

Thesis Proposal



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

Mathias Kehoe
Mechanical Option
Advisor: Stephen Treado
December 9, 2011

Table of Contents

<i>Executive Summary</i>	3
<i>Existing System Description</i>	4
<i>Proposed System Description</i>	
Ground Source Heat Pumps	6
Dedicated Outdoor Air System	6
Air Handler Consolidation	7
<i>Breadth Topics</i>	
Electrical Breadth	8
Structural Breadth	8
<i>Tools and Methods</i>	8
<i>Preliminary Research</i>	9
<i>Proposed Thesis Schedule</i>	10

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.

A dedicated outdoor air system 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 save energy. Because the ventilation will now be handled by the DOAS, the current air handlers will all be oversized. They will be resized and combined to simplify the mechanical system.

Because the entire mechanical system is being replaced, the electrical requirements for the building will change. For one of the breadth studies, a new electrical system will be sized and laid out in the building.

All of the new mechanical equipment will be placed on the roof, where the current mechanical equipment is already located. Because different size units and different amounts of equipment will be placed on the roof, the structural system will be reduced or increased as necessary. The structural analysis will make up the second breadth of the thesis project.

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 replaced 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 be installed to replace the 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 heat pumps will supply water at the correct temperature to all of the air handling units. An item that will require more study is whether or not the heat pumps will be able to condition the water for the two pools. The goal of using the ground source heat pumps is to completely remove the need for natural gas in the Kroc Center. The Kroc Center is surrounded by athletic fields which are owned by the Salvation Army and 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 does not have to meet the building loads; it only needs to be conditioned to 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. 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.

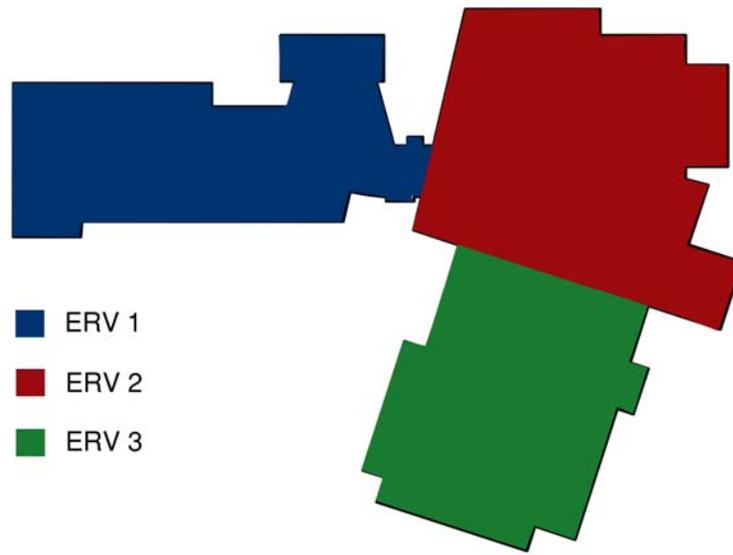


Figure 1 – Preliminary DOAS Layout

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.

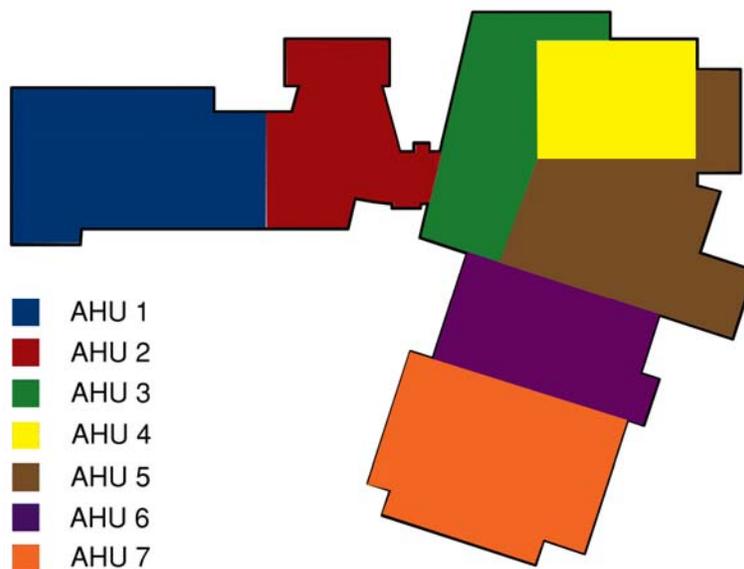


Figure 2 – Preliminary AHU Layout

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 wires will be installed to accommodate the changing requirements and the total change in electrical installation and operation cost will be determined.

Structural Breadth

All of the new mechanical equipment will be located on the roof of the building. The current mechanical equipment is also located on the roof of the building. In the new design, different pieces of equipment and different amounts of equipment will be located above different parts of the building, much 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; however, a new structural system must still be designed to insure that the building can support the new equipment.

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>>

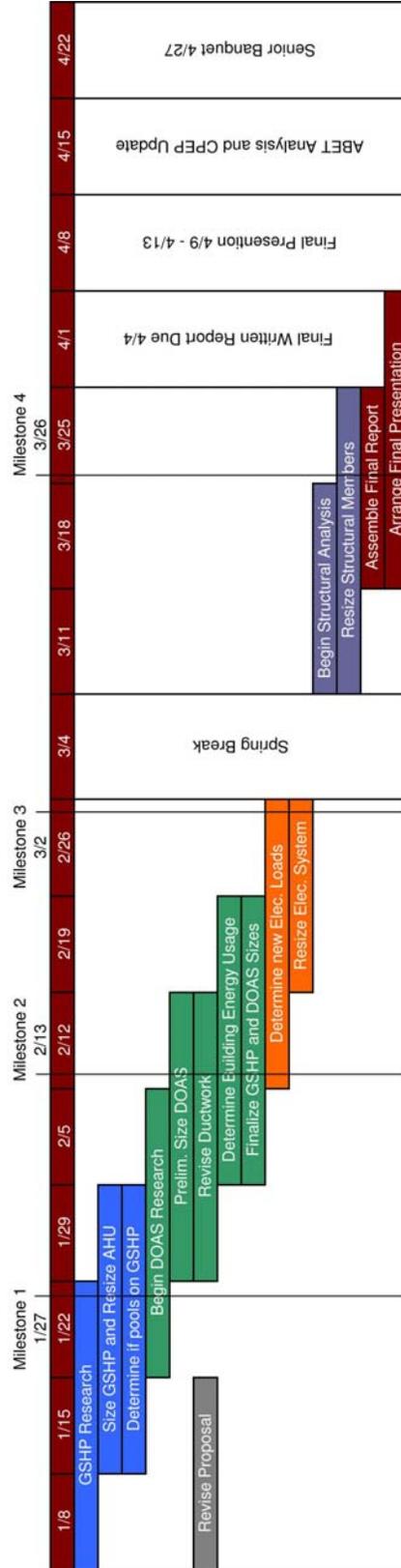
In this article published by the National Renewable Energy Laboratory talks about the advantages available with all geothermal applications including ground source heat pumps.

“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

Proposed Spring Semester Schedule
January 9, 2011 - April 27, 2011



Milestones	
1	Preliminary Sizing of GSHP
2	GSHP design complete, preliminary DOAS sizing
3	DOAS system completed, electrical breadth 95% completed
4	Structural breadth 95% completed

Depth 1 - Ground Source Heat Pumps
Depth 2 - Dedicated Outdoor Air System
Breadth 1 - Electrical Redesign
Breadth 2 - Structural Redesign
Final Report and Presentation

Ray & Joan Kroc Corp Community Center
Mathias Kehoe
Mechanical Option
Advisor: Stephen Treado