**AE 482 Mechanical Project Proposal**

**McKinstry Oregon Headquarters**

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**Prepared for**

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**1 Executive Summary**

The proposed redesign for the McKinstry Oregon Headquarters will be a Dedicated Outdoor Air System with radiant heating and cooling. A schematic is shown in Section 4. The thesis will also include 2 breadth topics: Lighting and Construction or Acoustics.

The new system will hopefully lower first cost of construction as well as reduce energy usage, saving annual operating expenses. Other advantages include better air quality and humidity control. With better air quality, workers will hopefully be more productive, which is a good selling point to owners and tenants. See Section 5 for full details.

Section 6 describes issues with integration and coordination. If a fully radiant heating/cooling system cannot meet the loads in the building, a second air handling system may need to be added to account for the loads. This would cause several issues, namely space coordination at the ceiling.

To prove the benefits of the DOAS system, I will use an eQUEST energy model to compare energy usage. Also, costs of ductwork, AHU, pumps, and pipes will be compared from manufacturer costs. Air quality and humidity control also needs to be addressed. Details can be found in Section 7.

Finally, a full semester work plan is laid out in Section 9.

**2 Existing Mechanical System**

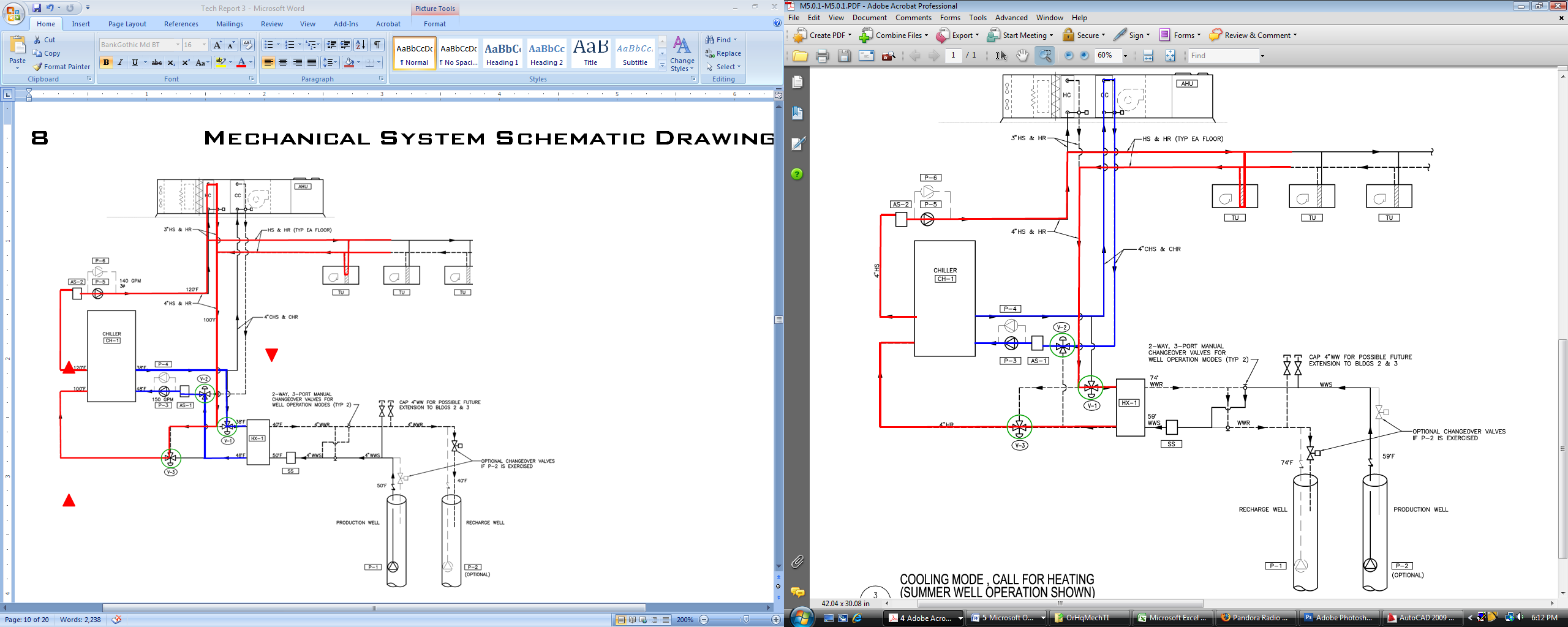
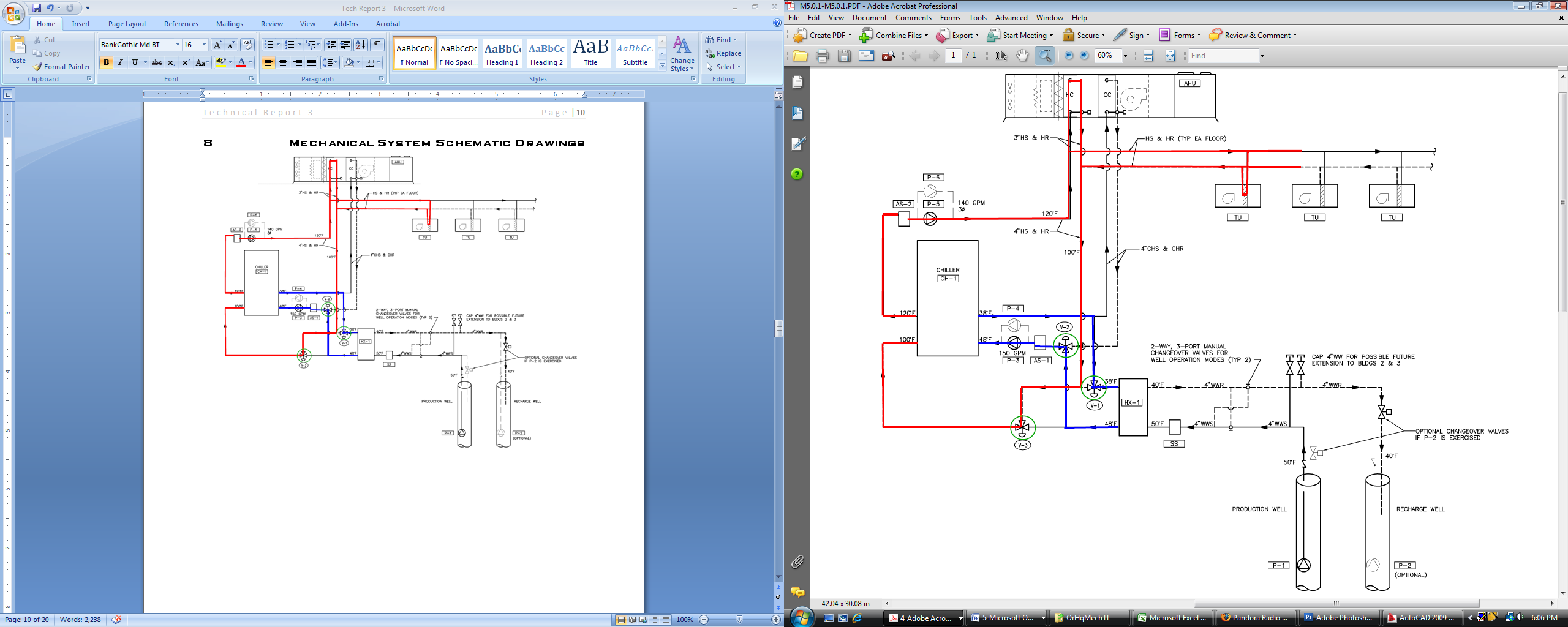
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Figure 2.1. Water Side System in Heating Mode

Figure 2.2. Water Side System in Cooling Mode

**Note position of  
 3-way valves**

**Air Side System:**

A single rooftop AHU (with VFD) distributes air via a medium velocity duct system to the office section of the building. There are no drop ceilings in the offices, as to expose the duct work. Thus there is no plenum and square diffusers distribute air from the ceiling. Series VAV boxes with hot water reheats are located throughout the office. Return air is also ducted.

**Water Side System**:  
**Cooling Mode**  
with Hot Water Reheat

**Water Side System**:  
**Heating Mode**  
with Airside Economizer

**3 Alternatives Considered**

Over the past semester, I have been studying and learning about the McKinstry Oregon Headquarters Building, and trying to find alternative ways to approach the mechanical system in the building. The system, while fairly efficient already, especially the water-side of the mechanical system is a fairly efficient (although expensive) system. While researching this semester, I came up with two possible alternatives for the mechanical system.

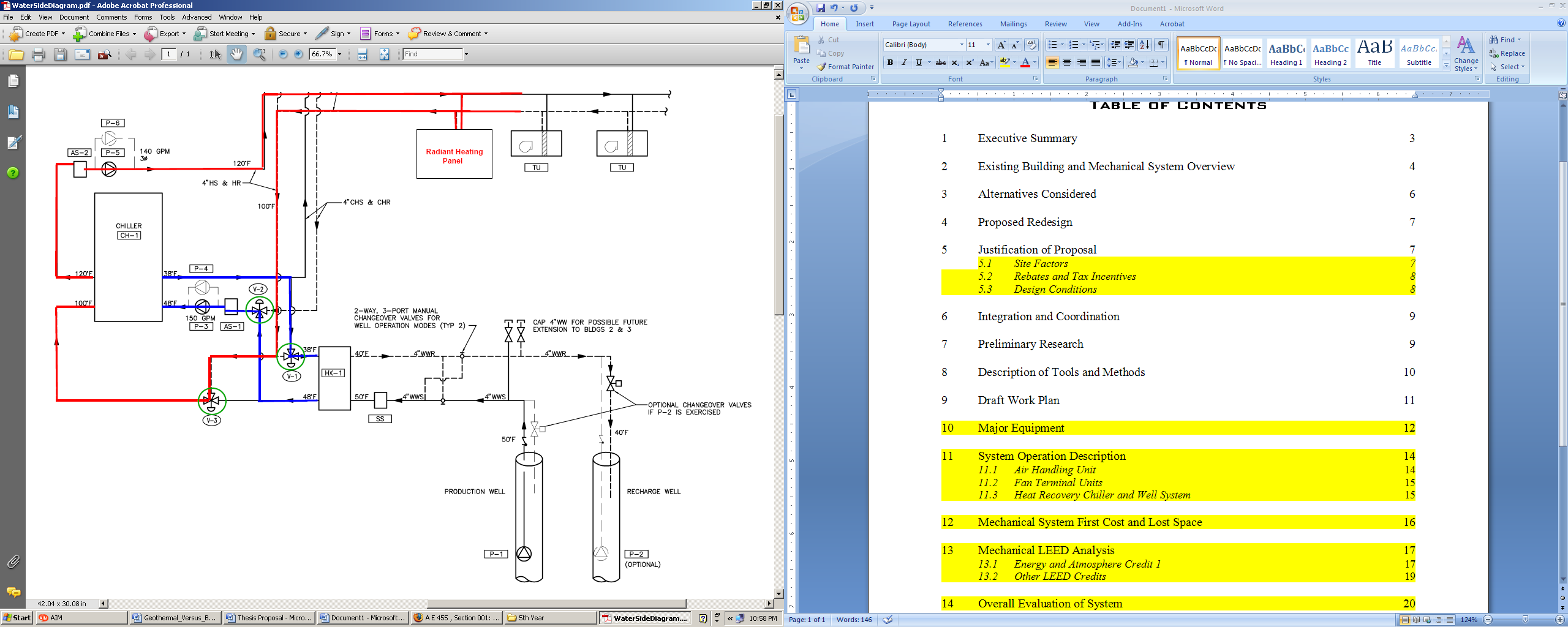
I originally was interested in doing a combined heat and power system. I first learned about the idea in Jim Freihaut’s AE 454 class during the Fall 2007 semester. While teaching the system, Freihaut mentioned the big issue with the system is storing energy. During a typical day, heat and electricity usage peak at different times. An efficient energy or electricity storage would be needed to make combined heat and power useful on a small scale. Then over the summer I ran into an article about fuel cells (Wald). If hydrolysis can be performed on a small scale at a low temperature, it could be ideal for energy storage in buildings.

The other consideration is Dedicated Outdoor Air System. According to the article, *HVAC: Dedicated Outdoor Air Systems* (MGOE), DOAS can typically save up to 12% in space cooling and 20% in space heating. DOAS would be beneficial to the Headquarters because most of the building is office space, which requires a relatively low ventilation rate. However, there are several conference rooms which require a much higher ventilation rate per square foot (Wyczalkowski). A DOAS system allows much more precise outdoor air control to each space.

**4 Proposed Redesign**

The proposed redesign will be a Dedicated Outdoor Air System. In addition to the advantages mentioned in Section 3, DOAS also can work well in humid climates. Portland, OR has a very humid climate for most of the year with the exception of several summer months (Appendix A).

Going along with the DOAS will have to be a separate system to address the heating and cooling loads. Possible options are separate VAV system, Radiant Cooling/Heating, and underfloor system. I would like to use these systems in conjunction with the existing ground source heat pump and heat recovery chiller. The following figure shows the redesigned waterside system using Radiant Cooling/Heating Panels. Note that the waterside system is separated from the rooftop HVAC unit.

  
Figure 4.1. Proposed waterside system shown in heating mode.

In this configuration, heating and cooling loads would be met by the radiant panels. The rooftop Air Handling Unit would be there to serve 100% OA to the building. A Heat/Enthalpy wheel would condition air so only a small load (or possibly none) would need to be met by the rooftop unit. This load would be met by small coils in the AHU or perhaps a DX unit.

In addition, I plan on doing a lighting breadth for this Thesis. Since the largest load on my building is lighting, I plan on trying to reduce this load as much as possible.

**5 Justification of Proposal**

Using a Dedicated Outdoor Air System has several advantages in an office space similar to the McKinstry Oregon Headquarters, namely energy usage and equipment size. This would reduce both first cost and operating cost. Comfort and air quality would also increase.

By using the DOAS, ventilation air is totally separate from heating and cooling loads. This is advantageous for several reasons. First, this requires less air to be moved by the Air Handling Unit. That will reduce the size of the fans in the AHU, as well as all the duct work throughout the building. The addition of a heat recovery device can eliminate 80%-90% of the load associated with bringing in outside air.

Each space can receive more precisely the amount of outdoor air it needs to maintain adequate CO2 levels. This reduces supplying too much outdoor air in some spaces (wasting energy) and not enough in others (poor air quality).

Some of the difficulty of achieving good ventilation performance with a VAV system is that the thermal loads of individual zones do not necessarily vary with the ventilation requirements, so increased total ventilation airflows are required to ensure acceptable zone ventilation at all operating conditions. (John Dieckmann)

In spaces with high occupancies, like conference rooms, low outdoor air rates will cause CO2 levels to rise, which can make workers drowsy. This reduces productivity and can be an additional selling point to owners or tenants.

Since the main latent loads in an office building are from people. So the latent load should in general be proportional to the occupancy. Since a DOAS already supplies air based on occupancy, a DOAS system is a very good way to control humidity in the building.

**6 Integration and Coordination**

The proposed DOAS redesign would have to coordinate with several other systems in the building, namely lighting and anything else that takes up space on the ceiling. If radiant ceiling panels are to be used, they would take up a large percentage of the ceiling space. This would affect the placement and direction (e.g. uplights) of the light fixtures. Also, the aesthetic look of the ceiling panels would have to be considered. With an enthalpy/heat wheel being added to the design, the return fan (and ductwork) would have to be rerouted to the roof near the intake.

If fully radiant heating/cooling is not an option, a separate VAV system may need to be used in parallel with the DOAS system. This would cause more issues with coordination. The amount of ductwork would double, increasing cost and further cramping ceiling space. One of the requirements from the owner was to have the ductwork exposed. With no drop ceiling, a cramped ceiling space may be displeasing. Also, the DOAS system would need to be CAV or VAV. I will look into which one of these options is feasible.

**7 Description of Tools and Methods**

For this thesis, I will claim that my redesign improves the building in several ways, namely first cost and energy savings. Many times, an owner must choose between saving up front and saving on energy in the long run. If a solution can provide both, with no other negative consequences, then it will clearly be a better choice.

To show energy savings, I will have to compare the two systems in an energy simulation. Technical Report II (Wyczalkowski) used an eQUEST model to estimate annual energy usage. The redesigned system will also be simulated in eQUEST. The two models will be compared to find yearly cost savings. One concern is the accuracy of the eQUEST model. In the original energy model, many assumptions were made about the system. Specifically it assumed the groundwater well was a high efficiency cooling tower and the heat-recovery chiller (heating mode) was a 410% efficient boiler. If many other assumptions need to be made in the redesign energy mode, the savings generated may be very inaccurate. A different energy model program such as Trace or HAP may need to be used.

To show a first cost savings, material and equipment costs would have to be obtained from the manufacturers. Specifically, costs of the AHU and ductwork would be compared before and after the design. If a radiant cooling/heating system can account for all the loads, the AHU and ductwork costs should go down. If a parallel VAV system is needed, costs would go up because 2 AHUs and 2 sets of ductwork would be needed. The proposed system would (hopefully) eliminate the series VAV boxes. It would add a large amount of radiant panels. The costs of these two items would need to be compared.

Additional piping may also be an issue. Piping would need to go to each radiant panel instead of just a FTU. More flow may be required as well, increasing pump size. For comparing these costs I am considering doing a construction breadth. If this is not adequate I may also do an Acoustics breadth

Finally, if the ventilation air system will be a VAV system, some control method will need to be devised to accurately count occupancy/CO2 levels.

**8 Draft Work Plan**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| January 2009 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  |  |  | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12  Classes Begin | 13  Update and Review Proposal | 14  Update and Review Proposal | 15  Update and Review Proposal | 16  Update and Review Proposal | 17 |
| 18 | 19  DOAS Research | 20  DOAS Research | 21  DOAS Research | 22  DOAS Research | 23  DOAS Research | 24 |
| 25 | 26  Radiant Panel Research | 27  Radiant Panel Research | 28  Radiant Panel Research | 29  Radiant Panel Research | 30  Radiant Panel Research | 31 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| February 2009 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| 1 | 2  Size Panels | 3  Size Panels | 4  Size Panels | 5  Size Panels | 6  Size Panels | 7 |
| 8 | 9  Lighting Breadth | 10  Lighting Breadth | 11  Lighting Breadth | 12  Lighting Breadth | 13  Lighting Breadth | 14 |
| 15 | 16  Resize AHU and Ductwork | 17  Resize AHU and Ductwork | 18  Resize AHU and Ductwork | 19  Resize AHU and Ductwork | 20  Resize AHU and Ductwork | 21 |
| 22 | 23  Construction/ Acoustics Breadth | 24  Construction/ Acoustics Breadth | 25  Construction/ Acoustics Breadth | 26  Construction/ Acoustics Breadth | 27  Construction/ Acoustics Breadth | 28 |
|  | | | | | | | |
| March 2009 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| 1 | 2  Energy Model | 3  Energy Model | 4  Energy Model | 5  Energy Model | 6  Energy Model | 7  Spring Break |
| 8  Spring Break | 9  Spring Break | 10  Spring Break | 11  Spring Break | 12  Spring Break | 13  Spring Break | 14  Spring Break |
| 15  Spring Break | 16  Fix Calculations | 17  Fix Calculations | 18  Fix Calculations | 19  Fix Calculations | 20  Fix Calculations | 21 |
| 22 | 23  Begin Presentation Design | 24  Begin Presentation Design | 25  Begin Presentation Design | 26  Begin Presentation Design | 27  Begin Presentation Design | 28 |
| 29 | 30  Last Check of Numbers | 31  Last Check of Numbers |  |  |  |  |
| April 2009 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  |  | 1  Put together Report | 2  Put together Report | 3  Put together Report | 4 |
| 5 | 6  Put together Report | 7  Put together Report | 8  Final Summary Report Due | 9  Finish Presentation | 10  Finish Presentation | 11  Finish Presentation |
| 12  Finish Presentation | 13  Presentation Week | 14  Presentation Week | 15  Presentation Week | 16  Presentation Week | 17  Presentation Week | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 |  |  |

**9 Preliminary Research**

**John Dieckmann, Kurt W Roth, James Brodrick. "Emerging Technologies: Dedicated Outdoor Air Systems." ASHRAE (2003): 58-59.**  
This article compares several advantages that DOAS systems offer over conventional VAV systems. It addresses the issue in VAV systems of ventilation rates not matching loads. It also discusses humidity management and how DOAS addresses the issue beter than VAV.

**MGOE. "HVAC: Dedicated Outdoor Air Systems." 2006.**  
This article provides more information about DOAS and the energy savings it can achieve over conventional VAV systems. It also diagrams several different types of DOAS such as separately ducted, dual path, and preconditioning.

**Wald, Matthew L. The New York Times. 1 August 2008. 10 August 2008 <http://www.nytimes.com/2008/08/01/us/01hydrogen.html?\_r=1&ref=environment>.**  
This article from the New York Times addresses a recent breakthrough in fuel cell production. A cheap way to store energy in fuel cells could make combined heat and power economical in small applications.

**Wyczalkowski, Alex. McKinstry Oregon Headquarters: Technical Report I & II. The Pennsylvania State University, 2008.**

**10 Appendix A – Portland Design Conditions**

