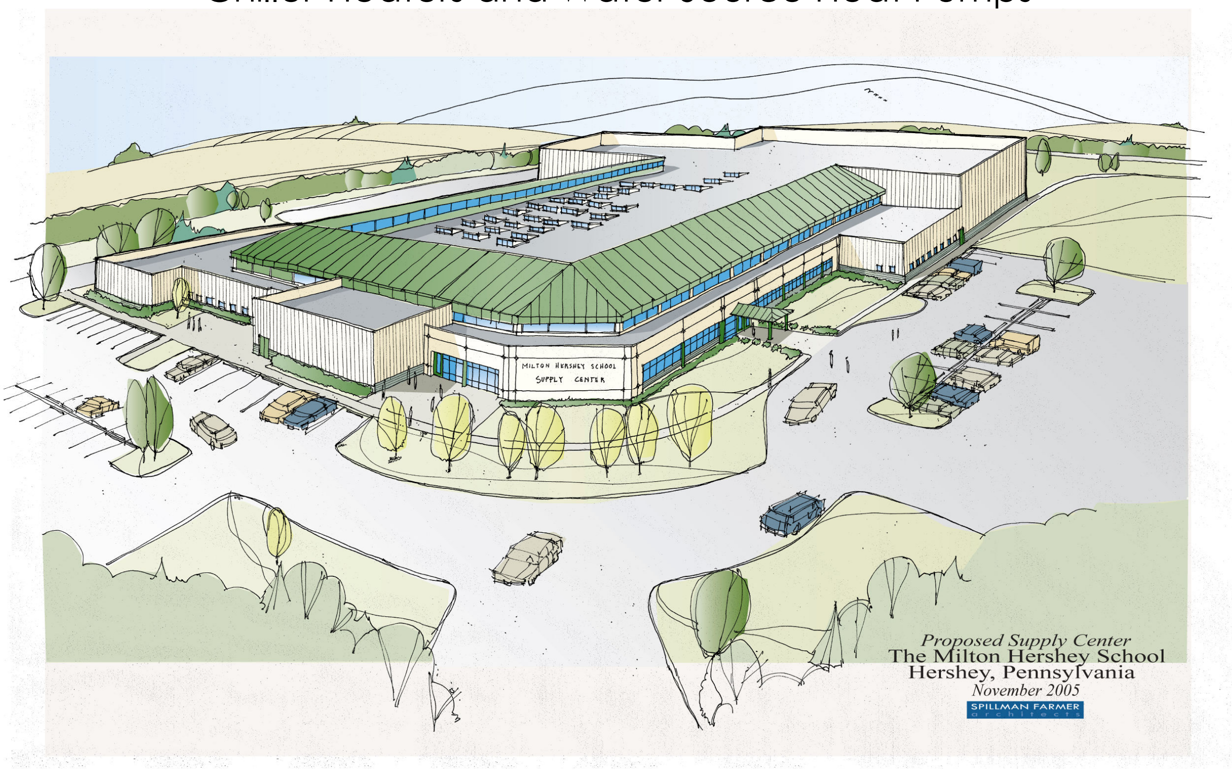
Thesis Proposal

Mechanical Systems Redesign:
Chiller-Heaters and Water Source Heat Pumps



The Milton Hershey School New Supply Center
Hershey, Pennsylvania

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1.0 EXECUTIVE SUMMARY

The Milton Hershey School New Supply Center is a very wide and long single story 110,000 square foot building. Analyzing the existing mechanical systems proves that the design is very practical and energy conscience for this application. However, there are specific features to the HVAC system that have potential for improvements.

The goal of this mechanical system redesign is to increase energy efficiency, decrease life cycle cost, and maintain or improve the level of thermal comfort that the existing systems set. The original design of the supply center achieves the status of LEED Certification. Any alterations to the mechanical system are not to lower this standard. The final goal of the redesign is to use unique or non-ordinary methods and systems for the study, and measure there performance in this situation. The results from the analyses will not only prove whether the redesign meets the project goals, but will serve as educational value to see how these different systems react with the given conditions.

Eliminating the air handling units that are part of VAV systems and replacing them with dedicated outdoor air systems is one part of the mechanical systems depth. The modifications to the air side system with the use of DOAS should see energy savings. Parallel cooling systems are also needed when using DOAS. Water source heat pumps will serve as the space conditioning devices as well as lead the way to integrating other building systems with the mechanical system. Using a water source loop that maintains a certain temperature for proper heat pump operation allows for other building systems to reject heat to this loop. The walk-in freezers and coolers will reject heat from their condensing units to the water source loop which will maintain the water temperature required for the heat pumps to cool the spaces. The cooling towers needed for the supply center is used to reject the water loop's excessive heat to maintain the appropriate temperature.

A chiller-heater plant is also proposed for examination. Producing chilled water for the DOAS units is the main purpose of the chiller-heater, but utilizing the capabilities of simultaneous heating and cooling is what the new plant is to accomplish. Using only the natural gas system as the main energy source for chilled and hot water production has the potential to save energy cost. All of the redesign alternatives must be justified by proving to have pay back periods of no longer than 3-4 years from their potential energy saving capabilities.

The new mechanical system redesign also creates structural, electrical, and construction management work. Detailed cost estimates on alterations to the buildings structural system due to the mechanical system redesign serves as the breadth topics.

2.0 BUILDING DESIGN BACKGROUND

The Milton Hershey School New Supply Center is a single story 110,000 square foot building with four elevated mechanical mezzanine rooms and contains a variety of spaces. The north and northwest sections of the building consists of general office spaces and conference rooms. Located in the center of the building is the food distribution center for the Milton Hershey School. This area contains large freezers, refrigerators, and temperature controlled storage areas, fifteen in all, totaling to 13,600 square feet to go along with its central food preparation spaces.

Aside from the food production section of the building, the New Supply Center also includes a central mail distribution center for the school and a clothing store with an alterations work area. Complementing the four mechanical mezzanine rooms that house the air handling units, a boiler and chiller plant is located on the north side of the building. The east side is mostly loading docks for deliveries, and the south side accommodates a variety of storage space. There are also two data rooms located in the center of the floor plan. Figure one, shown below, gives a breakdown of the space's location in the building as well as the portion of area each occupancy type consumes.

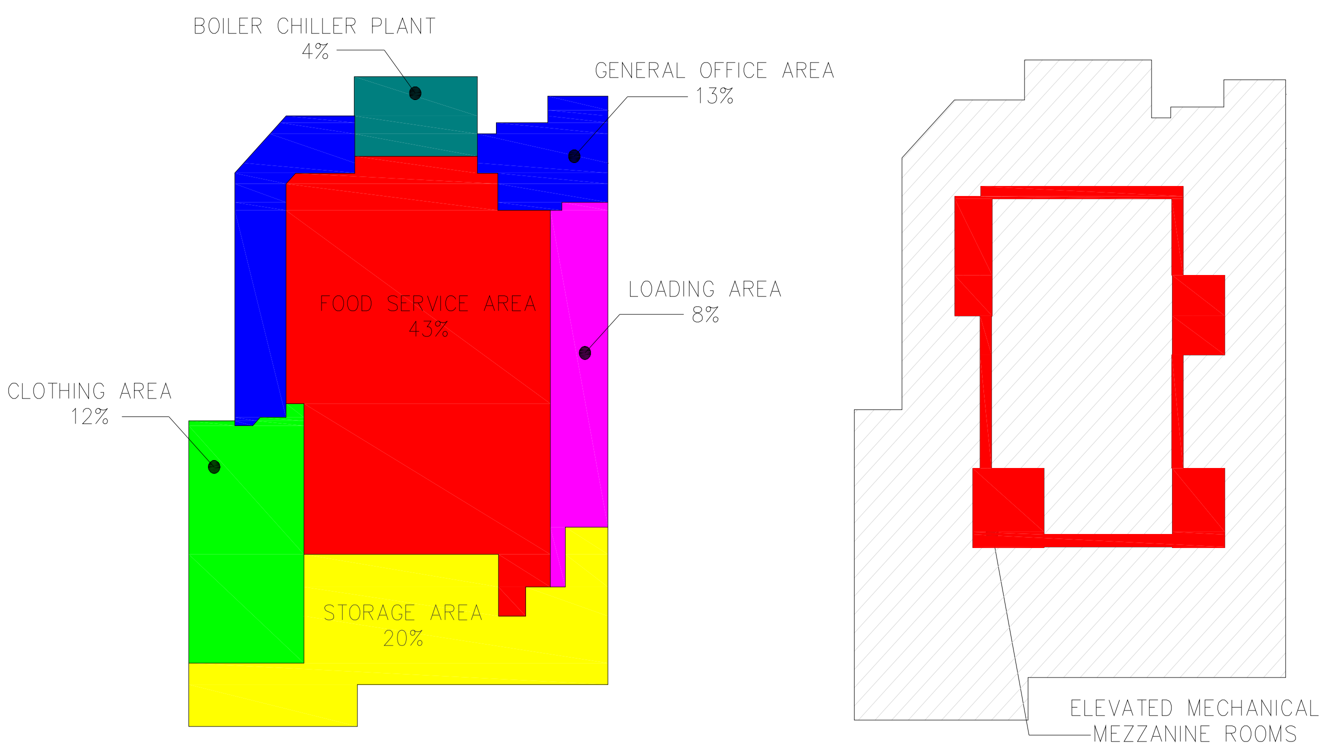


Figure 1 Space relationship and area breakdown

AIR SIDE MECHANICAL SYSTEM

The air side mechanical system for the supply center uses fourteen air handling units. Four of the AHUs are part of multiple zone VAV systems. These air handling units serve offices, dining areas, clothing display and alterations areas, and staff spaces. The air is distributed to these spaces through VAV terminal units with hot water re-heat coils. The perimeter spaces also include fin-tube radiation systems for winter heating. The four VAV air handling units consists of a supply and return fans, 30% and 85% efficient filters, hot water pre-heat and re-heat coils, and a cooling coil.

The remaining ten air handling units are single zone spaces that are either part of VAV or CAV systems. However, since they are single zone units, VAV boxes are not used for air distribution to the spaces. All ten AHUs consists of 30% and 85% efficient filters, hot water pre-heat and re-heat coils, cooling coils, and supply fans.

Six of the ten single zone AHUs are part of constant volume systems. These units provide make up air for spaces requiring excessive amounts of exhaust (kitchens spaces, loading docks, recycling room). Even though the units operate at 100% outdoor air when the spaces are in operation, the AHUs also have the ability to return air during unoccupied times. The final four single zone air handling units not mentioned are part of VAV systems. These units serve dry storage and clothing warehouse areas. The AHUs vary the volume of air supplied at the supply fan via variable frequency drives.

The two data rooms located in the center of the building incorporate two systems to provide cooling year round. The data rooms are served by VAV systems, however, when the central VAV air handling unit is operating at an unoccupied mode, ductless split system air conditioners are used to handle the cooling loads.

The following figure is a representation of the HVAC air side system zoning plan.

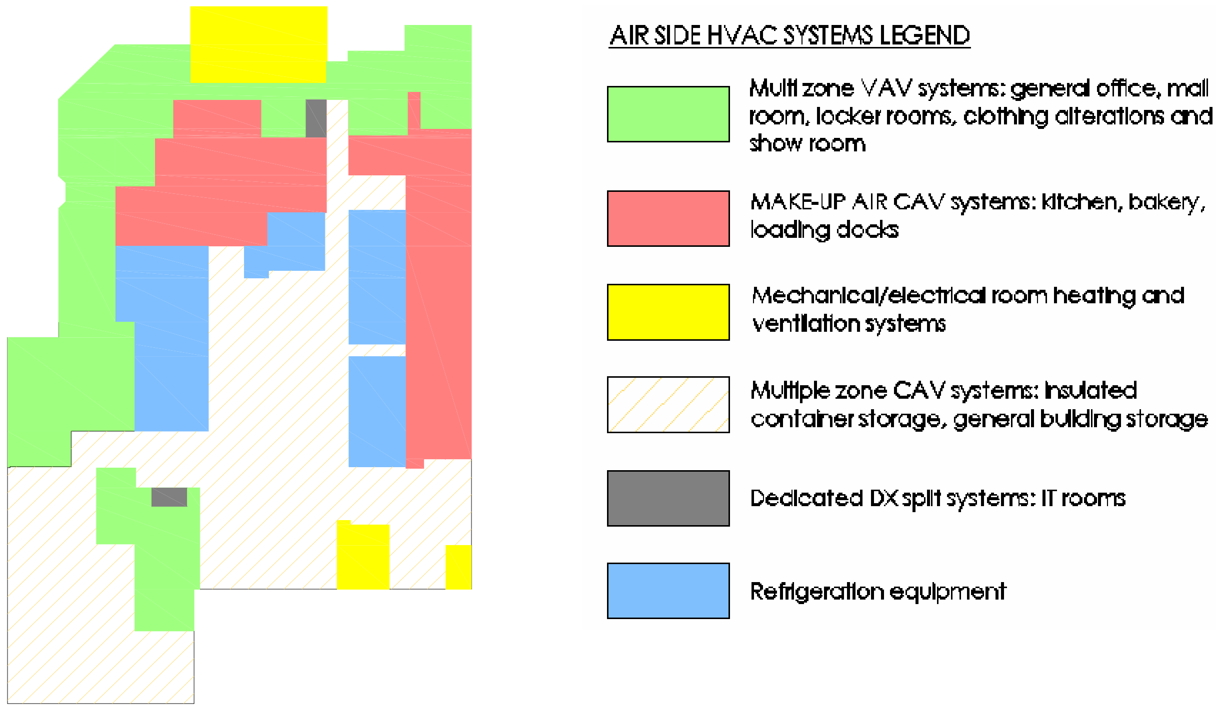


Figure 2 Air side mechanical systems zoning plan

CHILLED WATER SYSTEM

The chiller plant of the supply center consists of two (one duty one standby) 270 ton electric driven centrifugal water cooled chillers that produce 45°F water. These chillers are used to meet the normal HVAC building loads. Also included in the chilled water system are two (one duty one standby) water cooled brine chillers that produce 20°F water. These chillers service fan coil units located in walk-in-coolers and refrigerated rooms year round. The two sets of chillers in the plant are interconnected in that they all have the capabilities to produce either 45°F or 20°F water for emergency purposes. All four of the chillers operate with R-134a refrigerant and the entire chilled water system (both the HVAC and brine loops) are provided with a 35% propylene glycol solution.

As mentioned above, the 45°F water loop also serves two plate frame heat exchangers to pick up the rejected heat from the walk-in freezers. The rejected heat from the freezers is distributed to a condenser water loop. This water loop is then cooled by the chilled water system before returning to the freezer's condensing units.

The HVAC chilled water loop incorporates a primary-secondary pumping system. Three primary pumps are located in the chilled water plant and are of a duty-duty-standby configuration. Two secondary pumps with VFDs distribute chilled water to the building loop. A similar pumping configuration is used for the brine loop, however, only four pumps are needed (2 primary, 2 secondary).

The chiller room includes a refrigerant leak detection and exhaust system that complies with ASHRAE Standard 15.

CONDENSER WATER SYSTEM

The condenser water system for the chilled water plant includes two induced draft cooling towers for the heat rejection equipment. These service all four of the chiller's condensers. The walk-in freezer's condenser water loop also utilizes the chiller plant's condenser water system. As stated above, the freezer's rejected heat is handled by the HVAC chilled water loop. This operation occurs in the summer months, or when the ambient outdoor temperature is above 50°F. The freezer's condenser water loop bypasses the plate frame heat exchangers that are served by 45°F chilled water and enters a third plate frame heat exchanger served directly by 60°F condensing water from the cooling tower. This process is used for water side "free" cooling in seasons where the outdoor temperature is below 50°F.

STEAM BOILER AND HOT WATER SYSTEMS

The boiler plant in the supply center consists of three natural gas-fired fire tube boilers. The two larger boilers, 200 BHP, service the building HVAC heating and domestic water heating loads. The third smaller boiler, 125 BHP, meets the kitchen equipment hot water demands. The boilers also incorporate flue gas recirculation to lower pollution levels. NO_X levels are held to 30 parts per million due to this configuration.

A combination deaerator and condensate storage tank is used to provide feed water to the boilers. Three active feed water pumps operate continuously with feed water valves located on the boilers. The feed water valves are controlled by level sensors so that minimum water levels are met to avoid potential hazards.

As stated above, the steam boilers produce 40 psig steam to service kitchen equipment loads, such as dishwashers. However, hot water for HVAC heating is also produced by these boilers. Hot water is needed to serve fin tube radiators, VAV box reheat coils, and cabinet and horizontal unit heaters. The hot water is produced by conversion of low pressure steam in two (one duty, one standby) shell and tube heat exchangers. Two hot water pumps with VFDs distribute the hot water to the HVAC equipment.

3.0 PROPOSAL OBJECTIVES

The Milton Hershey School New Supply Center's mechanical systems are designed with careful attention towards energy conservation and thermal comfort. Overall, the combination of the HVAC system's ability to incorporate other building systems as well as its sophisticated control methods, used to minimize energy consumption while maintaining thermal comfort, classifies it as very good for this application. The design engineers at H.F. Lenz Company cut no corners in the design, however, there are still alternatives that need addressed. Adjustments to the current design or redesign of certain areas of the HVAC system can result in further optimization in first cost, construction cost, and operating cost.

The goal of this mechanical system redesign is to increase energy efficiency, decrease life cycle cost, and maintain or improve the level of thermal comfort that the existing systems set. The original design of the supply center achieves the status of LEED Certification. Any alterations to the mechanical system are not to lower this standard. The final goal of the redesign is to use unique or non-ordinary methods and systems for the study, and measure there performance in this situation. The results from the analyses will not only prove whether the redesign meets the project goals, but will serve as educational value to see how these different systems react with the given conditions.

The main goal of the ones listed above is to increase energy efficiency. Technical Assignment 2 looked at the supply center's annual energy usage. The results for the report indicate that the main source of energy to operate the refrigeration equipment and AHUs is electricity, and the heating equipment utilizes natural gas. Decreasing the amount of electricity consumed by the HVAC equipment will significantly lower the annual energy cost to operate the supply center. Lowering the annual energy cost will also create the potential for decreasing the life cycle cost of the HVAC systems.

Alterations to the HVAC system may result in significant differences in first cost compared to the existing system. The goal of this redesign is to recommend the most energy efficient, sustainable, and cost effective system. The recommended system must include a reasonable pay back period, about 3 years, when compared to the alternatives. Whether the existing system or the alternatives are selected as the best, pay back periods longer than 3 to 4 years will not justify their use in this application.

4.0 REDESIGN ALTERNATIVES

All phases of the existing HVAC system have design alternatives that can lead to improvements. This section examines all possible alternatives to each portion of the supply center's mechanical system

AIR SIDE SYSTEMS

The current method, as explained above, consists of 14 air handling units that are part of either CAV or VAV systems. These systems do have the potential to create humidity control problems. In order to eliminate these problems, replacing the all-air systems with a dedicated outdoor air system (DOAS) is an alternative. The DOAS configurations will result in a smaller quantity of required AHUs to handle both the ventilation needs and the latent loads of the spaces. However, since there are 6 AHUs that are constant volume make-up air units, these units are not replaceable with DOAS.

The 6 make-up air units operate at 100% outdoor air when the spaces they serve, the kitchen and bakery, are in operation. When the spaces are not in use, the units operate at minimum outdoor and have the ability to return air as well. This method of cooling these spaces makes sense from an energy standpoint, and it meets ventilation and indoor air quality requirements. Therefore, these air handling units should remain.

Replacing the remaining 8 AHUs with dedicated units requires the use of parallel cooling systems. The possible parallel cooling systems include fan coil units, chilled beams, radiant ceiling panels, and water source heat pumps. All of the alternatives do not affect the interior architecture, and there is room above the ceilings for these systems. The use of FCUs or WSHPs requires electricity for their fans to operate, however, and this is a downfall. Radiant panels and chilled beams only require the chilled water pumping energy for operation. The system that best optimizes the building energy use and also is easily integrated with the other building systems is to be analyzed.

CHILLER AND BOILER PLANT

The chiller plant at the supply center uses electricity for operation while the steam boiler plant utilizes the new natural gas service installed at the building. The natural gas service is also directly used by the kitchen equipment in the supply center and therefore is irreplaceable. The available energy sources create possibilities for alterations to the boiler and chiller plants.

Since natural gas is readily available at the supply center, using a direct fired absorption chiller-heater is a chiller plant alternative. This method will decrease the amount of electricity required for the refrigeration process, but will increase the natural gas consumption. The chiller-heater will produce the appropriate chilled water temperatures needed to handle the thermal loads in the spaces while simultaneously producing hot water used by both the HVAC equipment and the kitchen equipment.

The production of chilled water directly depends on the HVAC systems selected. DOAS systems will require chilled water for dehumidification, and the corresponding parallel systems may or may not require chilled water. Water source heat pumps do not require the use of a chiller, just heat rejection equipment.

5.0 PROPOSED REDESIGN

The design alternatives and methods are now explained in the above section. The mechanical system redesign proposal for the supply center is laid out in this section. The proposal design objectives are integrated with the existing building conditions as well as the design alternatives to create a potential energy efficient, sustainable HVAC system.

DOAS AND HEAT PUMP SYSTEM

Dedicated outdoor air systems are proposed to replace the air handling units that service general office spaces, clothing spaces, the mail room, and the locker rooms. The goal of using DOAS is to decrease the number of AHUs needed, improve energy efficiency, and improve indoor air quality. Using DOAS requires a parallel system to handle the remaining thermal loads in the spaces. The proposed system will incorporate water source heat pumps as the parallel cooling and heating system.

Using water source heat pumps opens up the opportunity to incorporate other building systems. As stated in the proposal alternative section, WSHPs require heat rejection equipment and heat addition equipment. The water loop that serves the heat pumps must follow the standards set by ASHRAE Standard 90.1 (ASHRAE 2004). Table 1 indicates the cooling and heating mode water loop temperatures set by Standard 90.1.

Table 1 ASHRAE Standard 90.1 WSHP Min. Efficiency Requirements

	HEATING MODE	COOLING MODE
Water Loop Temperature	COP = 4.2	EER = 12.0

The heat rejection will occur via cooling towers, there is already two cooling towers from the existing system, therefore there is no negative site impact. Heat addition to the water source loop will occur from many options.

The simplest way for heat addition to the water source loop is by adding a supplemental hot water boiler. However, incorporating the other HVAC and building systems is one of the major proposal goals. Heat addition to the water loop can occur from picking up the rejected heat from the walk-in freezer's and walk-in cooler's condensing units. This will occur when the condenser water temperature returned to the units is lower enough to properly create the needed supply temperatures. When heat rejection to the water source loop is not sufficient to operate the freezers correctly, the condenser water loop will by pass the heat pump source loop and will reject heat directly to a chilled water loop as in the original system. Appendix A shows a schematic of this redesign and illustrates this system more clearly.

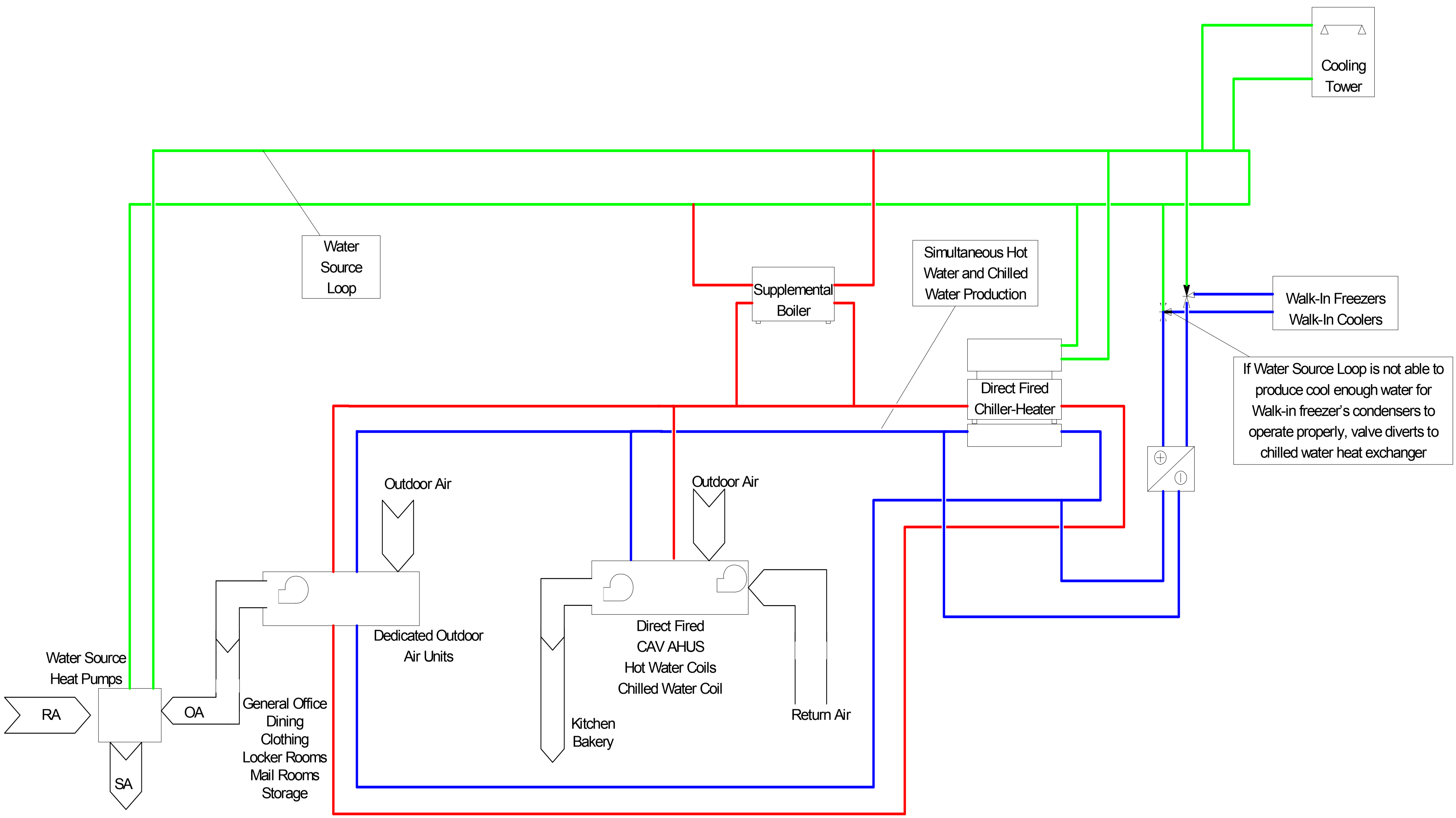
Even though chillers are not needed in water source heat pump systems, there are parts in the proposed HVAC system that still requires chilled water. Chillers are needed to supply chilled water to the DOAS and make-up AHUs. Since these chillers are a necessity, a plate frame heat exchanger that is currently in the existing system will pick up the rejected heat from the walk-in freezers when the water source loop can not. The chiller's condenser water system now has the potential for integration with the water source loop.

The rejected heat from the chillers will be added to the water source loop. Since the water source loop is directly connected to the cooling towers, when the loop becomes too hot for operation, the cooling towers will operate to maintain the loop temperature. The preliminary schematic shown in Appendix A further illustrates this point.

CHILLER-HEATER SYSTEM

The chiller-heater will not only produce the chilled water needed for HVAC cooling, but will also simultaneously produce domestic hot water. There is also potential for the hot water production to be added to the water source loop to help maintain the cooling mode temperature. The heat pump system is also to be modeled with electric chillers, such as the existing centrifugal chillers.

Comparisons between using the heat pump system in conjunction with electric driven water cooled chillers or with steam driven absorption chiller-heaters will lead way for recommending the best overall system. The entire DOAS/heat pump system plus chiller plant redesign must be compared to the original system as well, especially to calculate pay back periods. The best overall system will include a reasonable first cost, low operating costs, and a manageable pay back period when compared to the alternatives.


Cooling Tower
Water Source Loop
Supplemental Boiler
Simultaneous Hot Water and Chilled Water Production
Walk-In Freezers
Walk-In Coolers
Direct Fired Chiller-Heater
If Water Source Loop is not able to produce cool enough water for Walk-in freezer's condensers to operate properly, valve diverts to chilled water heat exchanger
Outdoor Air
Outdoor Air
Dedicated Outdoor Air Units
Direct Fired CAV AHUS Hot Water Coils Chilled Water Coil
Return Air
Kitchen Bakery
Water Source Heat Pumps
RA
OA
SA
General Office Dining Clothing Locker Rooms Mail Rooms Storage

6.0 BREADTH PROPOSALS

The redesign of the mechanical systems of the supply center directly affects other building systems. Integrating the changes to the HVAC systems with alterations to the structural system is the goal of this part of the proposal. The breadth studies will include structural work as well as construction management work. The overall idea is to fully incorporate all areas that play a direct or indirect factor in the mechanical systems redesign. Improving the other systems in terms of first cost is also an important goal of the project.

STRUCTURAL PROPOSAL

The reduction in the required amount of AHUs due to the proposed dedicated systems opens up other opportunities. Currently there are 14 air handling units total and they are all located in the elevated mechanical mezzanine rooms. Since the supply center is a single story 110,000 square foot building, there is plenty of open roof space. Reducing the amount of air handling units makes it possible to place the equipment on the roof. The smaller number of units results in each of them being fully accessible on the roof. However, a significant dead load and live load will occur from placing the units on the roof that affects the structural system. The structural breadth is to study the affect of relocating the AHUs and make the appropriate changes to the structural system. The cost difference, if any, will needed justification. Comparing the potential additional cost of increasing structural members to the potential cost saving from the mechanical redesign will help prove, overall, if the new systems are economically feasible.

CONSTRUCTION PROPOSAL

Replacing eight AHUs with fewer dedicated outdoor air units opens up the opportunity to move all of the AHUs to the roof and eliminate the elevated mechanical mezzanine rooms. However, as previously stated, this move affects the structural system and also affects the overall building cost. The construction breadth of the proposal will examine the cost of constructing the steel mezzanine rooms and compare it to the cost of increasing the structural members that is needed to support the added dead loads. The cost of outdoor ready AHUs are also more expensive than indoor AHUs. The cost difference must also be justified by the elimination of the mezzanine rooms. The construction breadth will also help to further justify the recommended mechanical system redesign with detailed cost estimates.

ELECTRICAL PROPOSAL

The proposed mechanical redesign includes the replacement of electric driven centrifugal chillers with natural gas fired absorption chiller-heaters. Therefore, a significant electrical change will ocurre dealing with the main distribution system as well as the mechanical room panel boards.

7.0 PROJECT METHODS

There are many engineer tools that are needed for execution of the thesis project. Taking full advantage of engineering software for calculations and using spread sheets for further calculations and organization will help the project run smoothly.

MECHANICAL DEPTH

Using Carrier's Hourly Analysis Program (HAP) for calculating space loads is the first step in the project. The program also can calculate annual energy usage from all AHUs and water source heat pumps. Using that load and energy data, the Engineering Equation Solver (EES) will further analyze the remainder of the redesign.

A chiller-heater model, set up in EES, will help calculate the annual energy consumption for refrigeration and domestic hot water heating processes. The model also will calculate the amount of steam needed to perform these tasks, which will then result in the calculation of natural gas consumption. Incorporating each major piece of equipment to the EES program is the key for the analysis. The walk-in refrigeration equipment, water source heat pumps, the Chiller-heater, the supplemental boilers, the steam boilers, the AHUs, the cooling towers, and all associated pumps and fans will, when properly written into the program, give a good annual cost of operation estimate.

As stated above, the loads for each space handled by the HVAC equipment is calculated using HAP. Therefore, these numbers will help calculate leaving and entering source water temperatures. The EES program will regulate the source water loop temperature and appropriate functions will indicate when the cooling towers must operate or when certain items must by-pass the water loop. Once all energy consumption data is found, EES or Excel will convert the energy values to cost using the site's utility rates.

BREADTH WORK

Structural analysis and steel design methods will be used for completion of the breadth work. For generating cost, R.S. Means along with cost from manufactures will provide realistic, accurate values. Excel spread sheets will serve as a major organization tool as well as perform many calculations. Life cycle cost calculations are easily performed in Excel. Structural take-offs for detailed cost estimates are also made easier with use of Excel.

8.0 CONCLUSIONS

The Milton Hershey School New Supply Center has a very involved, energy conscience mechanical system. There is room for improvement, however, and the proposed systems hope to find areas in the design that save cost and energy. While the supply center's existing conditions are good for this application, the goal of this redesign is to gain knowledge and experience. Understanding and evaluating the capabilities of systems, like DOAS and heat pumps, when applied to another type of building (in this case a supply center) is the main purpose of the proposed thesis.

9.0 PRELIMINARY RESEARCH

The following sources were used for preliminary research on the topics stated above.

ASHRAE, 2005 ASHRAE Handbook – Fundamentals. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA. 2001.

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R.S. Means, Mechanical Cost Data, 28th Annual Edition. R.S. Means, Kingston, MA. 2005.

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Bem, Justin S. *Technical Assignment 2: Building and Plant Energy Analysis Report of the Milton Hershey School New Supply Center*. October 27th, 2006.

Bem, Justin S. *Technical Assignment 3: Mechanical Systems Existing Conditions Evaluation of the Milton Hershey School New Supply Center*. November 21st, 2006.

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11.0 Schedules

A calendar of the spring 2007 semester at The Pennsylvania State University is used for setting completion milestones and schedules for work on the proposed mechanical systems redesign.

January 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 New Years Day	2	3	4	5	6
7	8	9	10	11	12	13
14	15 1ST Day of classes Start New HAP Files	16 Continue work on HAP files	17 Continue work on HAP files, Finish DOAS	18 Continue work on HAP files, Start Heat Pumps	19 Continue work on HAP files	20
21 Continue work on HAP files, Finish Heat Pumps	22 Organize Load Data from HAP	23 Organize Load Data from HAP	24 Select final AHUs	25 Contact Suppliers for AHU Cost	26	27 ASHRAE Winter Meeting in Dallas, TX
28 ASHRAE Winter Meeting in Dallas, TX	29 ASHRAE Winter Meeting in Dallas, TX	30 ASHRAE Winter Meeting in Dallas, TX	31 Start Chiller-Heater Model			

February 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 Continue Chiller-Heater Model	2 Continue Chiller-Heater Model	3
4 Continue Chiller-Heater Model Integrate With Cooling Tower	5 Continue Chiller-Heater Model Integrate With Cooling Tower	6 Continue Chiller-Heater Model Integrate With Heat Pumps	7 Continue Chiller-Heater Model Integrate With AHUs	8 Continue EES Model – Set up Source Water Loop Model	9 Continue EES Model – Set up Source Water Loop Model	10
11 Continue EES Model – Set up Source Water Loop Model	12 Continue EES Model – Set up Source Water Loop Model	13 Continue EES Model – Set up Source Water Loop Model	14 Start EES Model with existing Chillers	15 Continue EES Model with existing Chillers	16 Start Cost Analysis	17
18 Continue Cost Analysis	19 Continue Cost Analysis	20 Contact Suppliers for Major Equipment Cost	21 Continue Cost Analysis	22 Compile HVAC Results	23 Compile HVAC Results	24
25 Start Structural Analysis Work	26 Continue Structural Analysis Work	27 Continue Structural Analysis Work	28 Continue Structural Analysis Work			

March 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 Select New Structural Elements	2 Select New Structural Elements	3
4 Estimate new Structural Cost	5 Start Mezzanine Room Cost Take-off	6 Continue Mezzanine Room Cost Take-off	7 Continue Mezzanine Room Cost Take-off	8 Compare Cost Data	9 Compare Cost Data	10
11 SPRING BREAK Compare Cost Data	12 SPRING BREAK Compare Cost Data	13 SPRING BREAK Start organizing results	14 SPRING BREAK Start organizing results	15 SPRING BREAK Start organizing results	16 SPRING BREAK	17 SPRING BREAK
18	19 Create Visual Aids Summarizing Results	20 Create Visual Aids Summarizing Results	21 Create Visual Aids Summarizing Results	22 Continue Work on Final Report	23 Continue Work on Final Report	24
25 Continue Work on Final Report	26 Continue Work on Final Report	27 Continue Work on Final Report	28 Continue Work on Final Report	29 Finalize Work on Final Report	30 Start Work on Presentation	31

APRIL 2007						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
1 Start Work on Presentation	2 Start Work on Presentation	3 Start Work on Presentation	4 Start Work on Presentation	5 Start Work on Presentation	6 Start Final Revisions	7 Final Revisions
8 Final Revisions	9 Final Revisions	10 Final Revisions	11 Final Revisions	**12** **Final Report Due**	13 Revise Presentation	14 Revise/Practice Presentation
15 Revise/Practice Presentation	16 Presentations Round 1	17 Presentations Round 1	18 Presentations Round 1	19 Presentations Round 1	20 Presentations Round 1	21
22	23	24	25	26	27	28
29	30					