LONGWOOD AT OAKMONT HEALTHCARE CENTER

VERONA, PENNSYLVANIA

TECHNICAL ASSIGNMENT III

EXISTING CONDITIONS EVALUATION

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Mechanical Option
Senior Thesis

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EXECUTIVE SUMMARY

The Longwood at Oakmont Healthcare Center is a 45,000 square foot senior care facility located in Verona, Pennsylvania. The mechanical designer for the building was Reese Engineering Incorporated. The main design objectives for this project, as well as many of Reese Engineering's projects, were cost, energy efficiency, and indoor environmental quality. While examining this building it was observed that the mechanical systems are quite practical and sufficient for the needs of the facility. However, like any complex situation, there is always some room for improvement.

The building uses a water source heat pump system coupled with an energy recovery unit to condition and supply air to the required spaces within the Healthcare Center. Other equipment, such as cooling towers, pumps, boilers and fans, are used to aid the system in its functions.

The building's loads, ventilation rates, energy consumption, operating costs, and systems were all analyzed for this technical report. The building provides more than enough fresh air throughout, which improves the indoor air quality but also requires more energy to circulate. The design load for the building, based off of Pittsburgh outdoor conditions, was roughly 400 ft^2/ton. The building's energy consumption was mainly consumed by its heating demands which occupied almost 50% of the annual energy utilization. The building's annual operating costs had to be estimated due to the fact that construction is still underway. A total of $6.11 per square foot was estimated as the annual operating cost. All of these calculations and estimations were based off of the design conditions and the mechanical system's equipment.

The building's mechanical system seems to be energy conscious, cost effective, and very functional. The design team at Reese Engineering has done a number of jobs similar to that of the Longwood at Oakmont Healthcare Center and that is apparent in the design. While keeping all positive aspects of the mechanical system in mind, there is always room for improvement. Although, it is important that other options are analyzed thoroughly on all bases; cost, energy, functionality, etc.

MECHANICAL SYSTEMS DESIGN OBJECTIVES AND REQUIREMENTS

The Longwood at Oakmont Healthcare Center is a 45,000 square foot senior care facility. It consists of a wide variety of functional spaces. Such spaces include resident rooms, offices, dining rooms, public gathering spaces, and kitchens. The building's mechanical systems must be equipped to handle all of the loads produced by each space. The design team at Reese Engineering Inc. settled on the decision of a large energy recovery unit feeding single zone water source heat pumps to condition the spaces throughout the building.

This decision was made based on some of the principles of the firm and also on previous results of similar projects. Some of the main design objectives are listed as follows:

- Adhere to all applicable codes and standards, such as the International Building Code and ASHRAE Standard 62.1, which apply to the HVAC system.
- Design the most energy efficient, yet realistic, mechanical system as possible.
- Fulfill the needs and budget requirements of the client as best as possible in order to maintain a good working relationship with the owner.
- Minimize the amount of rooftop equipment to the best of your ability. This can provide easier access to mechanical equipment, increase the equipment's lifespan and diminish the negative effect to the building's exterior aesthetics.

Due to the variety of spaces within the Longwood at Oakmont Healthcare Center other minor mechanical items were used to cover the demand of the given space. For example, over head electric heaters were installed in the resident spas to handle the higher latent load within that space. Larger exhaust hoods were installed within the kitchen and were ducted directly to the outside to minimize the amount of odor and heat that would diffuse through the surrounding spaces.

OUTDOOR & INDOOR DESIGN CONDITIONS

The Longwood at Oakmont Healthcare Center is located in Verona, Pennsylvania which is just north-east of Pittsburgh. The energy recovery unit brings outside air to “room neutral conditions” which are described below. The air is then further treated by individual water source heat pumps. Each heat pump is controlled by its own thermostat.

DESIGN CONDITIONS FOR VERONA, PA

Latitude	40°, 30' N
Longitude	79°, 50' W
Elevation	853'
Summer DBT	90°F
Summer WBT	71°F
Winter DBT	4°F

DESIGN INDOOR CONDITIONS

	ERU	HP-1	HP-2	HP-3	HP-4	HP-5	HP-6	HP-7	HP-8	HP-9	HP-10	HP-11
Summer T_{SA} (°F)	75	62	63	61	62	60	60	58	55	57	57	56
Winter T_{SA} (°F)	72	100	100	102	100	101	104	103	108	106	106	106

VENTILATION RATE PROCEDURE ANALYSIS

For the evaluation of the ventilation rate procedure of the Longwood at Oakmont Healthcare Center the entire building was taken into consideration. This was simply due to the fact that a single energy recovery unit was used to handle the building's entire ventilation load.

The results that were gathered and calculated have shown that the building was designed in accordance with ASHRAE 62.1 Section 6 requirements. The following table illustrates the aforementioned data:

Space Name	V_{ou} (cfm)	V_{pz} (cfm)	Z_p (max)	E_v	V_{ot} (cfm)
Calculated Totals	6733	58073	0.34	0.8	8416
Designed Totals		58073			13200

There is a significant difference between the ASHRAE required outside air quantity and the designed outside air quantity. This could be looked at in two different lights.

On one side, this could be looked at as over engineering. If the designed value of outside air were to be closer to the minimum amount of outside air required by ASHRAE standards a smaller and subsequently less expensive energy recovery unit could be used. This would pose a great asset to the owner of the building.

On the other hand, an increased amount of ventilation air within a building has some great benefits. The building could have been designed this way to improve the indoor air quality for improved occupant comfort, well-being and productivity. By adding an additional 5000 cfm of outside air the ventilation system is in compliance with LEED Indoor Environmental Quality Credit 2. Although this building was not being considered for LEED certification it seems as though it was the engineer's intent to practice good indoor environmental quality methods.

DESIGN LOAD ESTIMATION

The Longwood at Oakmont Healthcare Center was analyzed using Elite to determine the demand load. Building information such as OA ventilation rates, building occupancy, lights (on a per square foot basis), equipment loads (from ASHRAE Fundamentals, Chapter 29, Table 5 and building plans), and building envelope construction (taken from specifications and design documents) was used to estimate the total demand for the building.

The outdoor design conditions were also taken into consideration while computing the design load. These conditions were found in the ASHRAE Handbook of Fundamentals. The conditions used for this analysis were based off of Pittsburgh, PA with a dry bulb temperature of 90°F and a wet bulb temperature of 71°F. For heating conditions temperatures of 4°F and 3°F, dry bulb and wet bulb respectively, were used. This information, along with the interior loads and building characteristics, inputted into Elite and then computed to acquire a total design load of the building.

Design Load Summary

	Design Supply Air (cfm/ft2)	Calculated Supply Air (cfm/ft2)	Ventilation Air (cfm/ft^2)	Design Load (ft^2/ton)	Calculated Load (ft^2/ton)
Heat Pump Sum	1.17	1.31		413	551
Energy Recovery Unit			0.29		

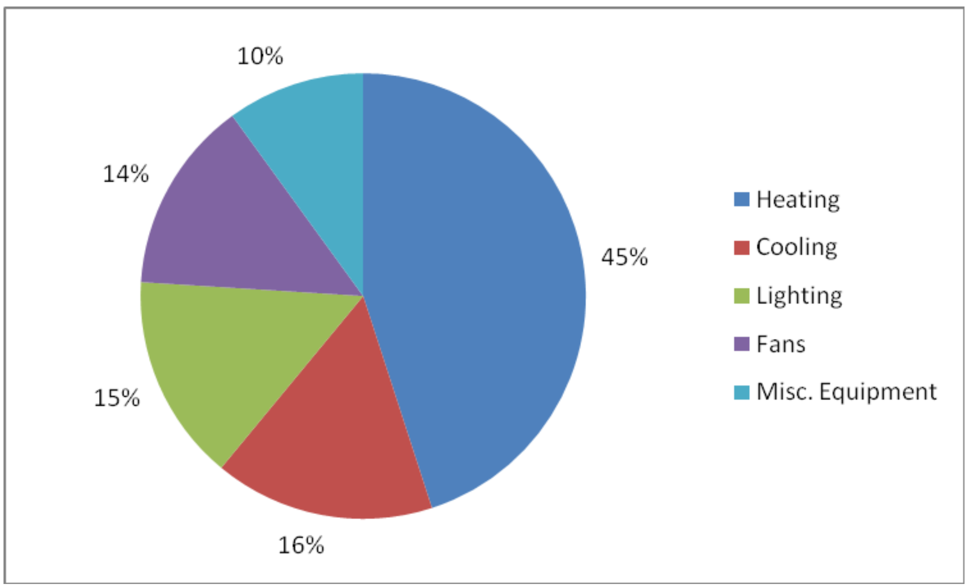
The results illustrate somewhat close similarities between designed and calculated values. The calculated values are a little higher than that of the designed values. One possible reason for this could simply be a lack of thorough knowledge of the simulation software (Elite).

ANNAUL ENERGY CONSUMPTION AND OPERATING COSTS

To analyze the Longwood at Oakmont Healthcare Center's energy consumption and operating costs Trane Trace 700 was used. The same information that was used to calculate the building's demand load was also used to analyze the energy usage. The necessary information either came from design data, provided by Reese Engineering, or from previously calculated values from earlier in this report. Because the building is not yet constructed utility rates could not be obtained. However, utility rates were obtained for similar buildings within the campus of Longwood at Oakmont and were used in the analysis of the Healthcare Center. These rates are listed below.

Energy Generation (0-20000 kWh): $0.0727/kWh
Energy Generation (>20000kWh): $0.0304/kWh
Energy Transmission: $0.0035/kWh
Energy Distribution (0-20000 kWh): $0.0179/kWh
Energy Distribution (>20000kWh): $0.0055/kWh
Natural Gas: $1.31/therm

Multiple elements contribute to the building's energy consumption and the below graphic illustrates a breakdown of such elements:



Based on the Trace input data and the utility rates given by the owner an overall annual energy cost was estimated for the building. It costs $275,115 dollars a year to operate the Longwood at Oakmont Healthcare Center, which is equivalent to $6.11 per square foot (based on a 45000 square foot building). This value seems surprisingly high as well does the amount of energy it takes for the heating portion of the building's energy consumption. After multiple attempts to eradicate the problem little was resolved. One main hurdle while performing this analysis was thoroughly understanding the modeling software (Elite and Trace).

During the design of the Longwood at Oakmont Healthcare Center there was no energy analysis performed by the hired engineers. There were multiple reasons for not performing such an analysis. The main players on board for this project, architect, MEP engineer, and contractor, all possess a great deal of expertise and experience on such Continuing Care Retirement Community (CRCC) buildings and the type of systems that are most economical to build and operate. A few main systems, mechanically speaking, were presented to the owner based on previous experience, location of the project, the capability of the Owner's Facility Group, and historical construction costs. The systems options were spelled out to the owner along with pricing narratives, provided by the contractor, and then one such option was selected by the owner, based on cost and effectiveness. In today's demanding building industry energy studies are most frequently performed on projects looking to achieve LEED certification, projects with large central plants, and/or projects located in dense cities where utility rates tend to be higher.

MECHANICAL SYSTEMS INITIAL COST

The Longwood at Oakmont Healthcare Center's mechanical system is comprised of mainly an energy recovery unit with an integrated energy wheel, a 250 ton cooling tower, three gas-fired boilers, two end-suction variable speed pumps, and roughly 100 water source heat pumps. Such equipment as the energy recovery unit has a great potential in saving energy costs, but also has a greater initial cost.

The initial cost estimates of the mechanical system were provided by Reese Engineering Inc. The actual bid values were asked to be withheld upon request of the owner.

Mechanical Systems Initial Cost	$1,875,088
Mechanical Systems Initial Cost per Sq. Ft.	$33.02/ft^2

MECHANICAL SYSTEMS LOST RENTABLE SPACE

The Longwood at Oakmont Healthcare Center contains a multilevel area as well as a single story level. The building footprint is just under 50,000 square feet with 45,000 square feet of that being usable space. The mechanical systems of the building occupy a portion of that usable space by means of shafts, heat pump closets, and a large mechanical room located on the second floor. In total the mechanical system takes up roughly 7% of the building's rentable space. Below is a more detailed breakdown of the lost usable space due to mechanical system components.

	Mechanical Room	Heat Pump Closets	Shafts	**Total**
Floor Area (ft^2)	2430	516	128	**3074**
% of Usable Space	5.3	1.1	0.3	**6.8**

DESCRIPTION OF SYSTEM OPERATION

COOLING TOWER

The Longwood at Oakmont Healthcare Center used a Baltimore Aircoil cooling tower to help aid in the air conditioning process. The cooling tower provided cooled condenser water for the heat pump loop. The water was fed to each individual heat pump and used to cool the air for its designated space.

The cooling tower is a closed circuit cooling tower. This means that the heat to be rejected is removed from the fluid being cooled to the ambient air via an exchange coil. By using a closed circuit the fluid being used is isolated from the surrounding environment and therefore remains clean and contaminant free.

WATER SOURCE HEAT PUMPS

Water source heat pumps are located in virtually every conditioned space, or combination of smaller spaces, throughout the building. These units can operate at both heating and cooling conditions, which is one main reason why they were incorporated in the design of this project. The units are also energy efficient and allow for occupant control which improves the indoor environmental quality.

In the summer, cooling, months the water from the cooling tower is used to chill the air within the heat pump. The air is cooled to the desired set point and then supplied to the space.

In the winter, heating, months the water from the gas-fired boilers is used to warm the air within the heat pump. The air is heated to the desired set point and then supplied to the space.

ENERGY RECOVERY UNIT

A Desert Aire energy recovery unit with an integral energy wheel was used to distribute ventilation air throughout the building. Outside air flows through the unit and exchanges characteristics with return air passing through the energy wheel. The outside air is then treated to “room neutral” conditions, 79°F DB for cooling and 34°F DB for heating. Cooling and heating coils are used inside the unit to reach these “room neutral” conditions. The air is then fed to the water source heat pumps where they will be fully conditioned and supplied to the designated spaces.

BOILERS

Three Patterson Kelley boilers are used to heat the heat pump loop for the Longwood at Oakmont Healthcare Center. Two of the boilers will be active and the third boiler will be stand-by for emergency purposes, maintenance issues, or high demand circumstances.

PUMPS

The Longwood at Oakmont Healthcare Center utilizes two Bell & Gossett pumps to circulate the warm and chilled water through the heat pump loop.

EXHAUST FANS

A number of Greenheck exhaust fans are used throughout the facility. Most of the fans are located on the roof or in the attic of the building, with architectural louvers located under the roof gables. The fans service areas within the building that require immediate exhaust so that the air is not mixed with other return air. Such areas include the kitchens, the beauty salon, soiled utility rooms, attic spaces, and machine rooms.

MAKE-UP AIR UNIT

The main kitchen area directly exhausts so mush air that extra outside air needs to be supplied to the space to maintain air quality and sufficient pressure. This requires a Greenheck gas-fired make-up air unit. The unit brings in fresh air, heats the air using a gas-fired heat exchanger, and supplies the air to the space.

DESIGN CRITIQUE

The first thing that is usually analyzed in a building is its cost. The initial cost of the mechanical systems for the Longwood at Oakmont Healthcare Center was $1,875,088 which is roughly 16% of the building's total construction cost. Obviously this value could be decreased. However, the designers and owner chose to select a more costly, yet more environmentally friendly, energy recovery unit and water source heat pump system. This can be argued that over the years the energy savings that will accumulate will eventually pay for the equipment itself. Without exact operating costs, as the building has not finished construction yet, it is unable to make a fair cost comparison.

Another issue that is examined is the amount of space the mechanical systems occupy. In the case of this project the majority of the HVAC equipment is located in a designated mechanical room on the second floor of the Healthcare wing. It consumes a little over 5% of the total building area. This space could be used more profitably by converting it into more resident rooms and moving the mechanical equipment onto the roof, but then other aspects of design and operation, such as those described in the Design Objectives section of this report, would be compromised. One design element that I though was unique and well thought out was the location of the interior corridor duct work. The wood roof trusses were constructed to allow the duct runs to pass through them above the ceiling. This allowed for maximum ceiling heights throughout the high profile corridors.

Air quality and environmental control is also an important factor of design. In the Longwood at Oakmont Healthcare Center each zone, consisting of either one or two rooms, was given its own water source heat pump and corresponding thermostat. This allowed the individual occupants of each zone to control the climate in which they were living or working in. The energy recovery unit also supplied these spaces, either directly or via the heat pumps, with an abundant amount of outside air. This greatly helped improve the indoor air quality.

With all things considered, the Longwood at Oakmont Healthcare Center seems to be a well designed building. The designers at Reese Engineering Inc. were able to create a building that met their design objectives in a practical and effective manner.

REFERENCES

"ANSI/ASHRAE Standard 62.1-2007 – Ventilation for Acceptable Indoor Air Quality." ASHRAE, Inc. Atlanta, GA. 2007.

"Additions and Renovations to Health Center for Presbyterian Seniorcare – Longwood at Oakmont." Plans and schedules. Reese, Lower, Patrick, and Scott, Ltd. September 2007.

APPENDIX A – EQUIPMENT SCHEDULES

ATMOSPHERIC WATER BOILER SCHEDULE

PLAN CODE	MBH INPUT @ S.L.	HEATING OUTPUT @ S.L.	WATER VOLUME (GAL)	ASME PRESS RATING (PSIG)	OPER PSIG	VOLTS/ PHASE/HZ	EWT	LWT	WATER FLOW (GPM)	WPD (FT HD)
B-1 THROUGH B-3	2000	1700	7.3	160	100	120/1/60	160	180	135.0	7.2

COOLING TOWER SCHEDULE

PLAN CODE	FAN CFM	AMBIENT AIR		SPRAY PUMP GPM	WATER			ELECTRICAL						
		DB	WB		GPM	EWT	LWT	FAN		PUMP		BASIN HEATER	VOLT & PHASE	
								MOTOR QTY.	HP	MOTOR QTY.	HP	KW		
CT-1	45,000	90	78	650	525	102	90	2	10	1	3.0	7.0	208 / 3	

ENERGY RECOVERY UNIT SCHEDULE

PLAN CODE	SUPPLY FAN			EXHAUST FAN			ENERGY WHEEL							
	SPACE CFM	ESP (IN. W.C.)	HP	SPACE CFM	ESP (IN. W.C.)	HP	SUMMER				WINTER			
							OA DB/WB	SUPPLY DB/WB	RETURN DB/WB	EXHAUST DB/WB	OA DB	SUPPLY DB/WB	RETURN DB/WB	EXHAUST DB/WB
ERU-1	13,200	2.25	20	12,155	2.25	15	90/73	79.1/65.8	75/62.4	84.0/68.4	-10	34.2/28.3	70/50.1	22/21.6

ENERGY RECOVERY UNIT SCHEDULE *(CONT.)*

COOLING COIL (WSHP)							HEATING COIL (WSHP)							VOLTAGE/ PHASE/HZ
TOTAL CAP. (MBH)	SENS. CAP. (MBH)	EAT DB/WB	LAT DB/WB	EWT	LWT	TOTAL HEAT REJECTED (MBH)	TOTAL CAP. (MBH)	EAT DB/WB	LAT DB/WB	EWT	LWT	INITIAL HEAT ABSORBED (MBH)	NET HEAT ABSORBED (MBH)	
422.8	318.5	79.1/65.8	56/55.1	90	95.2	534.7	579.8	34.2/28.3	75	65	55.9	579.8	538.8	208/3/60

EXHAUST FAN SCHEDULE

PLAN CODE	TYPE	AIR FLOW (CFM)	S.P. (IN W.G.)	MOTOR			FAN RPM
				HP	VOLTAGE/ PHASE/HZ	RPM	
EF-1	INLINE	9,220	0.40	3	208/3/60	1,725	1,000
EF-2	INLINE	7,500	0.40	2.00	208/3/60	1,725	840
EF-3	INLINE	6,170	0.40	1.50	208/3/60	1,725	725
EF-4	UPBLAST	2,475	0.80	1.00	208/3/60	1,725	1,631
EF-5	INLINE	330	0.50	1/10	115/1/60	1,550	1,545
EF-6	INLINE	150	0.50	1/12	115/1/60	1,550	1,486
EF-7	INLINE	240	0.50	1/10	115/1/60	1,550	1,460
EF-8	SIDEWALL	350	0.40	1/8	115/1/60	1,550	1,237
EF-9	INLINE	300	0.35	1/8	115/1/60	1,550	1,250
EF-10	INLINE	115	0.50	1/12	115/1/60	1,550	1,400

GAS FIRED MAKE UP AIR UNIT SCHEDULE

DESIG.	SUPPLY FAN				GAS FIRED HEAT EXCHANGER				
	CFM @ S.L.	EXT. SP (IN WG)	BHP/ HP	VOLT/ PHASE/HZ	OUTPUT CAP. (MBH)	INPUT CAP. (MBH @ S.L.)	EAT	LAT	MAX. AIR PD (FT. W.G.)
MAU-1	1,680	0.50	(0.76) / 1	208/3/60	149.1	137.2	-10.0	65.0	0.25

PUMP SCHEDULE

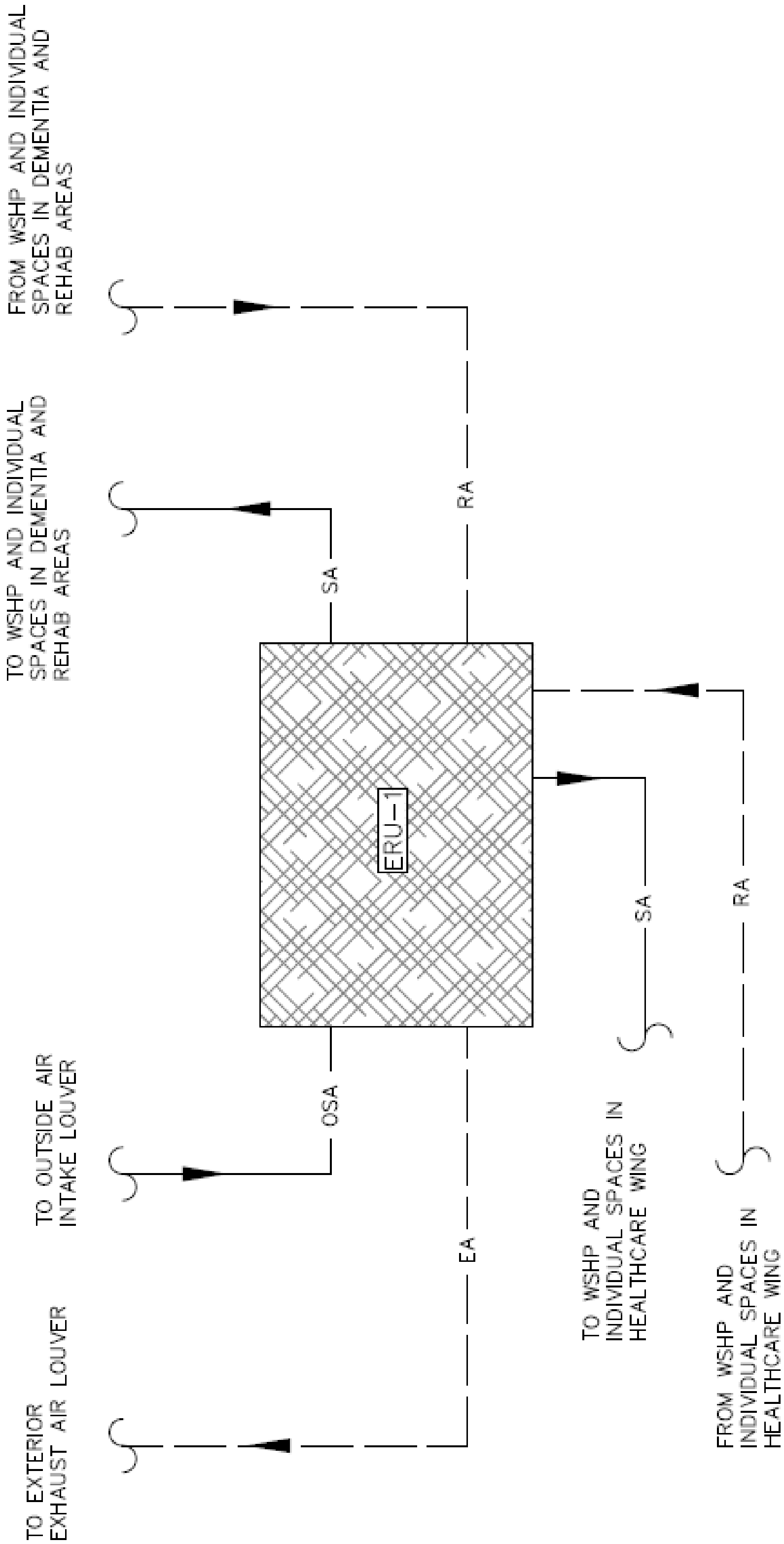
PLAN CODE	SERVICE	GPM	TDH (FT)	RPM	HP	NON OVER-LOADING BHP	VOLTAGE/ PHASE/HZ	IMPELLER SIZE (IN)	EFFIC. (%)
HWP-1	BOILER CIRCULATOR	135	15	1750	1	0.9	208/3/60	4.900	60.0
HWP-2	BOILER CIRCULATOR	135	15	1750	1	0.9	208/3/60	4.900	60.0
HWP-3	BOILER CIRCULATOR	135	15	1750	1	0.9	208/3/60	4.900	60.0
CWP-1	PRIMARY HEAT PUMP LOOP	425	90	1750	20	12.6	208/3/60		76.8
CWP-2	PRIMARY HEAT PUMP LOOP	425	90	1750	20	12.6	208/3/60		76.8

WATER SOURCE HEAT PUMP SCHEDULE

PLAN CODE	SUPPLY FAN			CONDENSER WATER		COOLING									HEATING				
	CFM TOTAL AIR	EXT. S.P. (IN. W.G.)	FAN HP	GPM	MAX. WATER PD (FT. W.G.)	TOTAL CAP. (MBH)	SENS. CAP. (MBH)	EAT DB	EAT WB	LAT DB	HEAT REJ. (MBH)	EWT	LWT	TOTAL CAP. (MBH)	HEAT ABS. (MBH)	EAT DB	LAT DB	EWT
HP-1	280	0.28	1/10	1.8	7.0	6.8	4.9	78	65	62	9	90	100	9.1	6.2	70	100	65
HP-2	380	0.36	1/8	2.4	9.3	9.5	6.5	78	65	63	12.7	90	101	12.5	9.3	70	100	65
HP-3	475	0.35	1/8	3.0	9.4	13.2	9.1	78	65	61	17	90	101	16.9	12.7	70	102	65
HP-4	525	0.5	1/8	3.0	9.4	13.5	9.5	78	65	62	17.3	90	102	17.3	13.2	70	100	65
HP-5	550	0.4	1/8	3.6	5.3	17.8	13.2	78	65	58	23.4	90	103	21.0	15.9	70	103	65
HP-6	800	0.5	1/3	4.8	5.6	23.8	17.9	78	65	58	31.7	90	103	29.8	22.6	70	104	65
HP-7	750	0.5	1/3	4.8	5.5	23.6	17.3	78	65	57	31.4	90	103	29.6	22.2	70	106	65
HP-8	1,375	0.5	1/2	9.6	7.2	44.3	32.1	78	65	57	59	90	102	53.8	39.3	70	106	65
HP-9	220	0.5	4/5	1.8	1.7	6.8	5.3	78	65	56	9	90	105	8.7	6.6	70	106	65
HP-10	1,520	0.6	1	12.0	9.2	55.0	42.0	78	65	57	72.6	90	102	70.2	52.8	70	105	65
HP-11	3,200	0.75	2	24.0	10.0	116.5	91.9	89	70	56	152.6	90	102	142.4	111.9	70	110	65

APPENDIX B – SYSTEM SCHEMATICS

AIR SIDE FLOW DIAGRAM



WATER SIDE FLOW DIAGRAM