Thesis Proposal

Blake Herrschaft
Mechanical Option
The Waverly on Lake Eola
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Executive Summary

The purpose of this report is to propose a redesign of the mechanical system used in The Waverly on Lake Eola. The building is a 317,000 square foot luxury condominium high-rise in Orlando, Florida. Work on redesigning the system will take place throughout the spring semester as my fifth-year design project.

The current system was analyzed in previous technical assignments and some of the information from these reports can be found in the following proposal. After researching the existing system, a variety of alternative solutions were looked at. These solutions included renewable energy technologies such as a surface water heat pump system, and use of photovoltaic cells. The idea of combined heat and power as a way to save energy costs not only on heating, but also on electricity was researched as well. These ideas were found to be unsatisfactory for The Waverly based on location and monetary constraints.

Over the course of the next semester I will propose a design using a desiccant wheel with heat recovery. The original design will be tweaked so that the desiccant wheel could be added with minimal first cost to the developer. The Waverly on Lake Eola had serious potential to be designed with LEED certification in mind. During the redesign process aspects of the building that could have been made to meet LEED standards will be analyzed, and interpreted. The redesigned Waverly will be able to gain LEED certification, however the costs of this process must be analyzed during the next semester in order to study the feasibility.

Improvements that can be made on The Waverly's other systems are important. During the redesign process possible improvements to the original construction process with relation to LEED certification and cost analysis will be researched. Since the desiccant wheel will require extra mechanical room space on the roof of the 19th floor, the structural stability must be analyzed to determine cost and feasibility issues involved with additional rooftop mechanical facilities.

System Background

Design Objectives and Requirements

The Waverly on Lake Eola is a high-rise luxury condominium facility located on beautiful Lake Eola in downtown Orlando, Florida. This 23 story building is designed to provide luxury lifestyle amenities to its tenants and has a total floor area of approximately 371,000 square feet. Views of the lake and downtown Orlando were important in design, and Graham Gund Architects came up with a curved design that maximizes panoramic views of the city.

Floor to ceiling windows throughout the building, while providing gorgeous views of the surrounding area, created a load issue for the mechanical designer of the project, GRG. The developer also requested 100% outdoor air supply to maintain a maximum air quality supply for the tenants of the building.

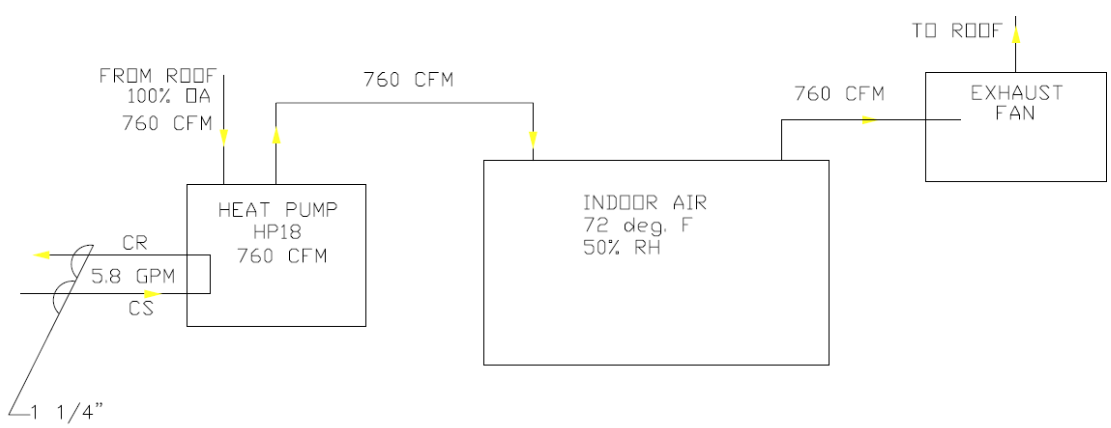
Since the condominiums are sold off to tenants by the developer, first cost of the mechanical system was a primary concern. While first cost is important, a good mechanical designer would prefer the opportunity to design based on life cycle cost, energy efficiency, and environmental impact. This, however, is not the case with The Waverly and had to be taken into account.

GRG utilized a system consisting of different water source heat pumps for each condominium to condition the spaces. Spaces are to be maintained at approximately 72 ºF and 50% RH. With the hot and humid climate of Orlando, this creates a large cooling load for the building. All these factors must be taken into account when designing the mechanical systems for the Waverly.

Basic System Operation

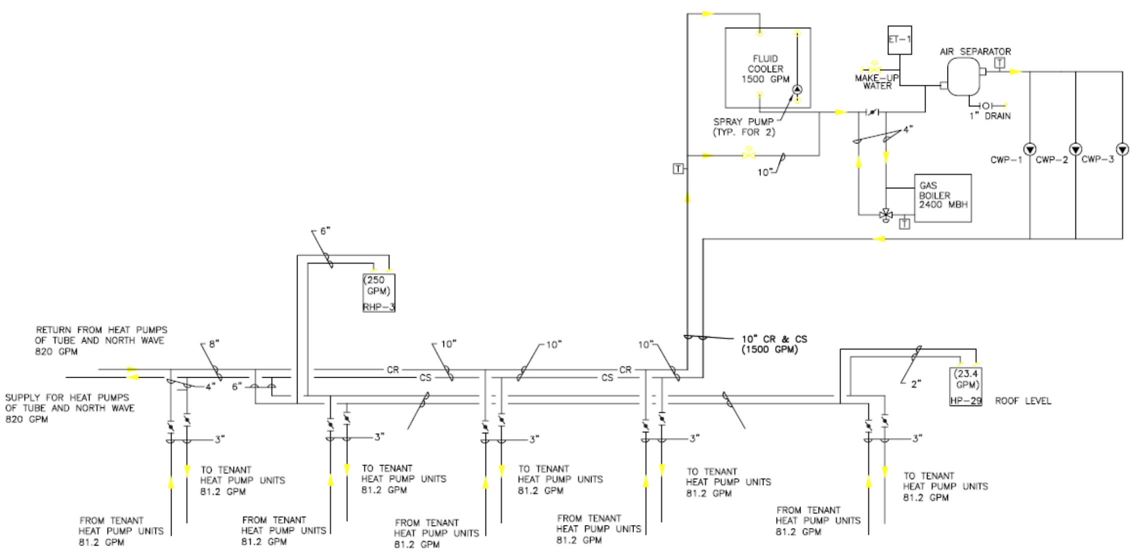
Water source heat pumps provide the primary heating and cooling of conditioned spaces throughout The Waverly on Lake Eola. Each condominium is serviced by at least one private heat pump servicing only that unit. Three rooftop heat pumps service the public and shared spaces of the building. This includes the gym facilities, lobbies, conference rooms, public restrooms, and other lifestyle amenities areas available for use by the tenants.

Tenant spaces account for the majority of the building layout, and basic operation of tenant heat pumps will be discussed first. Each water source heat pump is located in a mechanical room next to the unit. 100% outdoor air is supplied to the heat pump from a duct extending vertically to the roof. Cold water supplied from the rooftop closed circuit fluid cooler works with the heat pump to cool and dehumidify the outdoor air. The air is then heated by the heat pump and supplied to the space at conditioned temperatures. Cold return water is pumped back to the rooftop fluid cooler. A negative pressurization in the main part of the condominium creates an airflow taking the air towards exhaust ducts located in the hallway, kitchens, and bathrooms. Air exhausted from the space is brought to a vertical exhaust shaft and exhausted out the roof. The volumetric flow rates of air through these systems range from 460 to 3340 CFM. A flow chart for the heat pump for a 19th floor two bedroom, two bath unit is show below.



Rooftop heat pumps are used to condition the common areas throughout the building. The basic operation is the same as heat pumps located throughout the building with some minor differences. The rooftop location allows these heat pumps to be supplied directly from the outside without vertical supply ducts. Conditioned air is then supplied to the spaces below through vertical supply ductwork. All other parts of the operation are the same as listed above; accept this is on a much larger scale ranging from 4830 to 9250 CFM. The cold water supply to RHP-3 is displayed on the cdw flow chart shown below.

The cold water supply for the water source heat pumps both on the roof and throughout the building is crucial to the design. All pumps are supplied with water from one closed circuit fluid cooler located on the roof. This EVAPCO fluid cooler is capable of cooling 1500 GPM of return water. The water is supplied to the cooler from the return line coming from heat pump units. After cooling and condensing the water is temperature tested and can be mixed with water from the atmospheric boiler to heat if necessary. An AMTROL expansion tank is located at this point to maintain safe pressures so that equipment is not damaged. Next, a Bell & Gossett air separator is utilized to remove air bubbles from the supply water to ensure maximum efficiency. Cold water pumps then pump the water to heat pump units throughout the building. Cold water returns after it is used by the heat pumps to cool and dehumidify the outdoor air. A portion of the cdws system is shown in the flow chart below.



Potential Redesign

Upon attempting a redesign of the existing system for The Waverly on Lake Eola, many energy-saving solutions must be considered. Assessing a problem and its possible solutions is an essential first step in the engineering process. There were many possibilities for redesign on The Waverly's systems, however, only a few of these will be applicable for the springs design project.

Considered Alternatives

Next semester I will be taking a Co-generation class with the distinguished Dr. James Freihaut. As this class will be taking place during my senior design, I first considered the possibility of using combined heat and power on the building. When power is created by the local utility companies it is sent into the grid and distributed via high voltage cables to buildings and localized demand sites. As the electricity flows through miles of wire, approximately 50% of the energy will be lost due to wire resistance.

A building utilizing cogeneration makes electricity on-site, which means much less energy is lost due to transmission. The heat generated during the process of burning fuel to make electricity can then be used to help with heating the building. Recent applications of combined heat and power have proven both efficient and innovative. The Waverly is located in Orlando, FL meaning the system is primarily used for cooling. This makes the idea of heat recovery less than ideal for this specific application. Also, the extra cost and maintenance required in generating on-site electricity is not ideal in the case of residential development.

The idea of using solar power is always promising from the onset. Photovoltaic cells are probably the most well known renewable technology for use in the building industry, while solar hot water heating technologies have been practically applied for years. However, the use of active solar technologies on such a large residential building would prove an expensive first cost, with limited benefits for the life of the building.

The location of The Waverly directly on Lake Eola creates interesting cooling situations. A surface water heat pump system using the cooler temperatures of Lake Eola has the potential to produce high energy savings with low first cost using relatively simple technologies. This entails pumping water from the lake and using a heat exchanger to cool the cold water supply. This could mean being able to purchase a smaller closed circuit fluid cooler, and savings on water cooling throughout the life of the building. It will be difficult to find accurate annual water temperature data for Lake Eola. The lake most likely does not stay cold enough during the summer to create a worthwhile temperature difference for heat exchange. Also, the system could potentially alter the local ecosystem by raising the temperature of the lake.

Proposed Redesign

Scope:

The Waverly at Lake Eola uses 100% outdoor air for superior air quality. While this creates an ideal living environment, using 100% outdoor air creates an enormous load for the building's mechanical systems. The floor to ceiling windows throughout The Waverly also add to the large load on the mechanical system.

While not built with LEED certification in mind, I consider green design an important goal in today's world of depleting energy supplies and deteriorating environmental conditions. I will attempt to redesign The Waverly focusing on a decreased mechanical design load and meeting enough criteria to gain potential LEED certification. This will need to be done while maintaining a low building cost, and also maintaining the luxurious environment provided by excellent air quality in all spaces.

Most likely to cut down on first cost, The Waverly on Lake Eola's mechanical system was designed with no heat recovery in mind. Typically outdoor air is mixed with return air from spaces to minimize loads on the air handling units. Since The Waverly uses 100% outdoor air, a different system was designed which is outlined in previous sections of this report.

I will attempt to use a periodic type heat exchanger in order to use the already conditioned exhaust air to help cool or heat the incoming outdoor air depending on what the weather conditions require. This should provide substantial reduction of heating and cooling loads throughout the life of the building. The initial cost and payback period of the heat recovery system will be examined using Carrier's Hourly Analysis Program (HAP) and comparing the data with existing conditions calculated in Technical Report 2. A redesign of the ductwork for the exhaust systems will provide supply for the multiple heat exchangers that are required for this design.

The hot and humid climate of the Orlando area makes it an ideal candidate for the use of a desiccant enthalpy wheel. This will be used in conjunction with the heat exchangers already discussed. A wheel covered in desiccant will be used to absorb moisture from the supply air before conditioning to bring the relative humidity to acceptable levels for supplying a space. The moisture will then be absorbed by the exhaust air and expelled from the building. Since air needs to be supplied at 50% relative humidity, this wheel should significantly reduce the load created by the necessity to reduce the humidity of the outdoor air. Again calculations will need to be performed using HAP and comparisons to data found in technical assignment 2. Since the ductwork already is being redesigned for the heat recovery system, the only new costs produced by the desiccant wheel will be the equipment itself.

Justification:

The proposed redesign will provide a glimpse at experience of advanced HVAC design systems. By keeping the initial costs down and providing a payback period analysis, this system should help to prove that advanced, environmentally friendly designs are not only beneficial, but attainable. Providing technically sound and advanced engineering should be industry standard at this point. Hopefully knowledge learned during the next semester's analysis of The Waverly will culminate in the knowledge that I can use my education to have a positive impact on the world around me.

Integration and Coordination

The redesign of exhaust ductwork should prove relatively easy. Deciding where to put the desiccant wheels with heat recovery may affect other aspects of the building. Since there is not more space available in the building to place new mechanical equipment, a new mechanical room on the roof of the 19th floor may be required. This will mean checking the structural stability of the current structure against the new loads that must be considered. During my years of education as an Architectural Engineer I have learned that all aspects of the building must be taken into account as early in the design process as possible. Making sure to account for all possible problems at the beginning of the redesign process should ensure a smooth design process for the remaining term of my career at The Pennsylvania State University.

Breadth Work

Since mechanical rooms will need to be added to the roof of The Waverly on Lake Eola, an analysis of the current structural system is an obvious choice for a breadth design topic. Testing the feasibility of the current system to carry additional loads versus the added costs of additional concrete structure will be a critical design analysis.

I will also attempt to do a cost analysis on the construction methods used in building The Waverly. Since there are many LEED construction criteria that could have easily been met during the construction phase, it will be interesting to look into the added costs affiliated with sustainable design. I will focus on any unnecessary costs of construction that occurred during the building of The Waverly.

Project Schedule

January 9th - 15th

Return to campus and begin last semester of classes. Speak with consultants about issues concerning proposed system.

January 16th - 31st

Research Desiccant wheel with heat exchange system. Also research all other applicable technologies for thesis work

February 1st – 3rd

Discuss breadth topics with consultants from corresponding options

February 6th – March 4th

Begin preparing thesis report using in-depth research gained in January. Work on both mechanical option redesign and breadth areas.

March 5th – 9th

Visit site in Orlando over spring break. Study local Lake Eola water temperatures and any unknown aspects of The Waverly.

March 10th – 24th

Continue and complete thesis redesign report

March 27th – April 4th

Put finishing touches on thesis redesign report and begin preparations for thesis presentation

April 5th

Submit report

April 6th – 10th

Complete preparations for thesis presentation

April 10th – 12th

Present findings on thesis redesign project in front panel of faculty and peers.

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