Thesis Proposal

HITT Contracting Headquarters
2900 Fairview Park Drive, Falls Church, VA

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Executive Summary

The HITT Contracting Headquarters is a four story, 135,000 square foot office building located next to the Capital Beltway in Falls Church, Virginia. The building consists of a variety of spaces including office space, conference rooms, server space, café space, a fitness center and covered, under building parking.

The mechanical system is comprised of seven VAV direct expansion (DX) rooftop units with electric resistance heating that supply the floors below. Three split systems serve the fitness and café areas. Shutoff and series VAV boxes provide the final stage of heating and supply the air to the individual zones throughout the building. The existing system does an excellent job of meeting the thermal comfort and ventilation requirements, while meeting the base energy efficiency standard of 90.1-2007. This study is intended to develop unrealized designs that can contribute to an increase indoor air quality, energy efficiency and life cycle cost savings without the added constraints of the original project.

The following proposal describes the methods and systems that will be studied for the mechanical redesign of HITT Contracting Headquarters. The mechanical redesign proposal will replace the existing direct expansion rooftop units with a centralized heating and cooling plant that consists of a gas fired chiller-heater and air handling unit.

Two breadth areas will also be investigated in addition to the mechanical depth. The first breadth will be the structural breadth. The addition of a cooling tower and the removal of the seven original rooftop units merit a study of the roof structure. The second breadth area will be the sustainability breadth. The addition of a cooling tower the building system increases the amount of potable domestic water used to cool the building. Since rainfall is between 40-50 inches in the Northern Virginia area, a rainwater harvesting system will be designed and used to provide a portion of the cooling tower makeup water.

The mechanical depth and the breadths will be analyzed using a variety of programs. Trane Trace 700, Microsoft Excel, and Engineering Equation Solver will be used in both the mechanical redesign and breadths of HITT Contracting Headquarters. A timeline is also included as a schedule the workload as evenly as possible throughout the semester and to gauge progress.

Building Design Background

The HITT Contracting Headquarters is a four story, 135,000 square foot office building located next to the Capital Beltway in Falls Church, Virginia. The building consists of a variety of spaces including office space, conference rooms, server space, café space, a fitness center and covered, under building parking. HITT Contracting is a general contractor based in Northern Virginia and their current headquarters is located in Fairfax, Virginia.

The HITT Contracting Headquarters has seven (7) 50 Ton AAON air-cooled VAV DX packaged rooftop units with energy recovery wheels serving the four (4) occupied floors; three above ground and the cellar. The heating is supplied to electric resistance heating coils in each of the VAV rooftop units. Each above ground floor has at total of two (2) units that serve the North and South sections respectively, with one (1) unit serving the cellar level. Series and shut-off Variable-Air-Volume (VAV) terminal units control the final supply temperature and flow to individual zones throughout the building. Three (3) split-system air-conditioning units provide air for loads in fitness and café spaces. All of the systems utilize electricity for operation in both heating and cooling. A Computer Room Air Conditioning (CRAC) unit is located in the server room on the cellar level and utilizes a split system with a condensing unit on the roof.

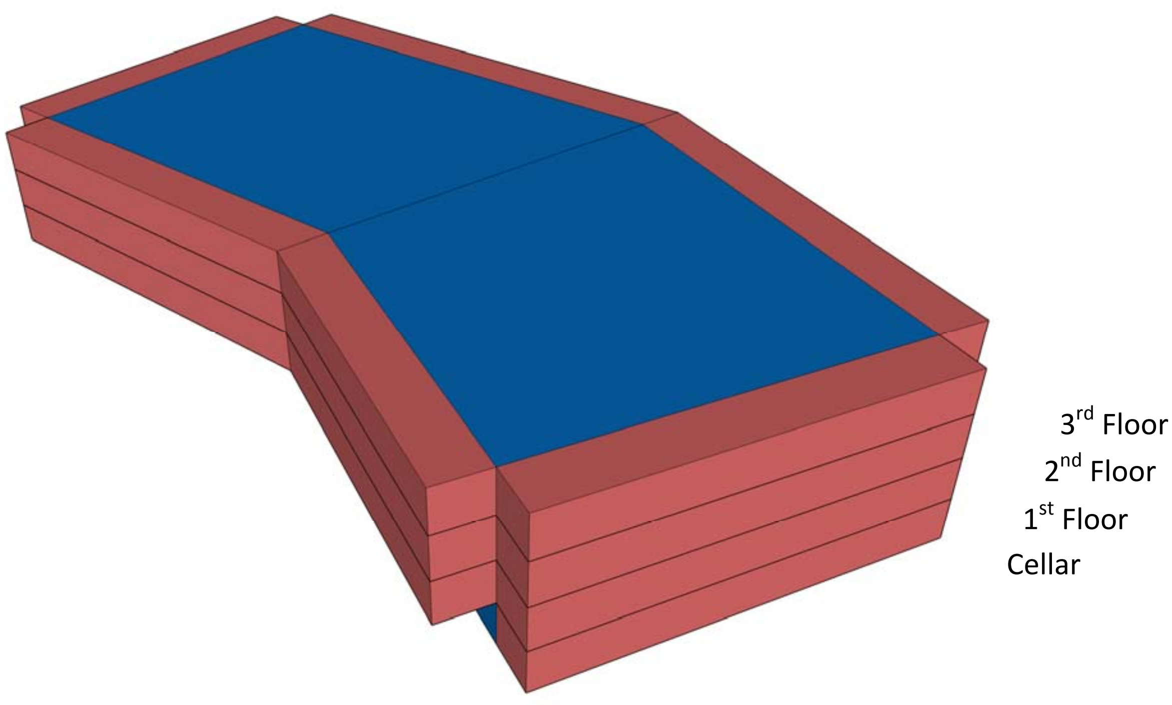


Figure 1 – Zone Layout Schematic – All Floors

Powered Roof Ventilators (PRV) provide exhaust for restroom and locker spaces throughout the building. Additional exhaust for storage and trash rooms is provided by ceiling mounted exhaust fans. Exhaust fans also exist in entry rooms from the parking garage to expel harmful vapors that enter from the parking area.

Proposal Objectives

HITT Contracting Headquarters was designed with the focus on the thermal comfort of occupants, minimal impact on rentable square footage, and meeting the minimal ventilation requirements for occupants. The system, as designed, does a great job of meeting these specifications but an analysis can be performed to expose the benefits options that were unrealized. The building was designed to meet both ASHRAE 90.1-2004 and ASHRAE 62.1-2004, the goal of the new design will be to meet the newer standards of ASHRAE 90.1 and ASHRAE 62.1-2007. The original design of HITT Contracting Headquarters aimed for a LEED silver rating and the modifications to the building systems will be designed as such to maintain this rating.

In summary the main design points are listed below.

- Retain LEED Silver rating
- Meet minimum ventilation requirements
- Provide thermal comfort for occupants
- Minimal impact on rentable square footage
- Energy efficiency

Design Alternatives

Chiller and Boiler Plant

A chiller and boiler plant would centralize the system from the existing DX VAV rooftop units while providing energy savings through its ability to handle peak load throughout the day in the building. The current system has a DX VAV rooftop unit for each side of each floor, peak loads will not occur on both sides of the floor at once, so extra capacity is built into the system. The chiller-heater approach was chosen over the chiller and boiler plant due to the chiller-heater's potential economic lifecycle cost improvement, energy savings potential and other educational reasons.

Radiant Panels and DOAS System

An air side system and DOAS system was considered and would have two separate systems that work to meet the sensible and latent loads in the space respectively. These systems combined could utilize more fan energy than the existing VAV system. The chiller-heater approach was chosen over the air side and DOAS due to the chiller-heater's potential economic lifecycle cost improvement, energy savings potential and other educational reasons.

Proposed Design

The proposed system redesign uses a centralized natural gas absorption chiller-heater to meet the cooling and heating loads of HITT Contracting Headquarters. The heating system would be comprised of a heat exchanger attached to the absorption chiller that uses heat that is not used in the cooling process. This system would reduce the heavy electric load that the building uses in the existing system in electric resistance heating. The absorption chiller will replace the existing direct expansion coils that provided the cooling load in the original design, also shifting electric demand to natural gas.

This chiller-heater system will require the addition of a new air handling unit on the cellar level with the removal of the seven existing rooftop units. A new cooling tower will be required to reject the heat from the absorption chiller. The system will also be used to heat the domestic hot water supply to the spaces, which was previously heated by individual electric water heaters.

The long term flexibility of the central plant system is also a benefit to the building owner; when technologies become more efficient and available the building can be easily retrofitted. The centralized chiller-heater with cooling tower was chosen for its anticipated improvement in energy efficiency, smaller shaft space requirements, diversification of primary energy sources and for educational purposes. The system will maintain its ability to simultaneously heat and cool in different parts of the building, provide adequate thermal comfort to building occupants, and provide minimum ventilation.

Breadth Proposals

Structural Breadth

The changing the building mechanical system will have an impact on the design of the structural system, particularly the roof structure. A reduction in the number of rooftop mounted air handling units will change the design of the structural system and construction cost savings are possible. The centralized chiller-heater and associated air handling units would be indoors on the cellar level to accomplish this. However, a cooling tower will be needed to cool the condenser water from the absorption chiller. The location of the tower is to be determined but would most likely be on the roof structure. The structural plans that are too be analyzed were provided by KTA Group.

Sustainability Breadth

The addition of a cooling tower brings with it the need for additional domestic water supply for operation. A rainwater harvesting system installed on the roof would reduce the use of potable domestic water used in cooling. The Northern Virginia area is rated at 40-50 inches of rainfall per year, where 20 inches per year is noted as the minimum practical amount to consider such a system. The roof structure is large in comparison to the square footage of the building due to it only being four stories in height. This leaves approximately 38,000 square feet of roof space to harvest rainwater. A treatment system for the captured water will have to be addressed before the water can be used in the cooling tower to prevent unnecessary damage. A storage system would also have to be designed for the water to be used in all conditions. The system would be relatively inexpensive to install and maintain when compared to the benefits received.

Master’s Thesis Integration

The topic of the absorption chillers was studied in AE 557 – Central Cooling Systems instructed by Professor Bahnfleth and is included in the mechanical system redesign senior thesis proposal for AE 481.

Breadth Integration

The integration of the mechanical depth and the two breadths is a very important aspect of the Architectural Engineering Senior Thesis process. The mechanical depth involves the installation of an absorption chiller which in turn requires heat rejection. The heat rejection requirements are met through the addition of a cooling tower on the roof. This, along with the removal of the existing air handling units will change the loads on the structural system and will affect the size of the members. The first breadth focuses on these structural changes. The addition of the cooling tower also creates a demand on the domestic water supply for potable water for use in cooling. The second breath focuses on rainwater harvesting to supply some of the makeup water that is used by the cooling tower. Figure 2 below shows the integration of topics in a flow chart format.

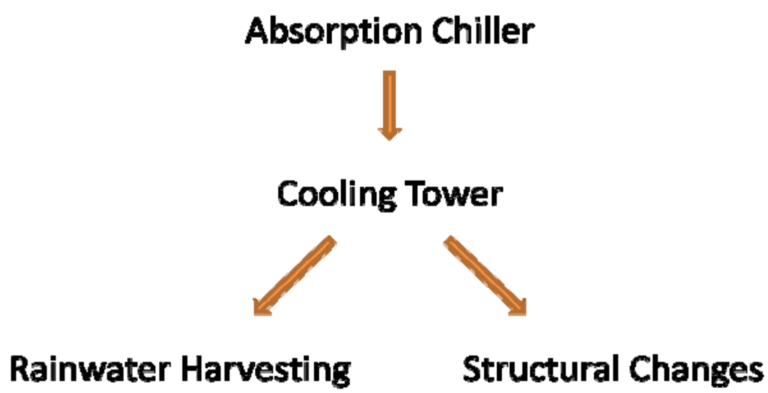


Figure 2 – Integration Flow Chart

Tools and Methods

Trane Trace 700 will be used to model the cooling and heating loads on HITT Contracting Headquarters as well as perform energy usage and economic calculations. Engineering Equation Solver (EES) will be used to model the interaction between the absorption chiller and the cooling tower to acquire sizing information. Cost estimates for the new equipment will have to be obtained from vendors as they are determined.

Preliminary Research

Bahnfleth, William P, PhD, PE, Thies, Roger M. Gas-Fired Chiller-Heaters as a Central Plant Alternative for Small Office Buildings. HPAC Engineering. January 1998.

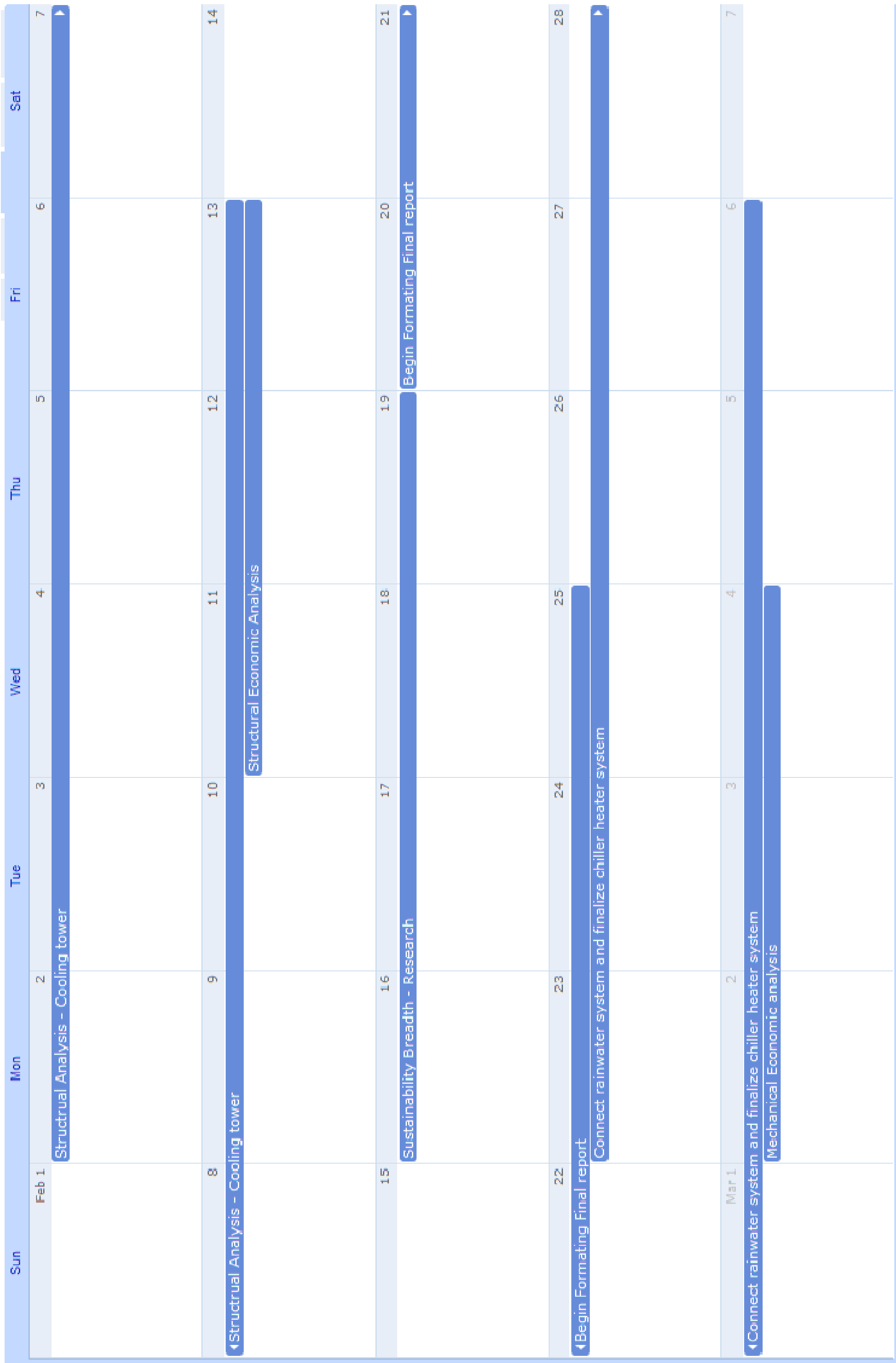
Work Schedule

Listed on the follow pages are calendars that describe the proposed work schedule for the spring of 2009. This is an estimate of the work schedule and adjustments may occur.

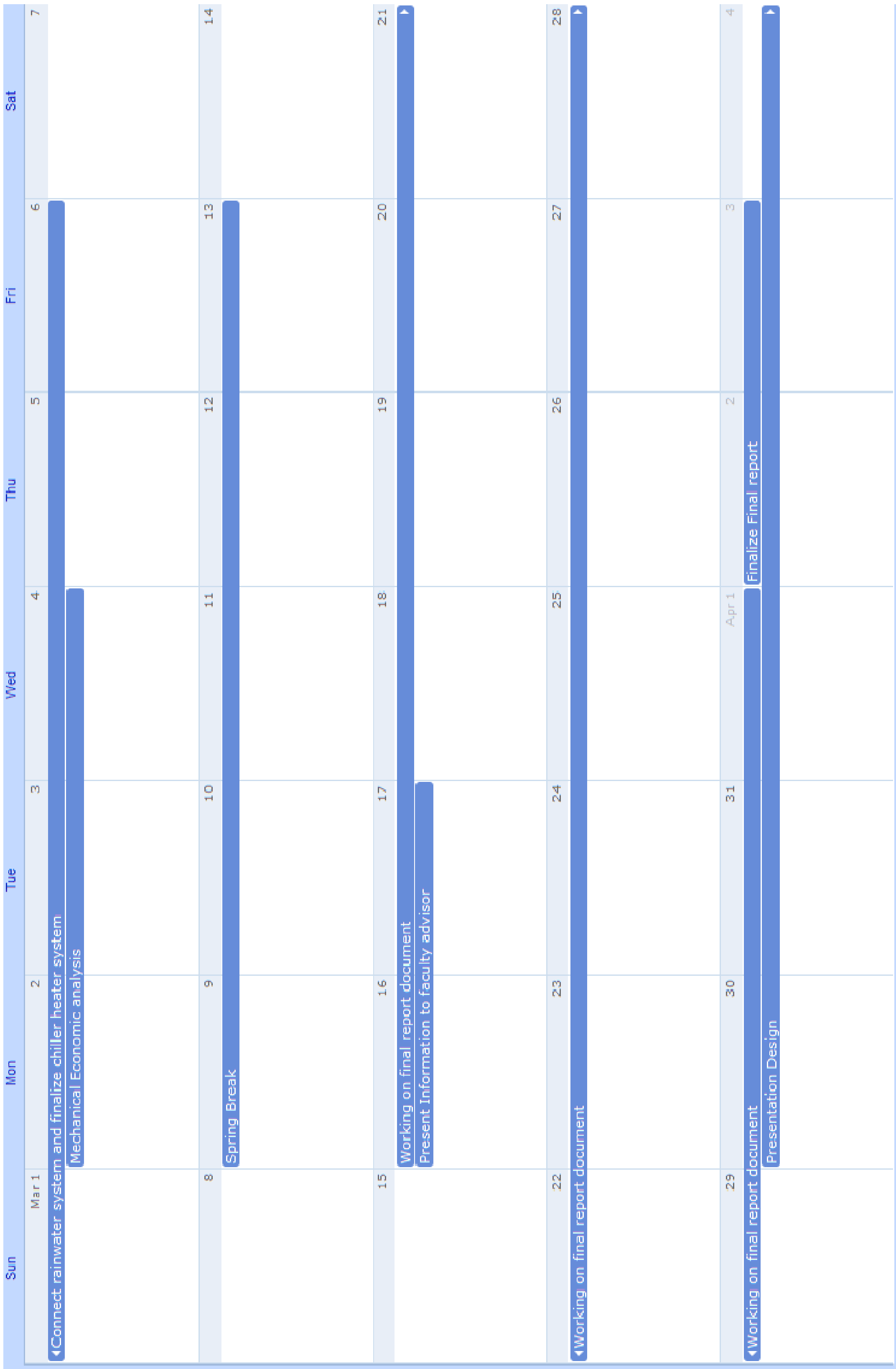
January 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	31	Jan 1	2	3
4	5	6	7	8	9	10
11	12 Research Types of Absorption Chillers; Classes Start	13	14	15 Use EES to model various chillers and cooling towers	16	17
18 Use EES to model various chillers and cooling towers	19 Martin Luther King Day	20	21	22	23	24
25 Use EES to model various chillers and cooling towers	26	27	28 Specify Chiller/Cooling tower	29 Contact Vendors: Absorption Chiller & Cooling Tower Costs	30	31

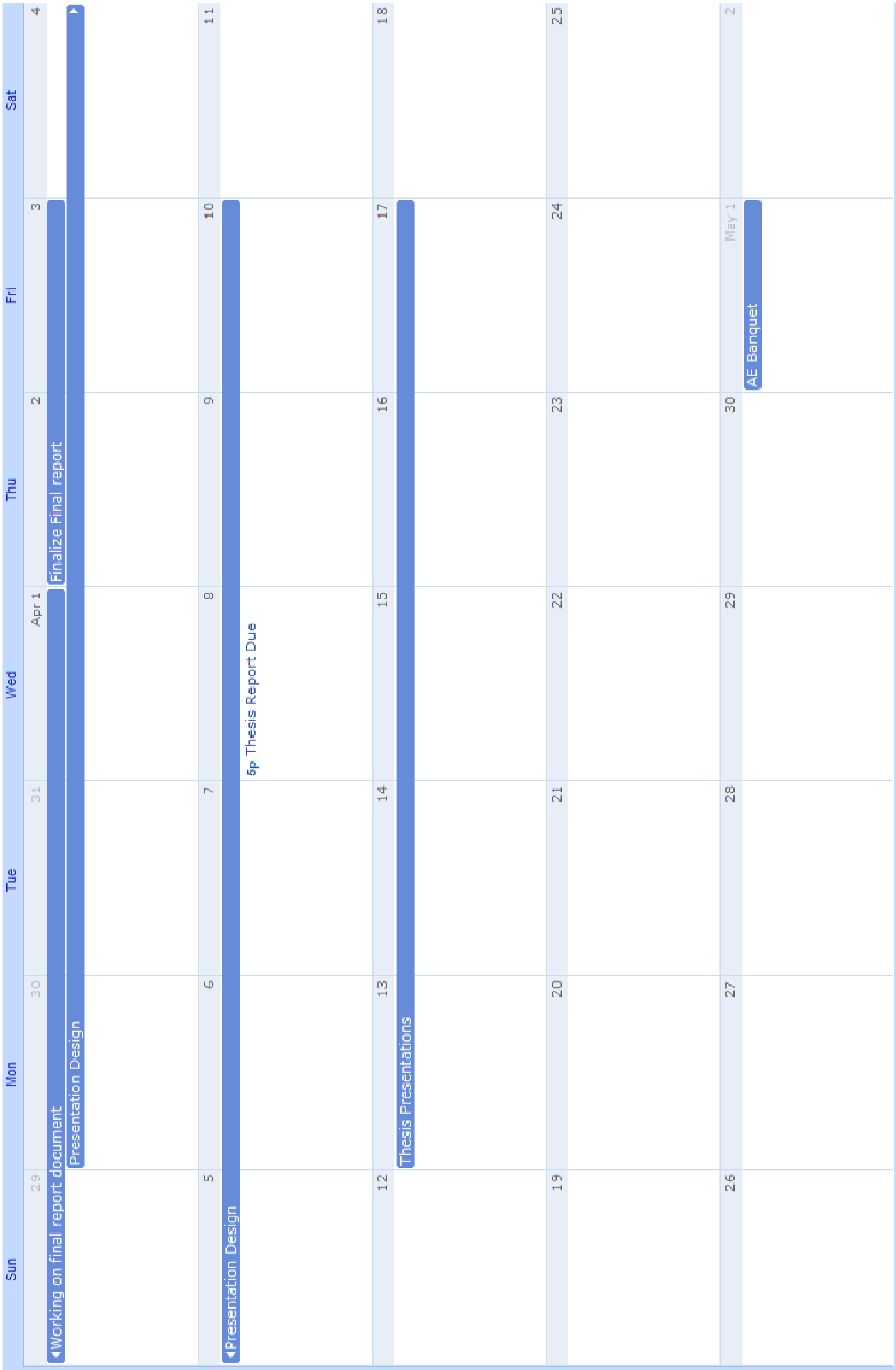
February 2009



March 2009


Sun
Mon
Tue
Wed
Thu
Fri
Sat
Mar 1
2
3
4
5
6
7
Connect rainwater system and finalize chiller heater system
Mechanical Economic analysis
8
9
10
11
12
13
14
Spring Break
15
16
17
18
19
20
21
Working on final report document
Present Information to faculty advisor
22
23
24
25
26
27
28
Working on final report document
29
30
31
Apr 1
2
3
4
Working on final report document
Finalize Final report
Presentation Design

April 2009


Sun
Mon
Tue
Wed
Thu
Fri
Sat
Working on final report document
Presentation Design
Finalize Final report
Presentation Design
5p Thesis Report Due
Thesis Presentations
AE Banquet

References

Haack, Charles. Technical Assignment One: ASHRAE Standard 62.1 and 90.1 Evaluation. September 29, 2008.

Haack, Charles. Technical Assignment Two: Building and Plant Energy Analysis. October 24, 2008.

Haack, Charles. Technical Assignment Three: Mechanical Systems Existing Conditions. November 21, 2008.

KTA Group, Inc. Mechanical Construction Documents. KTA Group, Herndon, VA. 2008.

Noritake Associates. Architectural Construction Documents. Noritake Associates, Alexandria, VA. 2008.