Thesis Proposal

MECHANICAL SYSTEM REDESIGN

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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. After examining the building's existing mechanical systems it has been determined that the facility is designed in a very practical and energy efficient manner. However, there are a few aspects within the mechanical system that could be improved upon.

The main objective of this redesign is to increase the building's energy consumption and in turn minimize the building's life cycle costs. All of the existing design criteria established by Reese Engineering are to be upheld at the same time, including minimizing the amount of rooftop equipment, fulfill the needs and budget requirements of the client, and adhere to all applicable codes and requirements.

The main redesign consideration for this project is to utilize a geothermal or ground source heat pump system. This would step in for the duties otherwise performed by the building's cooling tower and gas-fired boilers. The system uses the Earth's constant underground temperatures as a heat source in the winter and a heat sink in the summer. These systems can be very efficient and depending on energy prices, very cost effective. In order to determine if this system is beneficial to the building and its owner a number of aspects will have to be analyzed, including; initial costs, construction time and costs, energy savings, geological characteristics of the site, maintenance, and indoor environmental quality.

The system will also impact other aspects of the building in addition to the mechanical system. Breadth topics will be analyzed to assess what changes will be made. The construction of a geothermal well site can be costly and time consuming and can sometimes inflate the projects budget and schedule. This will be examined to ensure the system is advantageous. With the system's elimination of certain equipment, electrical consumption will be reduced. The impact of minimizing electrical usage will also be looked into and the resizing of electrical equipment will be examined.

Hopefully after intense examination of the new system's characteristics it will prove to be a smart, cost effective, and energy conscious decision.

MECHANICAL SYSTEMS BACKGROUND

The Longwood at Oakmont Healthcare Center is a 45,000 square foot senior care facility located in Verona, Pennsylvania. It consists of a number of resident rooms both multi-living and individual. Along with these resident rooms the building has a number of multi-functional spaces, including dining rooms, offices, kitchens, resident spas, and general gathering spaces. All of these rooms need to be conditioned to desired conditions and ventilated per ASHRAE Standard 62.1.

This is done by using an integrated water source heat pump and energy recovery unit system. The “single zone,” some zones consist of two or three smaller rooms, water source heat pumps condition “room neutral” air for the spaces they are designated to. Each zone and coincidentally heat pump is controlled by its own thermostat to ensure the best possible thermal comfort for the occupant. During the colder months three gas-fired boilers (one of which is stand-by for peak loads) use combustion to heat loop’s water which is then used to heat the supply air in each heat pump. As for the warmer months of the year, a 250 ton cooling tower is used to chill the water in the loop which is then used to cool the supply air for each space.

Ventilation air is also needed throughout the building. This is provided by the utilization of an energy recovery unit with an integrated energy wheel. Outside air is brought in through the unit and brought to “room neutral” conditions, so that the smaller capacity heat pumps aren’t doing as large an amount of work. The air is then distributed to each water source heat pump and in some circumstances directly to the spaces. Return air is then consolidated back to the unit and exhausted out after exchanging conditions with the fresh air coming into the unit, hence recovery energy. With the combination of this equipment the building is able to receive the necessary conditioning while being energy conscious.

REDESIGN CONSIDERATIONS

REDESIGN BACKGROUND

A big proponent of why I began studying Architectural Engineering at The Pennsylvania State University, especially with a mechanical emphasis, was to learn more about how I can help change the world. The global environment is constantly changing and over the past few decades it has been changing in a negative way. I want to be a part of the solution. Because of this I am going to investigate ways in which I can lessen the impact my building has on the environment and also possibly improve the indoor environment it is creating.

One such design alternative that I am going to be looking at is the use of geothermal heat pumps instead of water source heat pumps. The two essentially work the same way, with the exception of the way heat is generated or absorbed. Geothermal heat pumps use the Earth (below the surface) to transfer heat to and from the water loop. In the heating months geothermal heat loops pipe the water or water-glycol mixture into the ground. The Earth's constant temperature heats the heat pump loop which is then fed to the heat pumps themselves and is used to condition the supply air for each space. On the other hand, in the cooling months the Earth absorbs the heat within the loop. The now chilled water is then distributed throughout the building and the heat pumps use the chilled water to cool the supply air.

MAINTENANCE

One immediate benefit of using geothermal heat pumps is the minimization of maintenance needs. Without a boiler or cooling tower to condition the water loop there are that many fewer pieces of equipment that need to be maintained. However on the other hand, if something should go wrong with the heat pump loop that is underground maintenance becomes a lot more complicated. Geothermal heat pump systems are also not as widely well known which leaves certain maintenance groups out in the cold when it comes to trouble shooting. For the purposes of my thesis I will analyze the familiarity of geothermal products among the building's owner and the design engineer. I will also look at how easily the system is to turn over to an owner and what costs are associated with maintenance issues.

ENERGY CONSUMPTION

Without the use of boilers and cooling towers there is an obvious decrease in energy consumption when using geothermal heat pump systems. I will analyze the amount of energy that is consumed on an annual basis with a geothermal system in place of a water source heat pump system. I plan on looking at the cost differences between the two systems with regards to annual energy costs.

SYSTEM COSTS

One of the biggest issues with geothermal heat pump systems and sustainable design methods all together is the initial costs of equipment and installation. As mentioned early the energy savings created by geothermal system could be substantial. However I will need to look at the initial cost of the equipment as well as the cost it takes to install everything and drill the well field. Hopefully upon my analysis the payback period will be minimal enough to utilize the system.

ENVIRONMENTAL IMPACTS

Another benefit of using geothermal heat pumps is the minimization of harmful emissions. Without a combustion boiler overall building emission can be greatly decreased. I plan on calculating the difference of emissions between the existing and redesigned solutions. A downside of geothermal systems is the possible loop leak or break. If a water-glycol mixture is used there is the potential of polluting the surrounding area. I will analyze all the possible problems that could occur if this were to happen, what measures can be taken to prevent it from happening, and what regulations are already in place.

PHYSICAL APPLICABILLITY

When considering a geothermal heat pump system a lot is dependent on the physical characteristics of the site. I will look at whether or not the site could be a plausible host for a geothermal well field. I will determine if there is enough space, both vertically and horizontally, to construct a well field. I will analyze, as best as possible, the geology of the site and whether or not it would be cost effect to drill on the site. I will also look at whether a horizontal or vertical loop should be used. Regulations could also come into play due to the drilling process. Local drinking wells could be on site or marsh land might be near which could limit the drilling process. All of this will be looked at in the future.

INDOOR AIR QUALITY

Along with the geothermal heat pumps the already designed energy recovery unit will be used to ventilate the spaces. This has already been shown to supply sufficient outside air to ensure a healthy working/living environment. One thing that could occur with only using geothermal heat in the winter is a decrease in supply air temperatures. This has the potential to generate a drafty environment in colder days of the year. In a senior care facility such an occurrence is more widely noticed and could result in unsatisfied occupants. This condition will be analyzed and the addition of a back-up supplementary heat source, such as a boiler, could be utilized.

PROPOSAL BREADTH TOPICS

CONSTRUCTION MANAGEMENT PROPOSAL

Using a geothermal heat pump system to condition the building requires a lot of upfront consideration. Due to the system's unfamiliarity among much of the industry, costs for installation and equipment can be pricey. The costs for additional equipment will also add to the building's overall cost. More subcontractors will also be added to the already lengthy list of construction members adding potential unseen problems. The overall schedule of the project will be lengthened due to the geothermal heat pump system. For the case of this construction breath an adjusted schedule will be formulated. The location of the well field and the sequencing of the drilling process will also have to be taken into consideration. A cost break down will also be estimated to the best of my ability, with bids for equipment and labor being used as a spring board. By altering the mechanical system of the building to help improve the building's energy usage other elements, such as this construction breadth, are affected and could possibly negate the mechanical benefits of the system.

ELECTRICAL PROPOSAL

The geothermal heat pump system will eliminate some previously necessary equipment. This means that there is much less energy and electricity being used on a daily basis. The possibility of downsizing electrical equipment presents itself with this change in mechanical systems. This opportunity will be analyzed and the cost savings in the change will be assessed.

ANALYSIS TOOLS AND METHODS

In order to make as accurate as possible cost comparison some steps will have to be made to my original existing conditions reports. A more precise energy analysis and annual energy cost analysis will have to be performed so that when the new system is examined there is a good benchmark to compare it to. This will be done using a program called Equest. Due to the lack of knowledge and problems that occurred using Trane Trace a new route is to be taken with hopes of better results. Certain breadth topics will have to be examined with a lot of help from outside sources and consultants due to my lack of knowledge of the subject matter. One item that might present itself to be cumbersome is the geological assessment. Since no such test was performed on the site, and no test will be performed, an estimation or assumption might have to be made based off of surrounding area characteristics. Hopefully with new data, an increasing understanding of the system, and help from knowledgeable professionals a thorough analysis can be made for the use of a geothermal heat pump system in the Longwood at Oakmont Healthcare Center.

REFERENCES

The following sources were and will be used to help aid in the research of geothermal heat pump systems. Further sources will probably used in the development of this thesis project.

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