PSUAE

Technical Report: Three

Mechanical Systems Existing Conditions Evaluation

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Mechanical Option-IP

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Executive Summary

The Sunshine Elementary School is being constructed in the Hershey, PA area. The project goal is to gain a Silver Rating from the Leadership in Energy and Environmental Design (LEED). A LEED analysis has been performed using the 3.0 version of the rating scale. This is the most current version of LEED. The analysis showed the design proved to be both highly efficient while being environmentally conscious throughout the design. This includes ensuring high quality indoor conditions and thermal comfort for the occupants of the building.

The school includes accommodations for kindergarten through 5th grade students. Within the school there is also a gymnasium, large kitchen, cafeteria and administrative space. The school has been designed primarily as a single floor with only one two story section being the 3rd through 5th grade classrooms. The design was focused on a school within a school concept allowing the kindergarten students to merge with the older students and become comfortable within the environment.

The total cost, given by the project manager, of the MEP system was $5,271,200. The total area of the building was 103,000 ft^2, yielding a cost of $51.17/$ft^2$. This does not include approximate costs of $100,000 for commissioning and $69,100 for air balancing, hydronic balancing and commissioning support.

A highly efficient ground source heat pump was chosen for the mechanical design. Ninety-two ground wells were designed in order to create the capacity needed. The water loop is then pumped to small heat pumps severing individual spaces and five larger air handling units serving lager spaces such as the cafeteria and gymnasium. The heat pumps are a water-to-air system. The ventilation is ducted through the corridor to each space and is controlled by demand control ventilation by the way of CO^2 sensors located in each space. To further conserve energy recovery units with variable speed fans are located to exchange temperatures between exhausted air and outdoor air.

This report will analyze the overall system. It will include construction cost, operating cost, mechanical space requirements along with basic system analysis. The analysis should provide ideas of possible savings within the design. Though design changes may prove to not be cost effective, analysis will be created in later reports.

Mechanical System Description

New Construction Background

The Sunshine Elementary School is being constructed in the area of Hershey, PA. The exact location has been requested to remain anonymous by the owner. The school will support kindergarten through 5th grade. Included in the building is a gymnasium, offices, multi-purpose rooms, cafeteria and kitchen along with separate wings for kindergarten students and a two story section for the 1st through 5th grade classrooms. The building is constructed with concrete block and a gabled roof utilizing heavy timber trusses. The façade is brick with limited glazing.

Mechanical Design Objectives and Requirements

The overall design objective was to create a comfortable, reliable and safe mechanical system while reducing the energy usage of the building. Goals included an overall LEED silver certification for the building. The main occupants of the building are young students, so a safe and healthy atmosphere was major design objective. The designers used ASHRAE Standards 90.1 and 62.1 as a baseline for design conditions to ensure goals were met at or above typical standards.

Energy Sources

The primary energy sources utilized at The Sunshine Elementary School were electricity and natural gas. The rates of these utilities are negotiated by the owner and the power companies. Previous bills from the owner were used by the designers to estimated energy costs. Met-ed, A First Energy Company is the supplier of electricity and UGI is the supplier of natural gas. The rates have been estimated and can be seen in the tables below.

Annual Electricity Rates	
Electric Cost Rate ($/kW)	0.0764
Electric Demand Rate ($/kW)	6.96

Table 1- Electricity Rates

On Peak Monthly Natural Gas Rates	
Month	Price per Therm ($)
Jan	1.1787
Feb	1.1801
Mar	1.1807
Apr	1.1891
May	1.1917
June	1.2068
July	1.2083
Aug	1.2083
Sep	1.2003
Oct	1.1885
Nov	1.1864
Dec	1.1803

Table 2- Natural Gas Rates

Copies of the bills used to create these estimations can be found in the appendices of Tech 2 although all information which may invade privacy has been removed from the documents. The assumption has been made that these previously negotiated rates will be comparable to the rates that The Sunshine Elementary School will be subject to.

Design Conditions

The outdoor winter and summer design conditions that were used for the site can be seen below in Table 3. The outdoor conditions were taken from TRACE 700 Weather Data which is the same as the conditions given by The ASHRAE Handbook of Fundamentals.

TRACE 700 Design Conditions for Harrisburg, PA		
Summer		Winter
DB (^oF)	MCWB (^oF)	DB (^oF)
91	74	11

Table 3: TRACE 700 Weather Data

The indoor design conditions were obtained from the schedules provided by the designer can be seen below for both the heat pumps and the Air-to-air energy recovery units.

Heat Pumps- Scheduled Indoor Designed Conditions				
	Cooling		Heating	
	EAT		EAT	EWT
	DB (°F)	WB (°F)	DB (°F)	(°F)
HP-1-10	76	80	70	45
AHU-1-5	76	80	70	45

Air-to-Air Energy Recovery Units- Scheduled Indoor Designed Conditions				
	Summer		Winter	
	EAT	LAT	EAT	LAT
	DB/WB (°F)	DB/WB (°F)	DB (°F)	DB (°F)
ERU-1-9	90/74	79	10	59

Table 4: Scheduled Indoor Design Temperatures

Design Ventilation Requirements

An Analysis was performed using ASHRAE Standard 62.1 to determine if The Sunshine Elementary School design is compliant with the standard. This analysis used the prescriptive ventilation method given by ASHRAE. The procedure is a prescriptive measurement based on type/application, occupancy level, and floor area. The HVAC system utilized uses demand control ventilation. CO_2 sensors are located throughout the design to ensure proper ventilation to the space while limiting wasteful energy usage. The results of the analysis can be seen below in Table 5. The ventilation designed for the spaces were all individually compliant and overall the building receives more than adequate ventilation to ensure a healthy environment.

	ASHRAE 62.1-2007 Ventilation Requirements	Designed Ventilation Provided
CFM	**15394**	**19335**

Table 5: Ventilation Requirements

Design Load Estimates

The designer of the project created an eQuest model to perform an energy analysis of the building. A Trane TRACE 700 model was created for Technical Report: Two to compare the results of the designer's analysis to that of my own. The results of the comparison can be seen in Technical Report: Two. Below are some check values for the cooling, heating and ventilation values are listed in Table 6. The results were similar but vary. This variation is due to the designer's extensive schedule allowing for a very accurate energy model to be created.

COOLING AND HEATING LOAD ANALYSIS				
	Tons	ft^2/ton	MBh	Btu/hr ft^2
Designed Cooling	30.8	377.92	364.5	28.6
Calculated Cooling	32.2	395.08	387.9	30.37
Designed Heating	-	-	-187.6	-14.5
Calculated Heating	-	-	-199.7	-15.64

Table 6: Cooling and Heating Load Analysis

Estimated Annual Energy Use

A Trane TRACE 700 model was used to create a full 8760 hour energy analysis of the designed HVAC system. The system utilizes electricity for heating and cooling of the building by the way of highly efficient ground source heat pumps and Air-to- Air energy recovery units. Some natural gas is used mostly for domestic hot water. Design parameters for the model included occupancy, lighting and equipment schedules. These schedules can be found in the Appendices of Technical Report: Two.

The designer of the project utilized eQuest to complete an annual energy consumption analysis of the building. The schedules of the model were extremely detailed resulting in a very comprehensive model. Although more comprehensive the two models compared closely in total annual energy consumption as can be seen below in Table 7.

Overall % Difference	
	Btu/Hr
eQuest	4857923
Trace 700	5105408
% difference	5%

Table 7: Overall Percent Difference

The breakdown of energy usage was also analyzed in Technical Report: Two. Below in Figures 1 and 2 the energy consumption percentage by each part of the system can be seen.

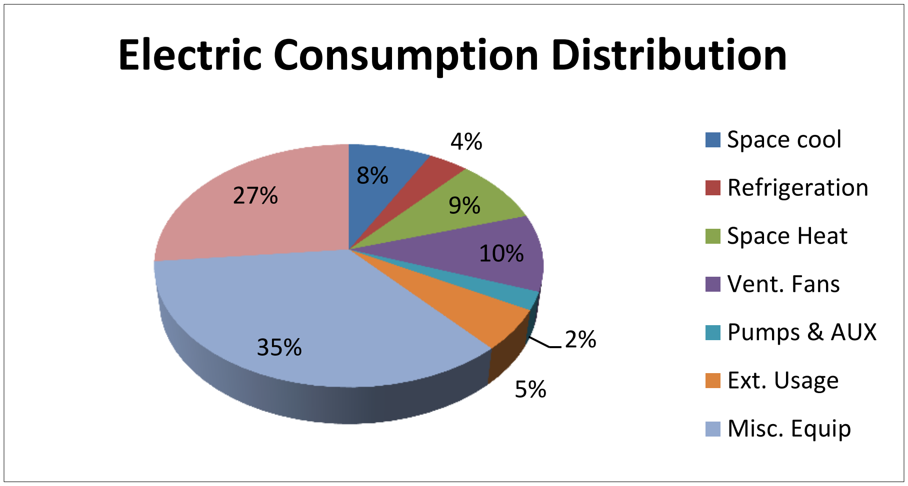

Figure 1: Electrical Consumption Distribution

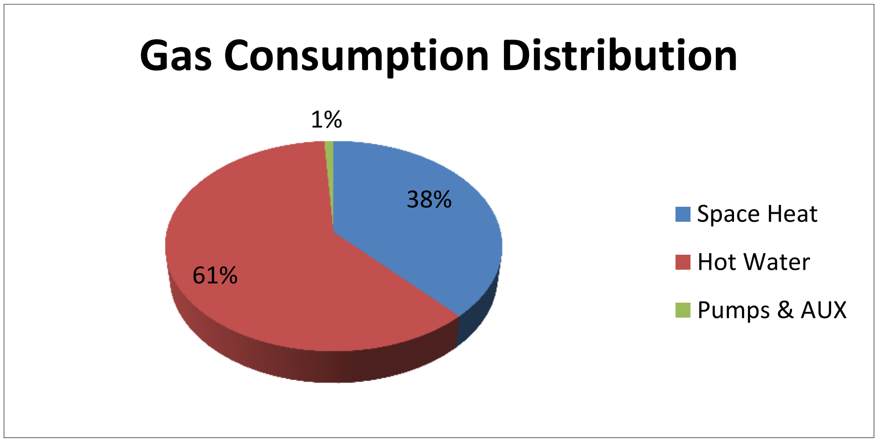

Figure 2: Gas Consumption Distribution

As can be seen from Figure 1 the majority of the electricity is consumed by miscellaneous equipment. This is the plug load for the building. The high percentage is due to the efficient usage of the rest of the design. ASHRAE prescribes a 0.5 W/ft^2 plug load in school buildings which in turn equals 32% of the total electricity usage of the proposed design. In Figure 2 hot water is the majority user of natural gas at 61%. These figures help identify possible areas for potential energy savings.

Mechanical Equipment Summary

The building utilizes ground source heat pumps, nine energy recovery units and five air handling units. The larger air handling units supply the gymnasium, cafeteria, kitchen, serving kitchen and multipurpose room. The heat pumps are located individual closets throughout the building serving a room each. The energy recovery units work in unison with both the air handling units and heat pumps. In the Tables below the scheduled equipment can be reviewed.

WATER SOURCE HEAT PUMP SCHEDULE									
	Airflow (cfm)	Supply Air Temp (°F)	Cooling				Heating		Flow GPM
			EWT (°F)	LWT (°F)	EAT		EAT (°F)	EWT (°F)	
					DB (°F)	WB (°F)			
HP-1	200-250	55	80	90	76	64	70	45	1.8
HP-2	300-360	55	80	90	76	64	70	45	2.1
HP-3	420-450	55	80	90	76	64	70	45	2.8
HP-4	600-660	55	80	90	76	64	70	45	4.2
HP-5	975-1000	55	80	90	76	64	70	45	7
HP-6	1100-1270	55	80	90	76	64	70	45	8.4
HP-7	1450-1540	55	80	90	76	64	70	45	11.2
HP-8	2000-2100	55	80	90	76	64	70	45	14
HP-9	1000	55	80	90	76	64	70	45	7
HP-10	1100	55	80	90	76	64	70	45	8.4
AHU-1	7200	55	80	90	76	64	70	45	50
AHU-2	7800	55	80	90	76	64	70	45	60
AHU-3	2400	55	80	90	76	64	70	45	18
AHU-4	1600	55	80	90	76	64	70	45	12
AHU-5	3600	55	80	90	76	64	70	45	30

Table 8: Water Source Heat Pump Schedule

ENERGY RECOVERY UNIT SCHEDULE								
	Supply Fan		Exhaust Fan		Energy Wheel			
					SUMMER		WINTER	
	Airflow CFM	HP	Airflow CFM	HP	EAT DB/WB (°F)	LAT (°F)	EAT (°F)	LAT (°F)
ERU-1	5070	3	5070	3	90/74	79	10	59
ERU-2	5730	5	5730	5	90/75	79	10	59
ERU-3	5660	5	5660	5	90/76	79	10	59
ERU-4	4410	3	4410	3	90/77	80	10	59
ERU-5	4950	5	4950	5	90/78	79	10	59
ERU-6	4300	3	4300	3	90/79	79	10	59
ERU-7	1750	1	1750	1	90/80	80	10	59
ERU-8	1400	2	1400	2	90/81	80	10	59
ERU-9	2160	1.5	2160	1.5	90/82	79	10	59

Table 9: Energy Recovery Unit Schedule

MAKE-UP AIR UNIT SCHEDULE			
	Gas Fired Heat Exchanger		
	Airflow (cfm)	EAT (°F)	LAT (°F)
MAU-1	3590	10	75

Table 10: Make-up Air Unit Schedule

PUMP SCHEDULE						
	GPM	HP	BHP	IMPELLER SIZE (in)	EFFIC (%)	TDH (ft)
P-1	850	50	32.9	11.875	82	120
P-2	850	50	32.9	11.875	82	120

Table 11: Pump Schedule

Mechanical System Cost

The Mechanical, Electrical and Plumbing system costs were given by the project manager. Below in Table 14 the costs can be seen and are totaled to $5,440,300. This equals approximately $51/ft^2.

SUNSHINE ELEMENTARY MEP COSTS		
Mechanical	$	1,979,200
Plumbing	$	1,154,000
Electric	$	2,138,000
Commissioning	$	100,000
Others	$	69,100
Total	**$**	**5,440,300**

Table 12: MEP Costs

Mechanical System Space Requirements

The mechanical system of the Sunshine Elementary School utilizes mechanical closets throughout the entire building for individual heat pumps. The average closet is 8' X 4' and serves the two adjacent rooms to the closet. In addition there is also a mechanical large mechanical room totaling 1964 ft^2. Below in Table 13 the required useable space of the mechanical system is broken down by section. The sections are as follows: Section A-Gym, Section B- 1st and 2nd floor classroom areas, Section C- Cafeteria and administration, Section D- Southern Kindergarten wing and Section E- Northern Kindergarten wing. The total of 2828 ft^2 accounts for approximately 2.7% of the overall 103,000 ft^2 usable area

MECHANICAL EQUIPMENT SPACE REQUIREMENTS	
	Area (ft^2)
Section A	16
Section B 1st	240
Section B 2nd	240
Section C	1996
Section D	176
Section E	160
Total	**2828**

Table 14: Mechanical Space Requirements

System Operation and Schematics

Airside System Operation

The Sunshine Elementary School utilizes demand control ventilation throughout the entire building. This is done with CO^2 sensors. The sensors are located within the room and control a damper on the outdoor air entering the heat pump closet. The outdoor air is supplied by energy recovery units through a centralized air duct locating in the corridor of the building. The energy recovery units are equipped with variable speed drive fans. The fans are controlled by a pressure sensor that is located in the intake duct of outdoor air. This sensor works on the principles of pressure differences. When the CO^2 sensor indicates the need for higher ventilation rates the damper located in the outdoor air duct opens thus reducing the pressure within the duct, this then causes the pressure sensor to signal to the variable speed fan to increase airflow to reach the pressure set point.

Below in Figure 3 and Figure 4 typical airflow schematics were created to simplify the system. Figure 3 show how typical rooms such as classrooms receive outdoor air. The flow rates for each ERU can be seen in the schedules created earlier in this document. The transfer air (TA) in the figure represents the ductless exhaust air which is removed due to the negative pressure within the corridor ceiling.

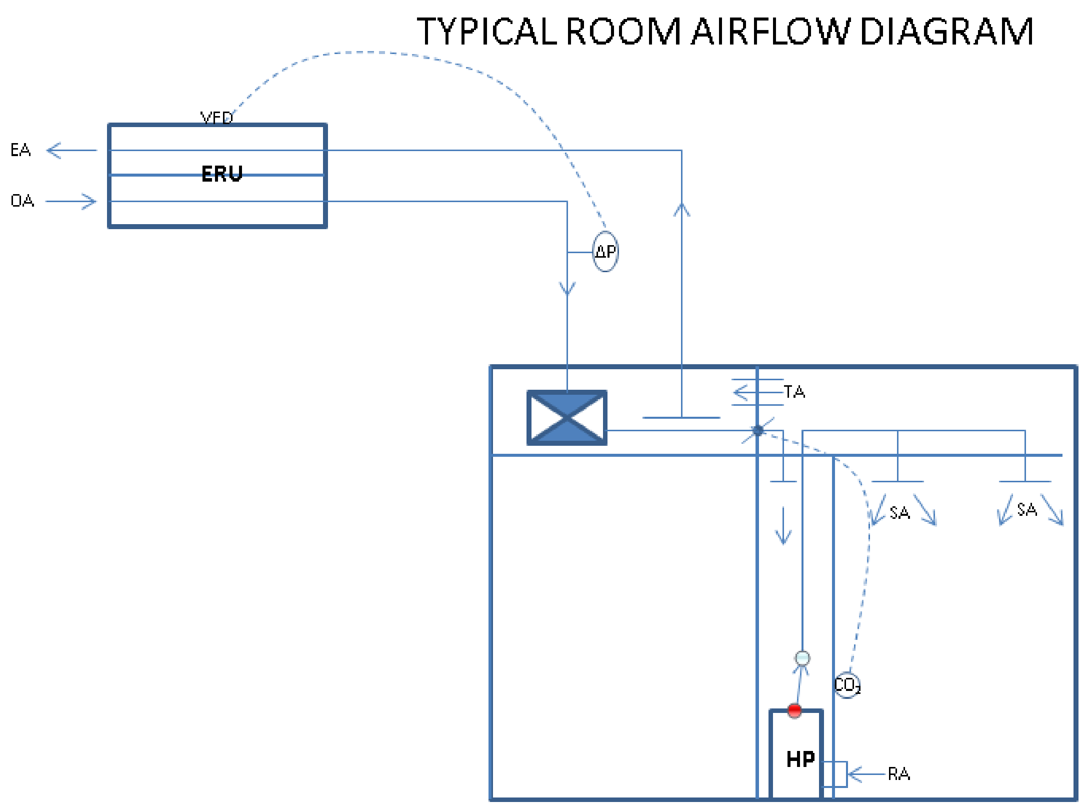

Figure 3: Typical Room Airflow Diagram

Figure 4 shows the two basic scenarios for the airflow throughout the school. Return air is typically mixed by the return air damper. In some cases within the building the exhaust air is not mixed due to poor air quality and is directly exhausted and not mixed.

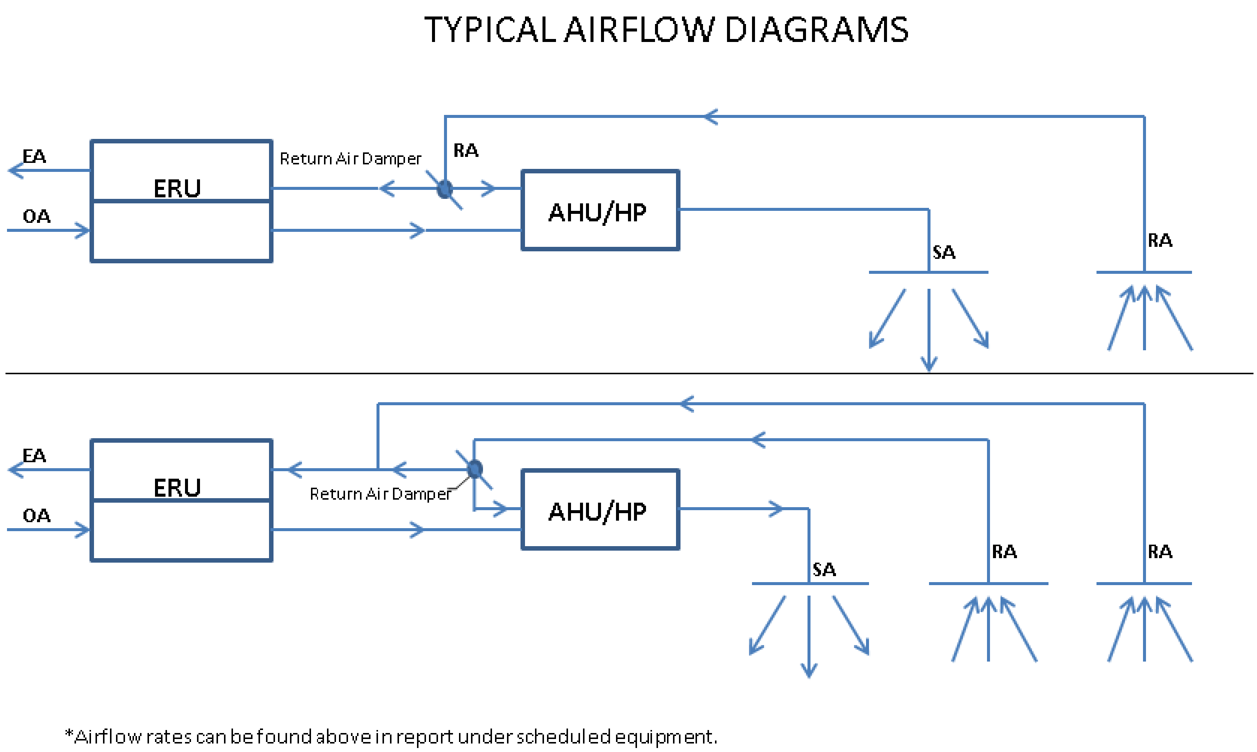

Figure 4: Typical Airflow Diagrams

Waterside System Operation

A highly efficient ground source heat pump system is used throughout the building. The system has an operating range between 45 and 80°F depending on cooling, heating or a mix of both modes. Below are schematic diagrams of how the systems work in each mode.

As can be seen in Figure 5 the entering water temperature is designed to be 80°F and leaves the heat pump at 90°F. The water is then pumped through the ground loop and the temperature is lowered to at least 80°F again. In heating the entering heat water temperature is specified to be 45°F and leaving water temperature is specified to be 35°F. During mixed heating and cooling cycles the operating leaving and entering water temperatures can be within in this range and increase the efficiency of the system.

The basic functioning of a heat pump can be seen in Figure 8. A thermostat located within the space signals to a control valve of water entering the heat pump which in turn controls the output of the heat pump.

COOLING CYCLE

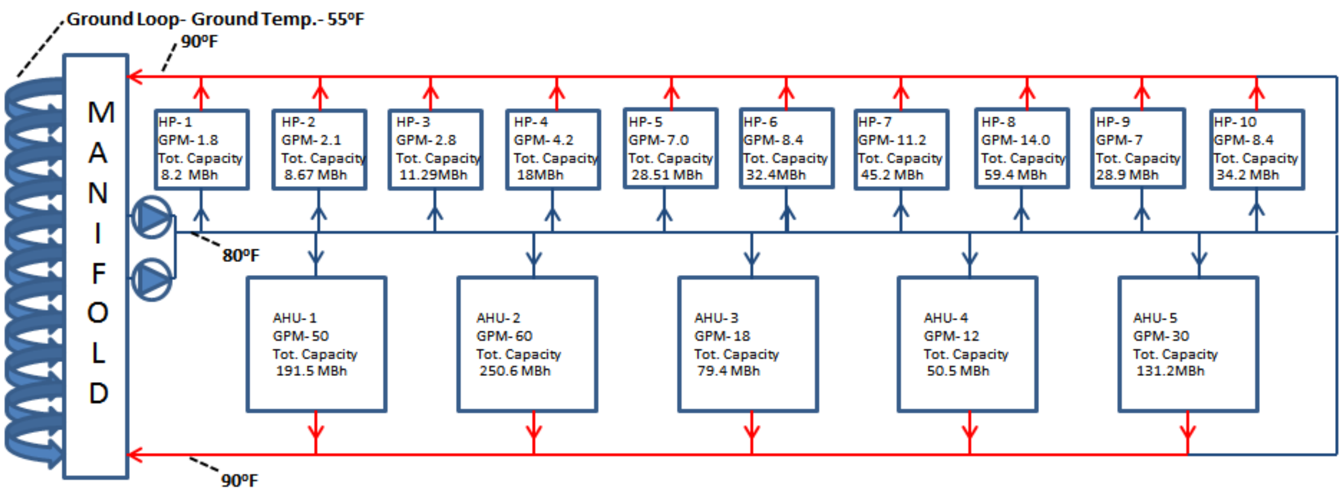

Figure 5: Heat Pump Cooling Cycle

HEATING CYCLE

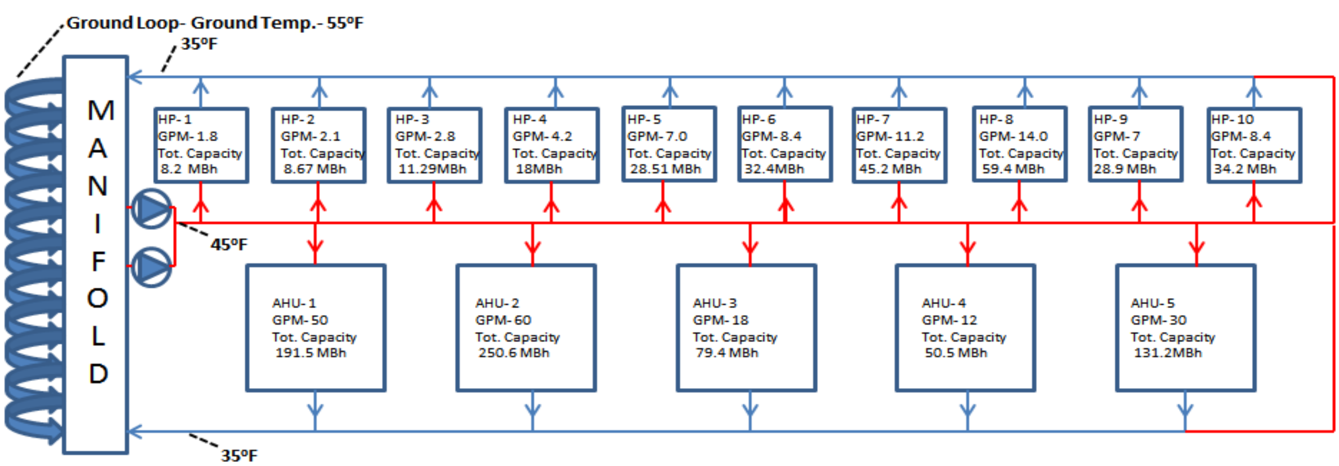

Figure 6: Heat Pump Heating Cycle

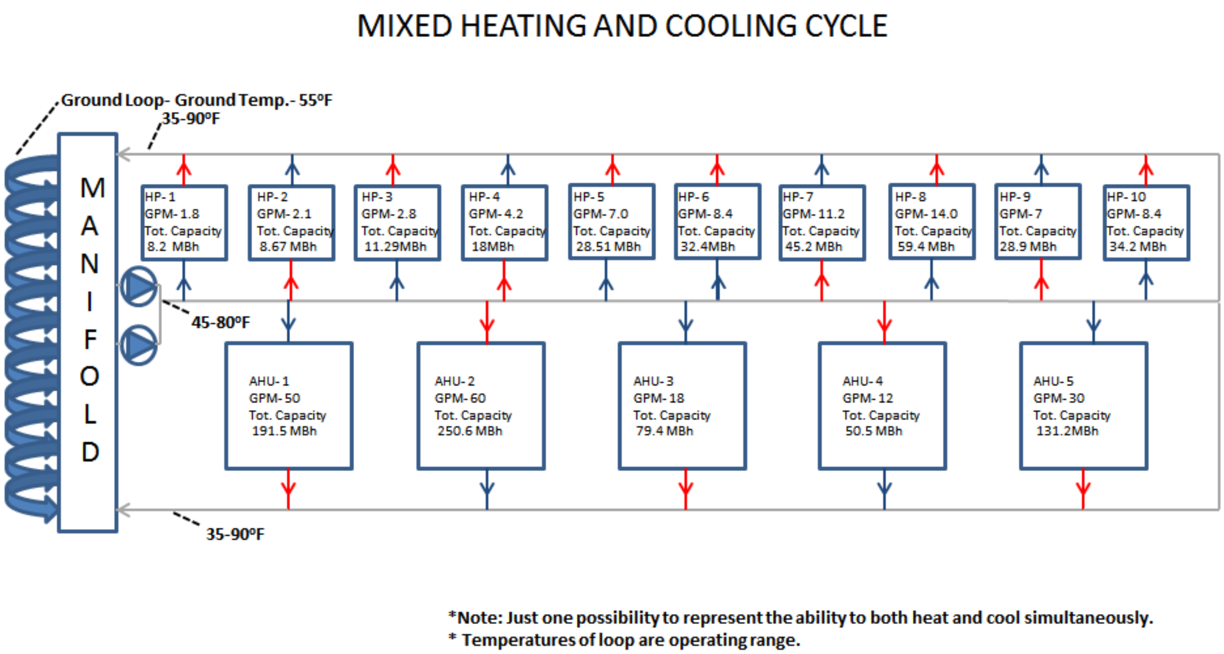

Figure 7: Heat Pump Heating/Cooling Cycle

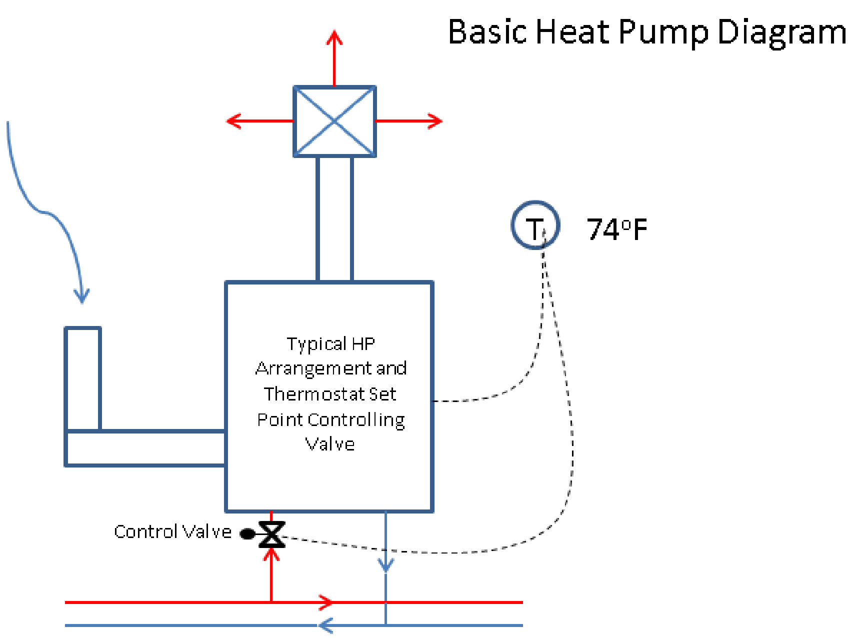

Figure 8: Basic Heat Pump Diagram

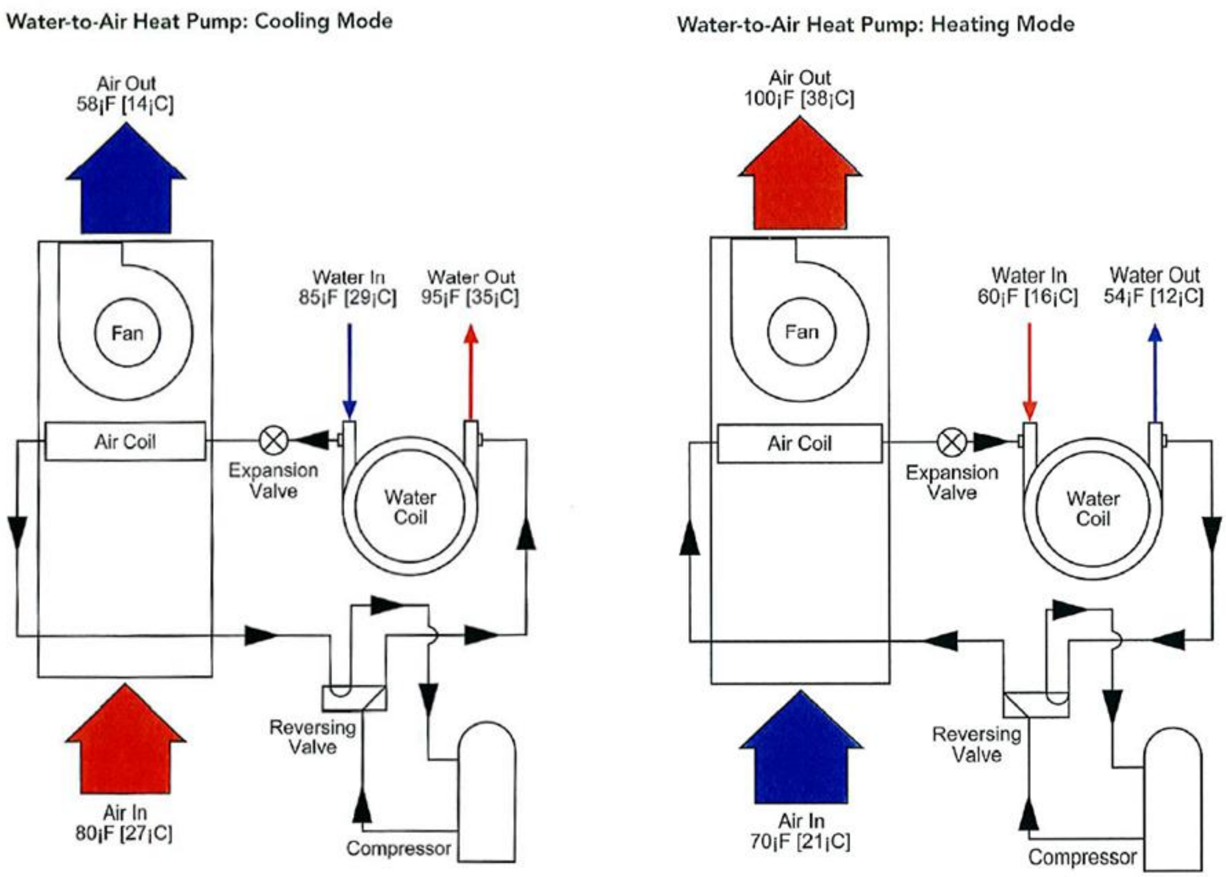

Figure 9: Heat Pump Cooling Mode
(Master, 2008)

LEED- NC Analysis

The United States Green Building Council (USGBC) created the Leadership in energy and Environmental Design (LEED) to help builders, designers and owners realize the importance of energy efficient systems. Environmentally conscious design is becoming a fundamental part of every new building throughout the United States. The two primary categories of LEED that are directly related to the mechanical design are Energy and Atmosphere (EA) and Indoor Environment Quality (IEQ). The goal of the project was to earn a silver accreditation. The mechanical design was a major part of this attempt. In the following analysis only the attempted credits from these two categories were analyzed.

Energy and Atmosphere

EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems – Yes

Intent: To verify that the project's energy-related systems are installed, and calibrated to perform according to the owner's project requirements, basis of design and construction documents.

Benefits of commissioning include reduced energy use, lower operating costs, fewer contractor callbacks, better building documentation, improved occupant productivity and verification that the systems perform in accordance with the owner's project requirements.

The Sunshine Elementary School: After installation is complete a commissioning authority with experience will perform a full controls and mechanical system run through and test. The results will be gathered from the commissioning reports complied and reported directly to the owner upon completion of the project.

EA Prerequisite 2: Minimum Energy Performance-Yes

Intent: To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.

The Sunshine Elementary School: Option 1- Whole Building Energy Simulation was used to attempt this credit. The designers created an energy model using eQuest for both the baseline model and the proposed model. The energy model analysis revealed a 47% decrease in energy usage from proposed model to baseline model allowing the building to easily pass this credit.

EA Prerequisite 3: Fundamental Refrigerant Management-Yes

Intent: To reduce stratospheric ozone depletion.

The Sunshine Elementary School: Zero use of Chlorofluorocarbon is scheduled for the building. R-410A is the scheduled refrigerant.

EA Credit 1: Optimize Energy Performance-Yes

Intent: To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

The Sunshine Elementary School: The model created using eQuest showed energy savings of 47% this will, if approved result in 18 points according to the LEED manual table given in this subsection.

EA Credit 2: On-site Renewable Energy-Yes

Intent: To encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.

The Sunshine Elementary School: Although renewable energy sources were considered they are not part of the end design due to a cost evaluation.

EA Credit 3: Enhanced Commissioning- Yes

Intent: To begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed.

The Sunshine Elementary School: Upon completion of the project the template shall be completed providing the name and company of the commissioning agent. The six requested tasks will be confirmed complete and documentation describing the results of the commissioning, implementation of systems manual and training and a plan for future review will be provided.

EA Credit 4: Enhanced Refrigerant Management-Yes

Intent: To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.

The Sunshine Elementary School: The calculated required by Option 2 was used by the designer to prove the design is within compliance of the Montreal Protocol.

Indoor Environmental Quality

IEQ Prerequisite 1: Minimum Indoor Air Quality Performance- Yes

Intent: To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

The Sunshine Elementary School: Case 1 was used from LEED which deals with mechanically ventilated spaces. The ventilation rate procedure was used given by the ASHRAE Standard 62.1.

IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

Intent: To prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to environmental tobacco smoke (ETS).

The Sunshine Elementary School: Being an Elementary School a no smoking policy is present upon school grounds thus easily ensuring this prerequisite.

IEQ Credit 1: Outdoor Air Delivery Monitoring- Yes

Intent: To Provide capacity for ventilation system monitoring to help promote occupant comfort and well-being.

The Sunshine Elementary School: CO_2 sensors were utilized throughout the design to ensure proper ventilation for all occupants. This corresponds with case one of this LEED credit. The Monitors are specified to be placed between 3 and 6 feet above the floor.

IEQ Credit 2: Increased Ventilation- No

Intent: To provide additional outdoor air ventilation to improve indoor air quality (IAQ) and promote comfort, well-being and productivity.

The Sunshine Elementary School: This credit was not attempted by the designers of this project.

IEQ Credit 3.1: Construction Indoor Air Quality Management Plan- During Construction- Yes

Intent: To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants.

The Sunshine Elementary School: A IAQ management plan was created to protect the heating, ventilating and air-conditioning system during construction. The minimum filtration required by ASHRAE Standard 52.2 has been met and filters are specified to be replaced at the end of construction. This responsibility has been given to the General Contractor.

IEQ Credit 3.2: Construction Indoor Air Quality Management Plan—Before Occupancy- Yes

Intent: To reduce indoor air quality (IAQ) problems resulting from construction or renovation to promote the comfort and well-being of construction workers and building occupants.

The Sunshine Elementary School: Developed an IAQ management plan and implement it after all finishes have been installed and the building has been completely cleaned before occupancy. This is also the responsibility of the General Contractor.

IEQ Credit 4.1: Low-emitting Materials –Adhesives and Sealants- Yes

Intent: To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

The Sunshine Elementary School: The requirements set forth by LEED shall be followed by the architect and the General Contractor to achieve this credit. All adhesives and sealants used on the interior of the building (i.e., inside of the weatherproofing system and applied on-site) must comply with the following requirements as applicable to the project scope1: (see LEED Requirements for table)

IEQ Credit 4.2: Low-Emitting Materials—Paints and Coatings- Yes

Intent: To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

The Sunshine Elementary School: The requirements set forth by LEED shall be followed by the architect and the General Contractor to achieve this credit. The requirements are as follows:

Paints and coatings used on the interior of the building (i.e., inside of the weatherproofing system and applied onsite) must comply with the following criteria as applicable to the project scope1:

- Architectural paints and coatings applied to interior walls and ceilings must not exceed the volatile organic compound (VOC) content limits established in Green Seal Standard GS-11, Paints, 1st Edition, May 20, 1993.
- Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates must not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, 2nd Edition, January 7, 1997.
- Clear wood finishes, floor coatings, stains, primers, and shellacs applied to interior elements must not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.

IEQ Credit 4.3: Low-Emitting Materials—Flooring Systems- Yes

Intent: To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

The Sunshine Elementary School: The flooring products installed shall be listed and confirmed to be compliant. All flooring materials shall be listed and proven compliant.

IEQ Credit 4.4: Low-Emitting Materials—Composite Wood and Agrifiber Products- Yes

Intent: To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

The Sunshine Elementary School: the following requirements shall be met by the designers: Composite wood and agrifiber products used on the interior of the building (i.e., inside the weatherproofing system) must contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on site and shop-applied composite wood and agrifiber assemblies must not contain added urea formaldehyde resins. Composite wood and agrifiber products are defined as particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Materials considered fixtures, furniture and equipment (FF&E) are not considered base building elements and are not included.

IEQ Credit 6.1: Controllability of Systems—Lighting- No

Intent: To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms and conference areas) and promote their productivity, comfort and well-being.

The Sunshine Elementary School: This credit was not attempted by the design of the project.

IEQ Credit 6.2: Controllability of Systems—Thermal Comfort- Yes

Intent: To provide a high level of thermal comfort system control1 by individual occupants or groups in multi-occupant spaces (e.g., classrooms or conference areas) and promote their productivity, comfort and well-being.

The Sunshine Elementary School: Individual comfort controls were provided to over the required 50% of building occupants to receive this credit. The total number of workstations and individual controls were provided within design.

IEQ Credit 7.1: Thermal Comfort—Design- Yes

Intent: To provide a comfortable thermal environment that promotes occupant productivity and well-being.

The Sunshine Elementary School: Data was provided indicating the seasonal temperature and humidity design temperatures ensuring a comfortable environment.

IEQ Credit 7.2: Thermal Comfort—Verification- Yes

Intent: To provide for the assessment of building occupant thermal comfort over time.

The Sunshine Elementary School: A survey is planned to provide verification of the thermal comfort within the school by all occupants.

IEQ Credit 8.1: Daylight and Views—Daylight-No

Intent: To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

The Sunshine Elementary School: This credit was not attempted by the designers.

IEQ Credit 8.2: Daylight and Views—Views- Yes

Intent: To provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

The Sunshine Elementary School: Views for 90% of spaces have been made by the design. The template spreadsheet shall be completed and summited to demonstrate overall access to the given views.

Overall System Evaluation

The Sunshine Elementary School needed a mechanical system which supplied healthy conditions for the students within. The mechanical system was to reduce operating cost and environmental impacts. The goal of Silver Rating by the Leadership of Energy and Environmental Design (LEED) a subsidiary of the United States Green Building Council (USGBC). The rating ensures an environmentally conscious design and an overall energy efficient design.

A ground source water loop heat pump system was chosen for the project. Ninety-two ground wells were created to meet the buildings loads. Heat pumps are located throughout the building and serve individual rooms. This allows for individual room controls. In larger areas five air handling units were utilized to serve the large load demand. These air handling units are basically large heat pumps and are a part of the ground source water loop. The ground loop operates in the range of 45^{o}F and 80^{o}F depending on if it is operating in heating, cooling or a mixed mode. Energy recovery units were also used throughout the building to save energy by exchanging energy between the exhaust air and the outdoor air.

The ventilation air is ducted through the main corridor of the building serving heat pump closets will outdoor air. Transfer air is carried from the positively pressurized space to the ceiling cavity located above room and through the corridor. Demand control ventilation is used by the way of CO^2 detection throughout the building. This ensures proper ventilation to spaces promoting a healthy environment. The CO^2 sensors control an air damper on the outdoor air supply to the heat pump closet. The fans located in the energy recovery unit are specified to be variable speed allowing for efficient control of air intake and exhaust. A pressure sensor located within the supply duct sense a change and pressure and the VFD fans either increase or decrease their speed thus increasing or decreasing pressure to set point.

Overall the system design is extremely efficient. According to a comprehensive energy model the design should perform at 47% energy savings compared to a baseline model. Improving this system will prove to be difficult but this analysis has shown places of possible improvements.

APPENDIX

List of Tables

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