Thesis Proposal

First Revision

The Salvation Army Ray & Joan Kroc Corps Community Center of Salem Oregon

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Mechanical Option
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Table of Contents

Executive Summary

The current mechanical system meets the heating and cooling loads of the building and even uses some energy saving technologies; but an alternative system could potentially save even more energy. That is why I am proposing that the entire current mechanical system be replaced. Ground source heat pumps will replace the natural gas boilers, and a DOAS system will provide all of the ventilation for the building.

Three natural gas boilers supply hot water to the two pools in the building and the two large air handlers. Smaller gas burners are located in the other air handlers. The ground source heat pumps will provide heating and cooling for all of the air handlers, and hopefully provide the hot water for the pools as well. Large athletic fields that surround the building provide adequate space for the wells to be drilled. The ground source heat pumps will reduce energy costs, emissions, and lengthen the life of the system.

A dedicated outdoor air system (DOAS) will be used to supply the proper ventilation to the spaces in the building. Energy recovery units will be put on the ventilation equipment to help conserve energy. Because the ventilation will now be handled by the DOAS, the current air handlers will all be oversized, so they will be resized and combined to simplify the mechanical system. The DOAS system will reduce energy usage and provide a better indoor environment.

For the first breadth study, a new electrical system will be sized and laid out in the building. Because the entire mechanical system is being replaced, the electrical requirements for the building will change. New equipment loads will be calculated, proper voltages will be determined, and the wires will be sized according to the National Electric Code.

A structural analysis will make up the second breadth of the thesis project. The new mechanical equipment will replace the current mechanical equipment which is located on the roof. The new equipment loads will be used to calculate proper structural member sizes; each current structural member will be evaluated and resized when necessary. This will create a new structural system capable of handling the new loads.

Once all of the changes are made, an analysis will be performed to determine whether the changes to the mechanical system are beneficial. The difference in initial cost and the changes in annual energy usage will be calculated.

Existing System Description

Fourteen packaged rooftop units supply the majority of air to the Kroc Center. The pieces of equipment and the areas of the building that they serve are summarized in Table 1 below. Also including in the chart are the scheduled heating and cooling loads given in the design documents.

Unit	Areas Served	Scheduled (MBH)	
		Heating	Cooling
AHU-1	Competition Pool	922	802.8
AHU-2	Leisure Pool	737	609.6
FCU-1	Platform - North	46.1	63.1
FCU-2	Platform - South	46.1	63.1
RTU-1	North Office Wing	697	763
RTU-2	Office Wing	284	208
RTU-3	Chapel	410	240
RTU-4	Climbing Wall	284	192
RTU-5	Gym - North	284	202
RTU-6	Gym - South	284	202
RTU-7	Aerobics Room	104	60
RTU-8	Fitness Center	324	265
RTU-9	Wet Multi-Purpose Room	120	79
RTU-10	Locker Rooms	202	119

TABLE 1 – Major Equipment Summary

AHU-1 and AHU-2

The two large air handlers condition the competition pool and leisure pools respectively. Though slightly different sizes, the two units operate the exact same way. First, the return air from the building is pulled by the return fan into the air handling unit and through a sound trap. A fraction of the return air is exhausted and passes through a heat exchanger to help precondition the entering outside air. The outside air and remainder of the return air mix and pass through the cooling and heating coils. The cooling coil is a DX system with the compressor, evaporator, and expansion valve housed in the air handling unit. The heating coil uses hot water supplied from the boilers in the mechanical room to heat the air. After passing through the coils, the supply air flows through a filter and into the supply fan. The supply fan sends the air through another sound trap before it leaves the unit. The supply air then travels through the supply air ducts and is distributed into the space. Figure 1 below is a simple schematic of the two large air handling units.

Rooftop Units

There are ten packaged rooftop units that supply air to the remainder of the spaces in the Kroc Center. The RTU's are very similar with only small differences between them; so only a typical RTU will be explained. All of the rooftop units have economizers that can use more outside air to condition the space when the outside air is in the desired temperature range. The economizers are capable of producing up to 100 percent outside air. The return air enters the air handler from the bottom of the unit and passes through a sound trap before entering the economizer section of the unit. Once the correct mixture of return and outside air is achieved, the air passes through the cooling coil and the heat exchanger. The cooling coil is a DX unit, the same as what is in AHU-1 and AHU-2. The rooftop units, however, use a heat exchanger instead of a heating coil. A small natural gas burner is located in the unit which heats air that passes through the heat exchanger and conditions the supply air. After passing through the heat exchanger, the air flows through a filter, supply fan, and sound trap before leaving the unit. RTU-1, RTU-2, and RTU-10 have variable frequency drives (VFDs) on the supply fans, because the loads they condition can fluctuate greatly throughout a day. The supply air from these three units passes through VAV boxes with reheat coils before entering the spaces they are conditioning. The other rooftop units have constant speed fans and do not use VAV boxes.

Fan Coil Units

Two small fan coil units supply air to the stage area of the chapel. The fan coil units use outdoor heat pumps to supply the heating and cooling necessary to condition the space. The FCU's are constant volume systems and do not have economizers. The space they condition is connected to the chapel, so the air handling unit that conditions the chapel can vary its supply air to properly condition that entire section of the building. The fan coil units and the outdoor heat pumps are mounted on the stage roof.

Hot Water Distribution

Three natural gas boilers are located in the mechanical room on the southern side of the Kroc Center. These boilers supply hot water to AHU-1, AHU-2, and the heat exchangers that heat the two pools. Smaller boilers are located in the building to provide domestic hot water, but they will not be analyzed in the report.

Proposed System Description

As mentioned above, the current system satisfies the building loads and takes steps to conserve energy, but there is still room for improvement. The mechanical system will be completely redesigned, focusing on three key changes. First, the natural gas boilers will be replaces with ground source heat pumps. Second, a dedicated outdoor air system will be installed to provide better ventilation control and higher energy savings. Because the outdoor air will be conditioned separately, the current air handlers will be consolidated to reduce expenses.

Ground Source Heat Pumps

Ground source heat pumps will replace the three natural gas boilers in the mechanical room. The heat pumps work by rejecting heat into the earth during the cooling season and collecting heat from the earth during the heating season. The new heat pumps will supply hot and cold water to all of the air handling units. One item that will require more study is whether or not the heat pumps will be able to condition the water for the two pools. Using the ground source heat pumps will reduce energy costs, eliminate all natural gas usage thereby lower emissions, and lengthen the life of the entire mechanical system. The Salvation Army owns athletic fields that surround the Kroc Center which will provide an excellent place for the wells to be drilled for this system.

Dedicated Outdoor Air System

In an effort to further reduce energy usage, a dedicated outdoor air system (DOAS) will be installed. In a DOAS system the outdoor air is not conditioned to meet the building loads; it is conditioned to meet room neutral conditions. This will save a significant amount of energy. Also, the outdoor air units will contain energy recovery units to take energy from the exhaust air and precondition the incoming outdoor air. A DOAS system is more expensive to install and will require extra ductwork but should save a significant amount of energy throughout the life of the building. The DOAS system will provide more accurate and flexible ventilation control by supplying outside air based on the current occupancy. This system will eliminate some wasted energy and provide a healthier indoor environment. Figure 1 contains a quick sketch of the DOAS layout and shows which areas of the building each unit will serve. The DOAS units are labeled as Energy Recovery Ventilators or ERVs.

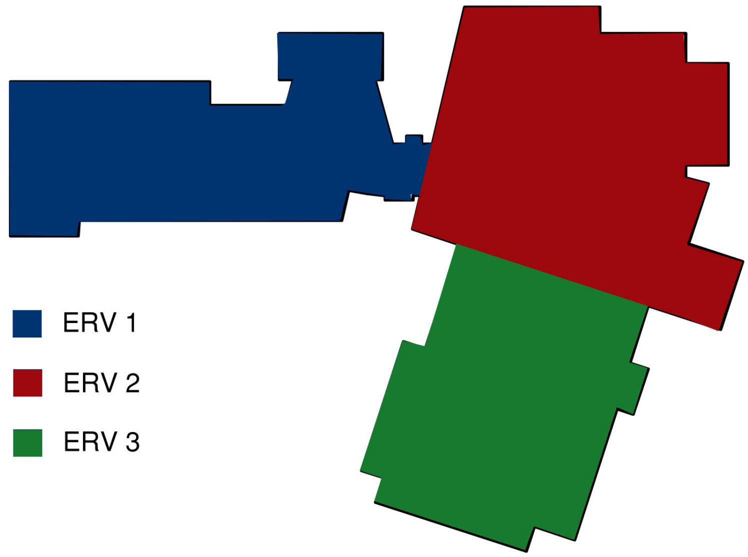

Figure 1 – Preliminary DOAS Layout

Air Handler Consolidation

Because all of the outdoor air requirements will be handled by the DOAS system, the current air handlers will need to be resized so they will more closely satisfy the lower building loads. Taking advantage of the resizing, the current mechanical system will be consolidated to use fewer units. Fewer units will simplify the system and hopefully save on initial cost. Figure 2 below shows the approximate locations each of the new air handlers will condition. This plan will reduce the number of major air handlers from fourteen to seven.

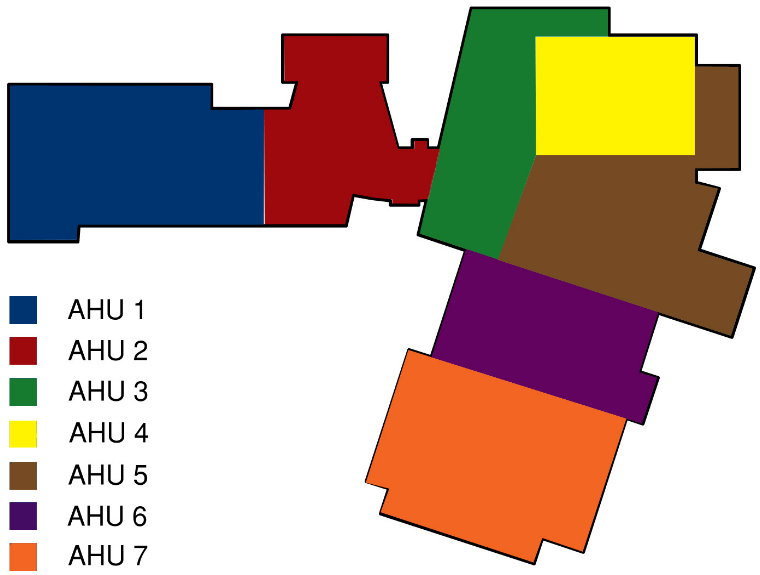

Figure 2 – Preliminary AHU Layout

Breadth Topics

Electrical Breath

The changes in the mechanical system will require completely new air handling units, energy recovery units, and pumps for the heat pumps. This equipment has very different electrical requirements than the current equipment so the entire electrical system will be resized. New electrical loads will be tallied and all of the new wires will be sized according to the National Electric Code (NEC). The electrical voltages at different parts in the building will be determined based on equipment needs and wire cost. All of these steps will be used to create an efficient electrical system.

Structural Breadth

All of the new mechanical equipment will be located on the roof of the building where the current mechanical equipment is located. In the new design, new pieces of equipment and fewer amounts of equipment will be located above different parts of the building. As a result most of the structural system will need resized. Some parts of the building will require more support, while some parts will allow for some support to be removed. Hopefully the total cost for the structural differences will be insignificant. The current structural system will be retained, but all of the individual members will be evaluated and resized when necessary.

Tools and Methods

To accomplish the redesign and analysis of the new mechanical system, revised building loads will be performed in Trane Trace. Because the ventilation will be handled exclusively by the DOAS, the building loads will need to be revised for each room. The new energy usage values will be calculated by Trace as well. To determine the new ventilation requirements, ASHRAE Standard 62.1 will be consulted and the loads will be calculated in Excel. The National Electric Code (NEC) will be used to resize the wires and panel boards in the new electrical layout. Excerpts of the Steel Manual will be used to resize the structural members of the Kroc Center.

Preliminary Research

“International Ground Source Heat Pump Association.” 2011. Web.
<http://www.igshpa.okstate.edu>

> This website provides information on how ground source heat pumps operate and the benefits that they provide for commercial or residential buildings. The website also contains a page with a number of links that can provide further information on the topic.

“Geothermal – the energy under our feet.” National Renewable Energy Laboratory.
Green, Bruce and Nix, Gerry. Nov 2006. Web.
<http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf>

> In this article published by the National Renewable Energy Laboratory talks about the advantages available with all geothermal applications including ground source heat pumps.

“Smart Dedicated Outdoor Air Systems.” ASHRAE. Murphy, John. July 2006. Web.
<http://www.trane.com/commercial/uploads/newsroom/July06ASHRAE11Rev.pdf>

> This article provides advice and tools to help optimize dedicated outdoor air units to save as much energy as possible. Dedicated outdoor air systems reduce energy usage, ensure adequate ventilation, and provide superior humidity control compared to traditional systems.

Thesis Project Schedule