THESIS PROPOSAL
Mechanical Systems Re-Design and Breadth Topics
Northfield Mental Healthcare Center
Northfield, Ohio

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EXECUTIVE SUMMARY

The Northfield Mental Healthcare center is located on the Northfield, Ohio. The building is a five story mental clinic building, and the project is renovation of three existing buildings and expansion of the existing facilities. Approximately 200,000 square feet would be added to the existing buildings, and the new portions of the buildings would be served as patient wings, administration, gymnasium, and clinic center. The new buildings were designed to provide better quality of building, safety of patients and staff, and aesthetically pleasing environment. The face brick walls were mainly used for the exterior walls, and smooth CMU, texted CMU, and curtain walls were also used to highlight freshness of new design. The building is not yet constructed but still in constructional document phase. The total estimated project cost is approximately $62.5 million, including 10.3 million of HVAC and fire protection equipment cost.

This proposal contains redesign of the mechanical system and electrical and acoustical breadth topics. This proposal also contains suggested timeline of the mechanical system redesign processes. Previous reports contain evaluations of the existing mechanical systems and descriptions of system operations including efficiencies of each mechanical system. Prior to this proposal, brief studies on efficient mechanical systems were conducted. This proposal suggests alternative mechanical systems that are more suitable and more

efficient in water-side and air-side and briefly explains why they are more efficient and which programs will be used.

The alternative mechanical systems that will be applied for the building are cogeneration system and the tri-generation system. The overall performance of each designed system will be evaluated, equipment for each system will be selected, and the total savings and payback periods will be calculated for each system.

CHP module, which consists of an engine and a generator, will be selected based on the minimum heating load required for the building. CHP system will be designed to meet the heating load by working along with existing conventional heating system. CHPC system will be designed to meet not only heating load by working along with existing heating system but also cooling load by working along with existing cooling system. CHPC system will also contain an absorption chiller which will maximize system efficiency.

Performances of both systems highly depend on how the engine and generator within the CHP module are connected to boilers and chillers. It is also very important to determine a proper amount of energy will be generated onsite by choosing appropriate an engine and a generator. Efficiency of a system highly depends on the engine type and a generator type.

This proposal also contains a brief explanation on two breadth studies that will be conducted and evaluated for the future research. The first breadth is acoustical aspects of the mechanical systems and reductions of noise productions from mechanical equipment. The sound attenuation device, such as an exhaust air silencer, will be studied, selected, and applied for the selected CHP module in order to achieve effective noise reduction.

The second breath is testing whether the CHP generator can replace one of the existing emergency generators. The NEC code requirements for the emergency generator and the CHP generator will be studied, and the load distribution systems of the existing generators will be examined. The calculation on the size of the conductors, which will be used to connect the CHP generator with the existing parallel switchgear, will also be performed.

SECTION ONE. PROJECT BACKGROUND

1.1 PROJECT BACKGROUND

The Northfield Mental Healthcare center is located in Northfield, Ohio. The building is a five-story mental clinic building, and the project is a renovation and expansion of three existing buildings. Approximately 200,000 square feet would be added to the existing buildings, and the new portions of the buildings would be for patient wings, an administrative facility, a gym, and a clinic. The new buildings were designed to provide better quality for the structures, deliver to the safety of patients and staff, and to become an aesthetically pleasing environment.

The main goal of the Northfield Mental Healthcare center project is to provide a comfortable and safe environment for both patients and staff members. The main purpose of this project is to establish more spaces for additional patients transferred from the Cleveland healthcare campus, which is going to be closed after the completion of this project. The building is not yet constructed, as it is still in the bidding process. The total estimated project cost is approximately $62.5 million, including $10.3 million for HVAC and fire protection equipment costs.

1.2 EXISTING MECHANICAL SYSTEM SUMMARY

From this section, the existing mechanical system is referred to a newly designed mechanical system for The Northfield Mental Healthcare center expansion and renovation project.

10 different air-handling units are equipped in the Northfield Mental Healthcare Center, including two already existing air handlers. Two 65,000 CFM rooftop air handlers serve the two patient wings. Clinic and administration areas are served by a 7,950 CFM rooftop air handler. A 3,700 CFM indoor air handler and an 8,400 CFM indoor air handler serve the gym area and dietary areas, respectively. The boiler plant, chiller plant, and electrical room are served by the other three indoor air handlers, which have a maximum capacity of 5,000 CFM, 5,000 CFM, and 6,000 CFM, respectively. The existing air handlers serve partially renovated areas and existing administration areas.

Customized air handler 1 and 2 for the two patient wings are equipped with DDC-VAV terminals, which will reset the ventilation rate based on occupancy. The DDC-VAV terminals continuously measure the amount of supply air and ventilation fraction for each space. A building automation system controls the DDC-VAV terminals and outdoor airflow by changing the position of the outdoor air dampers. The control system of a DDC-VAV terminal is described in the Figure 1.

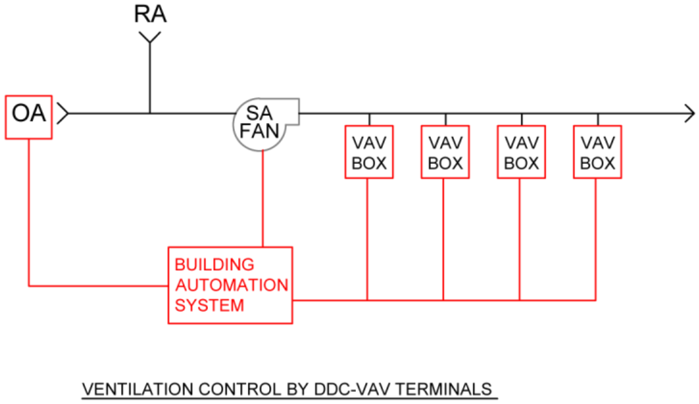


Figure 1: Ventilation Control by DDC-VAV Terminals

Air handler 3, which serves the gym area, is a dedicated outdoor air unit equipped with a sensible wheel. A total energy enthalpy wheel preconditions the outdoor air transferred to the unit. The total enthalpy wheel cools the outdoor air to 80.53 ˚F DB during the cooling season and heats the outdoor air to 51.55 ˚F DB during heating season, before delivering the conditioned outdoor air to the cooling coil and heating coil.

The building use programmable temperature control sensors and occupancy sensors, which reduce equipment load by a significant amount. Since most of the openings in the building are not operative, the amount of the outside air for each air handler is oversized in order to achieve the better indoor air quality. In order to maintain the comfortable temperature, even with the great amount of outside air entering the building, cabinet unit heaters and horizontal unit heaters are additionally placed to efficiently meet the space heating load.

Two 450-ton centrifugal chillers are located in the chiller plant and connected to a 2-cell-cooling tower, which is located outside of the energy center. Each chiller consists of two chilled water pumps: a primary chilled water pump and a secondary chilled water pump. The primary and secondary pumping arrangements help to increase system controllability, while decreasing total power input. It is recommended to use primary and secondary pumping systems for large complexes, all for energy efficiency. The primary chilled water pumps serve chilled water to chillers, while secondary chilled water pumps send chilled water to a cooling coil for each air handling equipment to serve the cooling load of the building.

Six 113.5-horsepower condensing boilers are located in the boiler plant and serve hot water. A primary pump equipped with each boiler sends heated water to the main hot water loop. Two secondary pumps, along with the main hot water loop, send hot water to a heating coil for each air handling equipment to serve the heating load of the building. Makeup water is heated by two domestic water heaters and served to the building. Variable frequency drive devices are used for most of the HVAC equipment, including heating water pumps, chilled water pumps, chillers, and cooling towers. Figure 2 shows the existing heating and cooling system.

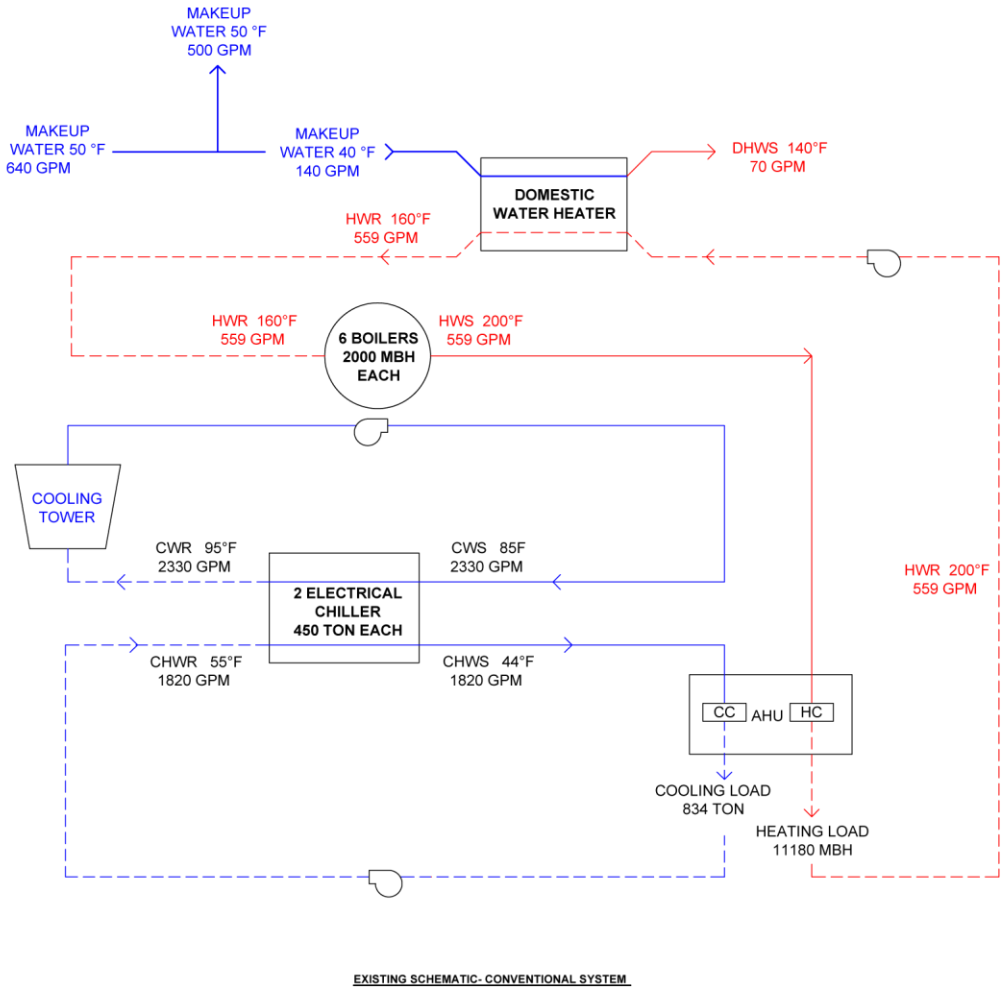


Figure 2: Existing Heating and Cooling System

1.3 DESIGN CRITERIA

The main goal of the Northfield Mental Healthcare center is to provide comfortable and safe environment for both patients and staff members. The main purpose of this project is establishing more spaces for additional patients transferred from Cleveland healthcare campus which is going to be closed after completion of this project. Since some of the mechanical systems remain the same, the newly designed mechanical systems need to be balanced with the existing one. Ten air handlers will serve the entire building, but two of them are existing one serving partially renovated areas and existing administration areas. Since the total pressure drop over the ductwork finally connected to the existing air handler remain the same, the total pressure drop accumulated through the newly designed ductwork needs to be balanced with that of ductwork which will be demolished.

The total designed energy load consists of cooling, heating loads and dominatingly hospital equipment load. This equipment load can significantly be reduced by using programmable temperature control sensor and occupancy sensors. Since the most of openings in the building are not operative, infiltrations as well as ventilation are one of the major design concerns. The amount of the outside air takes an account of infiltrations, and the amount of the outside air would be defined in accordance of ASHRAE 62.1 and ASHRAE 170. The amount of the outside air was oversized in order to achieve the better indoor air quality. In order to maintain the comfortable temperature even with the great amount of the outside air entering into the building, cabinet unit heaters and horizontal unit heaters were designed to be placed for the winter.

The heating water systems and cooling water systems have primary and secondary distribution systems that are recommended by ASHRAE Standard 90.1. It is recommended to use primary and secondary pumping system for large complexes for energy efficiency. The primary and secondary pumping arrangements help to increase system controllability and decrease total horsepower required. The primary pump serves chillers and boilers, while the secondary pump serves the cooling load and heating load.

1.3.1 DESIGN CONDITION

The Northfield Mental Healthcare Center is located in Northfield, OH. Since the Northfield area is not listed in the ASHRAE Fundamental 2009, Cleveland, the closest big city, was used for the analysis. Table 1 shows the weather data inputs that were used for the analysis.

Cleveland, OH	
Latitude	41.4N
Longitude	81.85W
Elevation	804 FT
Heating DB (99.6%)	2.5 ˚F
Cooling DB (0.4%)	89.4˚F

Table 1: Design Condition

The design temperatures are shown in Table 2. The sequences of temperature control would be achieved by programmable temperature controller. The supply air temperature would be maintained at set point by modulating the economizer control damper and valves' positions. The supply air temperature set point is linearly reset in a range of 5 F, and supply air can be set at a minimum temperature of 55 F. The supply air can be reset higher than 55F in order to maintain the room temperature as 75 F. When room temperature indicates below 70F, the controller would be deactivated. When the mixed air temperature is below 40 F, the outside air damper would be closed and return air damper would be opened.

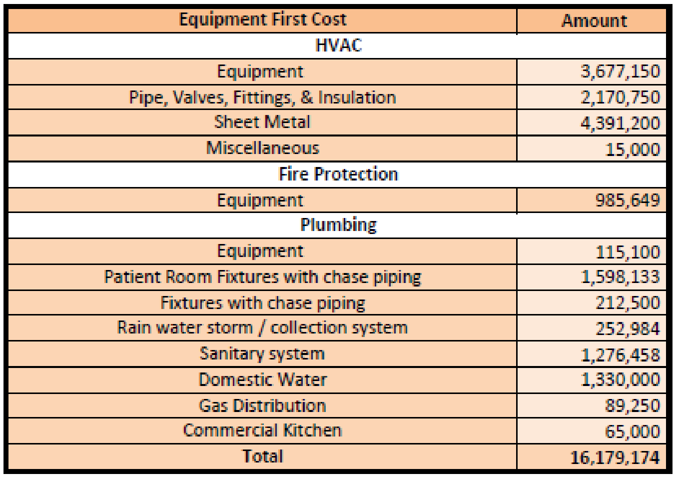
When the outside air temperature is between 65 F and the supply air temperature set point, the return air damper would be fully closed, the outside air damper would be positioned at the maximum outdoor air economizer position, and the digital panel would modulate the chilled water valve in order to call for cooling. When the outside air temperature is below than 65 F, the return damper would be fully opened and modulate the chilled water control valve to call for cooling. When the outside air temperature is below than the supply air temperature set point, the chilled water sensor becomes deactivated in order to maintain the supply air temperature set point. When the outside air temperature is below than the supply air temperature, the outside air damper would be positioned at the minimum position and the return damper would be opened. The ASHRAE weather data and design conditions of the project are described in Table 1 and Table 2.

Temperature Set Points	DB Temp (F)
OA	90 F DB, 71 F WB
RA	72 F DB, 50 % RH
SA	55 F DB
MA	Depends on OA %

Table 2: Design Temperature

1.3.2 MECHANICAL FIRST COSTS

Table 3 shows breakdown of first costs for HVAC systems, fire protection equipment, and plumbing equipment according to a report produced by the contractor. The costs include the costs of equipment, installation, material used for the equipment, and miscellaneous. The total estimated cost is approximately $16,180,000 with a cost per square foot of $81.00 / SF. The detailed cost breakdown is described in Appendix B.



Equipment First Cost	Amount
HVAC	
Equipment	3,677,150
Pipe, Valves, Fittings, & Insulation	2,170,750
Sheet Metal	4,391,200
Miscellaneous	15,000
Fire Protection	
Equipment	985,649
Plumbing	
Equipment	115,100
Patient Room Fixtures with chase piping	1,598,133
Fixtures with chase piping	212,500
Rain water storm / collection system	252,984
Sanitary system	1,276,458
Domestic Water	1,330,000
Gas Distribution	89,250
Commercial Kitchen	65,000
Total	16,179,174

Table 3: First Cost Summary

1.4 ENERGY MODELING - OUTPUT

1.4.1 COOLING, HEATING, AND VENTILATION LOAD

Load calculations of the Northfield Mental Healthcare Center, calculated by the engineer of the project, were performed by utilizing the CHVAC program. The CHVAC energy model created by the engineer might use different assumptions for lighting and electrical load, occupancy, and airflow, as well as different methods to separate rooms into zones. Also, the outputs of the CHVAC energy model was re-evaluated by using their own excel program to balance with the minimum outdoor airflow required for the hospital, as well as to take account of the reheating process. The summary of load calculations, provided by the engineer of the project and the output of the TRACE model, is described in Table 4.

ZONES		Design			TRACE		
		Cooling (Btu/hr)	Heating (Btu/hr)	Ventilation (CFM)	Cooling (Btu/hr)	Heating (Btu/hr)	Ventilation (CFM)
AHU-1	Patient Wing (Right)	2,871,500	2,128,464	65,000	2,565,694	3,565,409	57,377
AHU-2	Patient Wing (Left)	2,871,500	2,128,464	65,000	2,601,886	3,631,777	59,361
AHU-3	Gym	172,620	131,690	3,025	122,473	103,633	2,832
AHU-4	clinic/admin	338,530	250,150	7,950	367,611	461,731	9,314
AHU-5	Dietary	320,450	236,510	7,350	386,454	476,020	9,430
AHU 6	boiler plant	-	488,020	-	-	93,002	-
AHU 7	Chiller plant	-	488,020	-			
AHU 8	Electrical Room	262,710	224,920	-	274,841	105,323	-
AHU-9	Existing A/B	2,900,000	1,250,000	70,000	3,027,007	2,119,661	64,056
AHU-10	Existing C	600,000	750,000	14,000	656,227	623,479	13,044
Reheat		-	4,230,000	-	-	-	
Total		10,337,310	12,306,238	232,325	10,002,193	11,180,035	215,414
Tons		**861**			**834**		
MBH			**12,306**			**11,180**	

Table 4: Design Load Values VS. Calculated Load Values

The cooling load, heating load, and ventilation load, calculated by the engineer, seem to be larger than the output of the TRACE model. The comparison of loads, by zones, is unnecessary because zones are divided in a different manner. The difference between the engineer's design values and the TRACE output values is within 10 percent. The major difference can be found in the heating load. A possible reason, for the cause of the difference, is that the reheating process was considered in the CHVAC model. The cooling load and heating load outputs of the TRACE model are 834 tons and 11,180 MBH, respectively. These outputs will be used for mechanical alternatives' analyses. Table 5 contains a summary of load comparisons and differences in loads between the CHVAC model and TRACE model.

	Cooling (Btu/hr)	Heating (Btu/hr)	Ventilation (CFM)
Design	10,337,310	12,306,238	232,325
TRACE	10,002,193	11,180,035	215,414
Difference	335,117	1,126,203	16,911
Difference (%)	3.2 (Underestimated)	9.2 (Underestimated)	7.3 (Underestimated)

Table 5: Cooling Load, Heating Load, and Ventilation Load Summary

1.5 ENERGY CONSUMPTION

The total energy consumption was calculated based on the outputs of the TRACE model. Since the energy consumption rates of mechanical equipment were estimated, based on the general consumption rate specified either on product catalogs or specifications, the actual energy consumption of the mechanical equipment can differ from the estimated total energy consumption given by the TRACE model. Table 6 contains a summary of total annual electricity and gas consumption.

Summary of Load Calculation and Energy Consumption Calculation	
Total SF (SF)	260,000
Cooling (TONS)	834
Space Heating (MBH)	11,180
Chilled Water (GPM) @11F Difference	1,820
Hot Water (GPM) @ 40F Difference	559
Domestic Hot Water (GPM)	139
Total Energy Consumption (KWh)	32,779,802
Total Electricity Consumption (KWh)	14,127,906
Total Natural Gas Consumption (Therms / yr)	636,589

Table 6: Summary of Load Calculation and Energy Consumption Calculation

Energy Usage Breakdown of the TRACE model is described on Table 7. Space cooling requires almost 33% of the total electricity consumption, and space heating requires almost

85% of the total gas consumption. Figure 3 and Figure 4 show electricity consumption breakdowns and natural gas consumption breakdowns, respectively.

Energy Usage Breakdown									
Electricity (%)							Gas (%)		
Heating	Cooling	Lighting	Equipment	Fans	Pumps	Other	Heating	Equipment	Water System
0	33	10	14	27	5	10	85	13	3
100							100		

Table 7: Energy Usage Breakdown

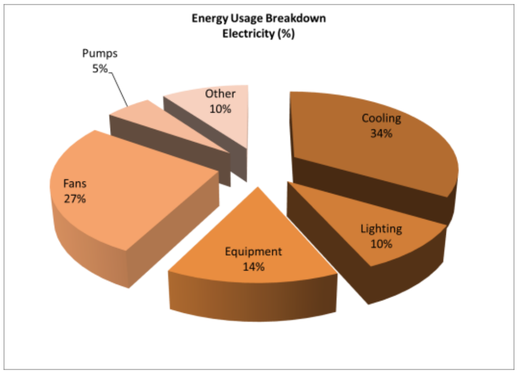


Figure 3: Electricity Usage Breakdown

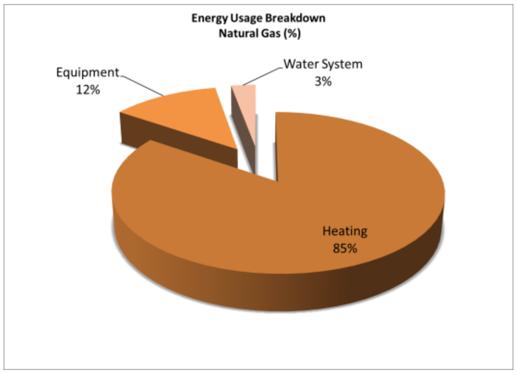


Figure 4: Natural Gas Usage Breakdown

Based on the estimated energy consumption, energy use index was calculated and summarized on Table 8. The EUI values are calculated based on energy consumption with a full load performance. Table 9 describes the typical EUI values of the hospital model, with base load performance, in climate Zone 5A. If a demand factor is applied for the TRACE model, the EUI value will be calculated much closer to the typical EUI value of the hospital model with baseline performance.

EUI Value Calculated		
Electricity EUI	185	kBtu/SF
Natural Gas EUI	250	kBtu/SF
EUI	435	kBtu/SF

Table 8: Calculated EUI Values

EUI Value of Typical Hospital (Baseline Model)		
EUI	388	kBtu/SF

Table 9: EUI Value of Typical Hospital

1.6 EMISSION

Emissions from the energy usage were calculated using emission factors from the Regional Grid Emissions Factors 2007 file. Table 10 shows the mass of each pollutant produced by electricity usage for this building.

	Emission for Delivered Electricity		Precombustion Emission for Delivered Natural Gas		On-Site Combustion Emission for Boiler		
	Factor	Mass of Pollutant	Factor	Mass of Pollutant	Factor	Mass of Pollutant	Total
Pollutant	lb/ kWh	lb	lb/ ft^3	lb	lb/ ft^3	lb	lb
CO2e	1.74E+00	9.46E+07	2.78E+01	2.64E+07	1.23E+02	1.17E+08	2.38E+08
CO2	1.64E+00	8.92E+07	1.16E+01	1.10E+07	1.22E+02	1.16E+08	2.16E+08
CH4	3.59E-03	1.95E+05	7.04E-01	6.69E+05	2.50E-03	2.38E+03	8.67E+05
N2O	3.87E-05	2.10E+03	2.35E-04	2.23E+02	2.50E-03	2.38E+03	4.70E+03
NOx	3.00E-03	1.63E+05	1.64E-02	1.56E+04	1.11E-01	1.05E+05	2.84E+05
SOx	8.57E-03	4.66E+05	1.22E+00	1.16E+06	6.32E-04	6.01E+02	1.63E+06
CO	8.54E-04	4.64E+04	1.36E-02	1.29E+04	9.33E-02	8.87E+04	1.48E+05
TNMOC	7.26E-05	3.95E+03	4.56E-05	4.33E+01	6.13E-03	5.82E+03	9.82E+03
Lead	1.39E-07	7.56E+00	2.41E-07	2.29E-01	5.00E-07	4.75E-01	8.26E+00
Mercury	3.36E-08	1.83E+00	5.51E-08	5.24E-02	2.60E-07	2.47E-01	2.13E+00
PM10	9.26E-05	5.04E+03	8.17E-04	7.76E+02	8.40E-03	7.98E+03	1.38E+04
Solid Waste	2.05E-01	1.11E+07	1.60E+00	1.52E+06	0.00E+00	0.00E+00	1.27E+07

Table 10: Emission Calculation

1.7 OVERALL EVALUATION SUMMARY

The mechanical systems of the Northfield Mental Healthcare Center comply with the mandatory provisions in ASHRAE Standards, but the maximum efficiencies of the systems were not achieved due to project budget issues. Some of the energy efficiencies were achieved by equipping programmable temperature controllers, occupancy sensors, BAS controllers, and variable frequency-derive controllers.

Increasing outdoor air intake for mechanical ventilation and equipping pre-filters and final-filters inside of each air-handling unit accomplishes indoor air quality for the Northfield Mental Healthcare Center. Even if routine maintenance is required for those filters and results in higher maintenance costs, those installed filters result in longer equipment life. VAV systems will also enhance the higher indoor air quality of the building; varying the supply air volume will reduce the building energy usage by reducing work done by fans, but it will still increase indoor air quality by producing a very little margin of error from desired temperatures. In addition, VAV systems enable the individually controlled zones to have their own thermostats, which can control their thermal comfort by adjusting the controller.

The cooling and heating loads are also efficiently served by using condensing boilers and electric centrifugal chillers. Also, VFD, installed in pumps and fans, saves energy by controlling their outputs based on the needs of occupants. However, adapting more efficient heating and cooling systems or on-site energy generation systems can reduce high annual total energy consumption.

The approximate construction cost is $62.5 million for the entire project and $312.5 /SF. According to the commercial real estate specialists' online resources, this cost lies in the mid-high region of the range. Figure 5 shows the construction cost per square foot, for a 4 to 8 story hospital. The first cost, including the costs of equipment, installation, material used for the equipment, and miscellaneous, was calculated to be $81.00 / SF. The first cost of the HVAC equipment, fire protection equipment, and plumbing equipment seems to be average when compared to hospital projects of a similar size.

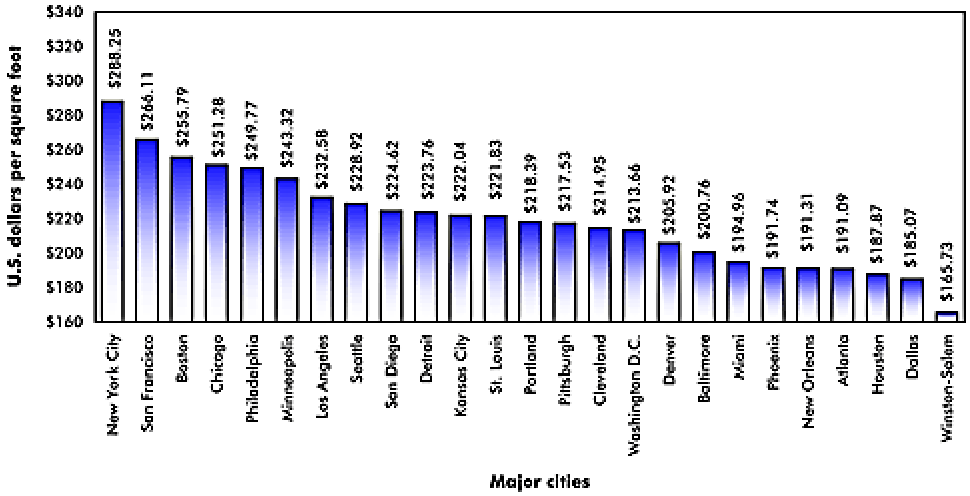


Figure 5: Construction Cost per Square Foot for 4 to 8 Story Hospital

Based on the construction cost, the first installation cost, and performance of the systems, this project is reasonably well designed. The annual operating and fuel costs for all of the mechanical equipment, however, seem to be higher than that of typical, large hospitals. A reduction of annual operating and fuel costs will be the primary consideration of this thesis project.

SECTION TWO. PROPOSED ALTERNATIVES

2.1 PROPOSED ALTERNATIVES

2.1.1 COMBINED HEAT AND POWER SYSTEM

The combined Heat and Power System, also known as the cogeneration system, is an integrated mechanical system, which simultaneously generates and utilizes heat and power. The majority of buildings in the world use the SHP system, which is known as the separate heat and power system, due to its low initial cost. The SHP system generates heat and power separately by implementing both power plants and heating equipment. The Northfield Mental Healthcare center also uses the SHP system, consequently with the high output of electricity and gas consumption.

A lot of healthcare facilities with high heating and cooling demands use the CHP systems. The CHP system in a healthcare facility reduces a significant amount of electricity and gas consumption by generating energy sources on-site, instead of buying them from energy companies. In addition, since water is used as the refrigerant, there are no harmful chemical pollutants emitted when using the CHP system.

There are various components of CHP systems, but a typical CHP system consists of mechanical conversion equipment, a prime mover, and a heat recovery system. A prime mover converts fuel energy into mechanical energy and sends the energy to the mechanical conversion equipment. The mechanical energy is then transferred to the mechanical conversion equipment and converted into power. Heat rejected from the prime mover is moved to a heat recovery system and converted into useful thermal energy. The overall efficiency of the system highly depends on the type of prime mover used for a system.

A simple calculation will be performed to see if the CHP system has more potential to be a favorable payback for the Northfield Mental Healthcare center, as well as to see which type of prime mover will be appropriate for the system

2.1.2 COMBINED HEAT, POWER, AND COOLING SYSTEM WITH ABSORPTION CHILLER

Alternative 2 is the Combined Heat, Power, and Cooling (CHPC) system, also known as the tri-generation system. With the similar manner of the cogeneration system, the same on-site energy-generating module will be used for the tri-generation system. The major difference between cogeneration and tri-generation is the usage of thermal energy output from the CHP module. While the thermal energy from the CHP module will be used for the heating process for the cogeneration system, the thermal energy from the CHP module will be used for the cooling process for the tri-generation system.

The tri-generation system utilizes energy in three forms: electricity, heat, and chilled water. However, the tri-generation system requires cooling equipment, which uses hot water or heat as a source, such as steam fired absorption chillers or hot water fired absorption chillers. Various types of absorption chillers that can be used along with the CHP module will be studied to see which type of absorption chillers provides a maximum efficiency of the entire system.

2.2 BREADTH TOPICS

2.2.1 ACOUSTICAL BREADTH

A noise reduction is one of the major considerations for the healthcare facilities. Considerable amount of the noise generated by mechanical equipment and electrical equipment needs to be reduced for patient safety. Especially this facility, mental clinic, needs to create better healing environment to ensure all the patients to have comfortable spaces. Airborne noise creation and noise attenuation through ductwork will be evaluated to ensure if all the exhaust and supply diffusers are properly selected and placed. If the redesigned mechanical system creates too much noise transmitting to adjacent rooms, proper acoustical equipment will be selected and placed in order to increase noise attenuations, or rearrangement of rooms will be conducted. The study will include an evaluation of the CHP module's noise generation. The sound attenuation device, such as an exhaust air silencer, will be studied, selected, and applied for the CHP module.

2.2.2 ELECTRICAL BREADTH

Due to the additions and changes of mechanical systems, electrical load will be affected. The study will include an evaluation of whether the CHP generator can replace one of the existing emergency generators. The NEC code requirements for the emergency generator and the CHP generator will be studied, and the load distribution systems of the existing generators will be examined. The calculation on the size of the conductors, used to connect the CHP generator with the existing parallel switchgear, will also be performed.

Health care facilities require maximized electromagnetic protection of wiring and minimized electrical hazard that can be caused by potential voltage flow between medical equipment and patients. Electrical equipment and wires will be resized in accordance of NEC requirements.

2.3 TOOLS FOR ANALYSIS

An energy-modeling program, Trane TRACE 700 will be used to calculate new energy consumption rate with the redesigned mechanical equipment. Previously evaluated file for the existing mechanical equipment will be compared with the new energy consumption calculation to evaluate how much energy will be reduced for the new system. Auto CAD and Revit programs will be used for drafting flow diagram and control diagram for the new mechanical system. When the mechanical systems will be redesigned, codes and standards, such as ASHRAE Standard 62.2 and 170 will be reapplied in order to ensure everything meets its requirement.

2.4 PRELIMINARY RESEARCH

ASHRAE. Advanced Energy Design Guide for Large Hospitals. Atlanta: W. Stephen Comstock, 212. PDF.

This documentation is a ASHRAE design guide explains recommendation of energy saving HVAC system for large hospitals. It also contains energy efficiency strategies for each climate zone. This source will be useful to determine which system and supplementary equipment will be suitable for this project.

Bhatia, A. HVAC Design for Healthcare Facilities. Stony Point: CED Engineering, n.d. PDF.

This document is a guideline for HVAC system of healthcare facilities. The document contains how to calculate air change rates and recommended air change rates for healthcare facilities. It also describes optimum indoor air quality level for the healthcare facilities.

Demand Controlled Ventilation Demand Controlled Ventilation System Design. Syracuse: Carrier Comfort Network, 2011. PDF.

This document is a good guideline for ventilation control and carbon dioxide control. It also explains what carbon dioxide concentration in a building means and how to reduce carbon dioxide concentration rate through effective ventilation system.

Marmion, Paul. Rethinking Hospital Design. N.p.: ASHRAE Journal, June 2012. PDF.

This documentation shows 2012 ASHRAE technology award case studies. It describes energy saving method and its real life application. One of the mechanical approaches that the example in the document has is a flue gas heat recovery system. The document explains how much the flue gas heat recovery system saved the total energy consumption.

Pearson, Andy. Thermal Coupling of Cooling and Heating Systems. N.p.: ASHRAE Journal, Feb. 2011. PDF.

This document compares energy ratings and life cycle costs for four different types of HVAC system. It also describes pros and cons for each type of HVAC system. This document will be helpful when the existing and redesigned HVAC systems are going to be compared.

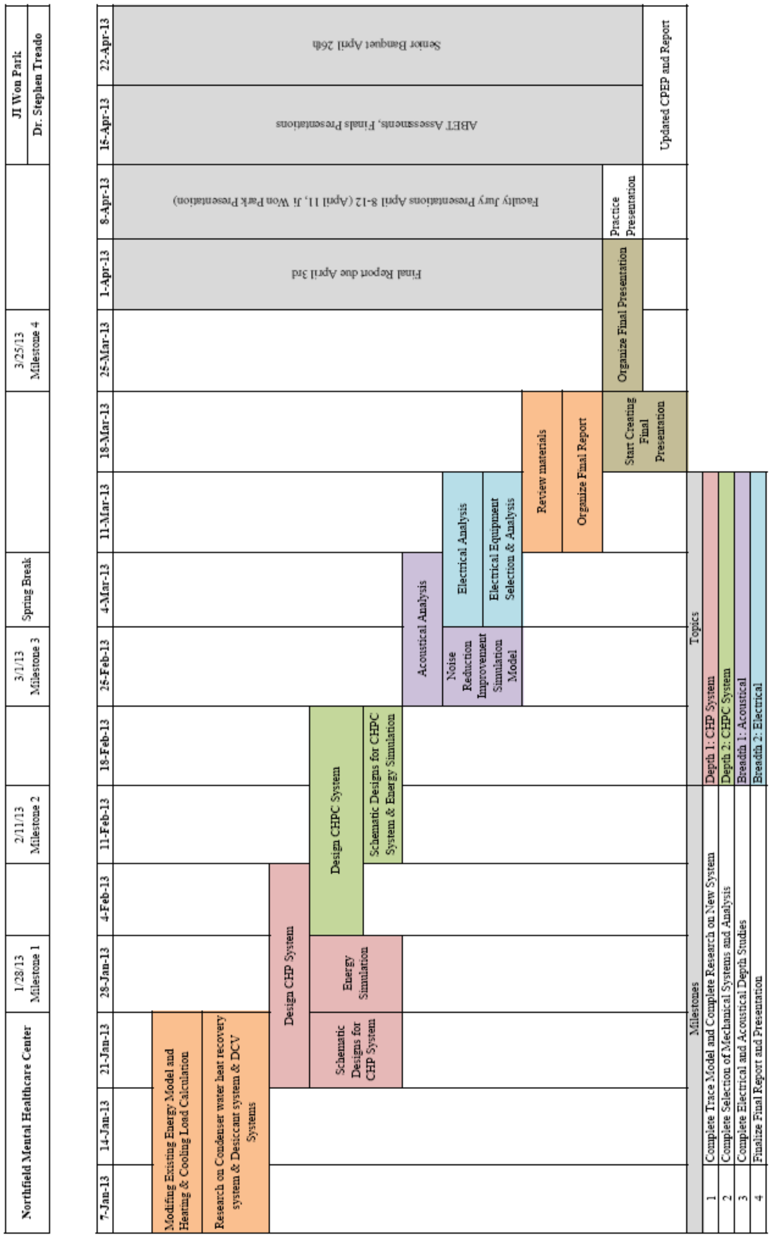
Sheerin, Michael P. Minimizing Noise in Healthcare HVAC Design. Orlando, Florida: ASHRAE Technical Committee 2.6 Sound & Vibration, Jan. 2009. PDF.

This document is a powerpoint that explains HVAC design strategies to reduce noise in healthcare facilities. Healthcare settings least affected by noise will be guidelines for acoustical analysis for the future report.

Using Demand Controlled Ventilation to Reduce HVAC Costs. Boulder: E Source Companies, 2005. PDF.

This document explains how much HVAC costs will be reduced with the application of demand controlled ventilation system. It also describes benefits of DCV system and special limits for the system.

2.5 PROPOSED SCHEDULE



Northfield Mental Healthcare Center	1/28/13 Milestone 1		2/11/13 Milestone 2		3/1/13 Milestone 3	Spring Break		3/25/13 Milestone 4		JI Won Park Dr. Stephen Treado

7-Jan-13, 14-Jan-13, 21-Jan-13, 28-Jan-13, 4-Feb-13, 11-Feb-13, 18-Feb-13, 25-Feb-13, 4-Mar-13, 11-Mar-13, 18-Mar-13, 25-Mar-13, 1-Apr-13, 8-Apr-13, 15-Apr-13, 22-Apr-13

Milestones		Topics
1	Complete Trace Model and Complete Research on New System	Depth 1: CHP System
2	Complete Selection of Mechanical Systems and Analysis	Depth 2: CHPC System
3	Complete Electrical and Acoustical Depth Studies	Breadth 1: Acoustical
4	Finalize Final Report and Presentation	Breadth 2: Electrical