealthGoods, LLC. http://www.healthgoods.com/education/healthy_home_information/space_heating_and_cooling/geothermal_heat.htm

Geothermal Heat Pumps. 2008. DOE. http://www1.eere.energy.gov/geothermal/heatpumps.html

Hanley, Daniel. Technical Assignment 1 - ASHRAE Standard 62.1 and Standard 90.1. 29 Sept. 2008.

Hanley, Daniel. Technical Assignment 2 - Design and Energy Analysis. 24 Oct. 2008.

Appendix A – Spring Schedule

January 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12 Class Begins Review Proposal	13 Review Proposal Research	14 Review Proposal Research	15 Research	16 Research	17
18	19 Research	20 Research	21 Faculty Consult	22 Select	23 Equipment	24
25	26 Select	27 Equipment	28 Redesign System	29 Redesign System	30 Redesign System	31

February 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 Faculty Consult	3 Model New System	4 Model New System	5 Model New System	6 Compare Systems	7
8	9 Compare Systems	10 Compare Systems	11 Organize Data	12 Organize Data	13 Organize Data	14
15	16 Faculty Consult	17 Make	18 Adjustments	19 Make	20 Adjustments	21
22	23 Prepare Final Model	24 Prepare Final Model	25 Prepare Final Model	26 Prepare Final Model	27 Prepare Final Model	28

March 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 Structural Breadth	3 Structural Breadth	4 Structural Breadth	5 Structural Breadth	6 Structural Breadth	7
8	9 Spring Break	10 Spring Break	11 Spring Break	12 Spring Break	13 Spring Break	14
15	16 Electrical Breadth	17 Electrical Breadth	18 Electrical Breadth	19 Electrical Breadth	20 Electrical Breadth	21
22	23 Faculty Consult	24 Work on Final Report	25 Work on Final Report	26 Work on Final Report	27 Work on Final Report	28
29	30 Work on Final Report	31 Work on Final Report				

April 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1 Work on Final Report	2 Work on Final Report	3 Work on Final Report	4
5	6 Prepare	7 Presentation	8 Prepare	9 Presentation	10 Rehearse	11
12	13 PRE	14 SEN	15 TA	16 TIONS	17 !!	18
19	20	21	22	23	24	25
26	27	28	29	30		