Thesis Proposal

Mechanical System Redesign: Heat Recovery and River Heat Rejection

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The Hospital for Special Surgery River Building
New York, New York

Prepared For:

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Executive Summary

The HSS River Building, a part of the Hospital for Special Surgery campus on the Upper East Side of Manhattan, is an 88,245-square-foot building rising 190 feet above the FDR Drive highway. The River Building is an acute care facility containing primarily exam rooms, X-ray rooms, doctor offices, and a rehabilitation gym on the second floor.

The mechanical system for the HSS River building is a constant air volume system (CAV) with heat pump water loop providing cooling and heating for the 100% Outdoor Air Handling Unit (AHU) and provides heat absorption and rejection to the terminal water-to-air heat pumps in occupant spaces on each floor.

This proposal will outline the topics, methods, and timeline that will be approached for the mechanical redesign and the structural and architectural breadth topics. The mechanical redesign proposal will replace the 100% OA AHU unit with one containing a heat recovery wheel. Also, the East River next to the building will be analyzed and used as a heat rejection source for the heat pump loop system.

In addition to the redesign of the air distribution system and heat pump system, two breadth areas will also be developed. The first breadth will look at the new mechanical equipments and its effects on the structural system of the building to see whether or not it can be downsized to save cost. The other area will be the architectural building façade to see whether or not reducing the 60% glass fenestration by solar shades or a different material will be the best option to lower internal thermal loads.

To analysis these topics, a schedule of the spring semester was created to organize research and allocate design hours for the thesis project. In the research phase, available products and previous projects from Cannon Design and other companies will be studied in order to gain familiarity and knowledge of the area of study. In the design phase, Trane Trace, a building energy modeling software will be used along with Microsoft Excel to calculate the necessary information needed to determine whether or not the redesign is feasible and correct. Also, the architectural breadth will require renderings done in Photoshop and Autodesk Revit, a computer aided 3D software.

Building Overview

The HSS River Building is a twelve story 88,245 square feet building located in the Upper East Side of Manhattan. The building is used for acute medical care, containing primarily exam rooms, X-ray rooms, doctor offices, and a rehabilitation gym on the second floor. The HSS River Building is designed to be on top of the FDR Drive highway, overlooking the East River. **Figure 1** shows the location of the building on the Upper East Side.

Inside the River Building, the project was designed as a core and shell, leaving the interior programming to the client's request. The core and mechanical system were designed to use the least amount of space possible so that the client will be able to rent out the space. This being said, the HSS River Building's mechanical system only takes up 1% of the rentable space available as all equipments are located in the penthouse and concealed in the plenum. **Figure 2** shows the west elevation of the HSS River Building.

The building is supposed to be built on the Hospital for Special Surgery campus located between 70th and 71st Street and borders between York Ave and the FDR Drive. The campus is very dense containing (3) buildings within that block. The HSS River Building is designed to be built as an addition to the Caspary Building to extend over the FDR Drive. The building also has more than 50% of the facade containing glass on the north, south and east exposures and also straddles over the busy FDR Drive.

Unfortunately, the project was stopped at 100% Bid Documents to be redesigned at the request of the Owner.

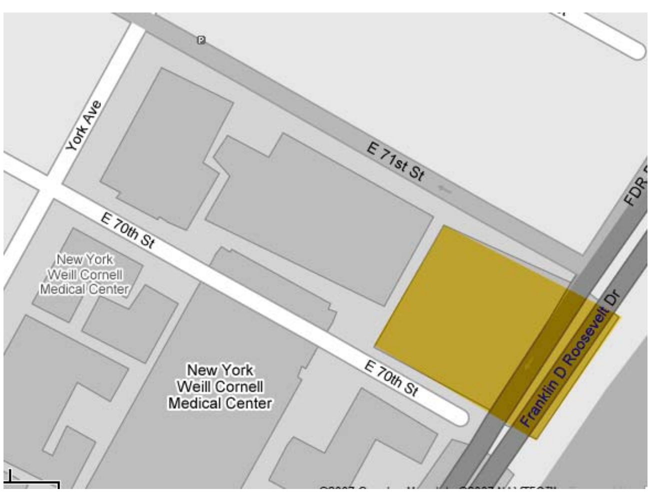


Figure 1. Location of the HSS River Building

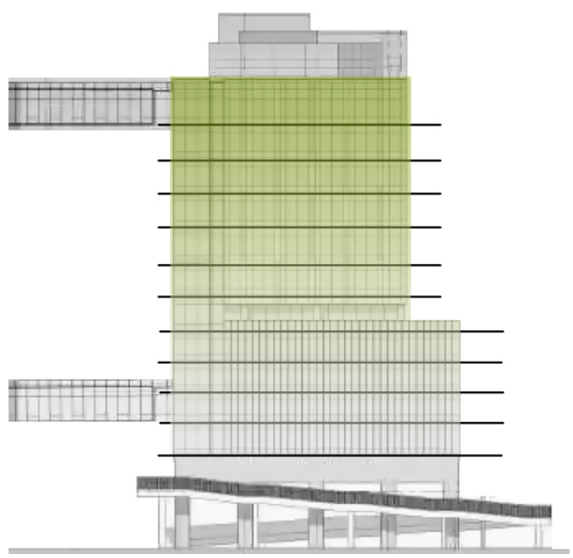


Figure 2. West Elevation

Mechanical Design Objectives

The mechanical system for the HSS River building is a constant air volume system (CAV) with heat pump water loop providing cooling and heating for the 100% Outdoor Air Handling Unit (AHU) and occupant spaces on each floor. The minimum outdoor air is brought in and mixed with the return air in each terminal heat pump unit serving each area. The main heat pump provides cooling and heating for the AHU is water-to- water system where as the terminal units are water-to-air. The design of the mechanical system for the HSS River Building was developed from the following objectives:

- Occupant Controllability
- Energy efficiency
- Space conservation
- Reduce spread of contaminates

With these objectives in mind, the HSS River Building uses multiple terminal heat pumps which can simultaneously provide heating and cooling, providing occupant controllability of temperature for each serving space. To increase energy efficiency, the HSS River Building mechanical system uses a heat pump loop with a 100% air handling unit sized for the minimum outdoor air, reducing energy needed to condition a larger amount of outdoor air. Lastly, by sizing the duct penetrations for the amount of outdoor air only and mixing the recirculation and outdoor air at the terminal end reduces the amount of space needed for the ductwork. By not mixing the return air with the outdoor air in the Air Handling Unit, the system prevents contaminates and air borne diseases to circulate throughout the entire building.

In a heat pump system, there are two sets of temperature ranges for the heat pump to work efficiently. One set is called the load loop temperature and the other is the source loop temperature. In the HSS River Building, a steady temperature range of 90F to 100F is need for the source loop and 46F and 55F for the load loop for cooling. For heating, a range of 60F and 70F is needed for the source loop and 90F and 100F for the load loop. In order to maintain this constant temperature, a cooling tower and heat exchanger are used to reject and supply additional heat to the system.

The HSS River Building was designed to also meet ASHRAE Standard 62.1-2004 Ventilation requirements but did not meet all requirements set forth for ASHRAE Standard 90.1. These results were studied in *Technical Assignment 1 – ASHRAE Standard 62.1-2007 Ventilation Report and Technical Assignment 2 – Building and Plant Energy Analysis Report*.

Mechanical System Overview

Air Distribution - The HSS River Building provides 100% minimum outdoor air (OA) through the McQuay roof top unit bringing 14,000 CFM into the building. The OA is conditioned by heating and cooling coils and ducted down to each floor. The outdoor air is mixed with the return room air by the terminal heat pump units in the plenum. The supply air is then conditioned again by the terminal heat pump unit. In order to provide thermal comfort, the AHU has an entering and supplying summer temperature of 95F and 57F respectively while the entering and supplying winter temperature is 0F and 92.5F respectively. The HSS River Building also contains (6) centrifugal roof up-blast exhaust fans. They are used mainly for exhausting air from toilet rooms and locker rooms. Other exhaust fans are used for exhausting the exercise room on the 2nd floor and also for smoke purging all floors in case of a fire.

Heat Pump System

The mechanical system contains (3) water-to-water heat pumps to condition the 100% outdoor air and provides heat rejection and absorption for the (157) terminal water-to-air heat pumps serving the floors. The heat pump source and load loop system contains a mixture of water and 35% propylene glycol to prevent the loop from freezing. The (3) water-to-water heat pumps provides the entering water temperature needed for the terminal heat pump units to reject and absorb heat during cooling and heating seasons. This being said, the terminal heat pump units provides their leaving water temperature as the entering water temperature needed for the source loop for the (3) water-to-water heat pumps. This delicate balance is kept in check by a cooling tower and heat exchanger to reject or add more heat to the system to maintain constant temperature differences.

Heat Absorption - Steam

Con Ed, the utility provider for electricity for the HSS River Building also provides high pressure steam at 160 psi. The steam is stepped down from 160 psi to 80 psi and then down to 15 psi by two sets of Pressure Reducing Valves (PRVs). This low pressure steam (LPS) is then directed to the heat exchangers to provide heat to the heat pump source loop.

Heat Rejection – Cooling Tower

When additional cooling occurs, the heat pump loop load leaving temperature from each terminal heat pump will increase. This increase in temperature is rejected through the cooling tower to maintain the constant 90F entering temperature for the (3) heat pumps serving the AHU. It is a closed loop system to minimize process fouling and also contains a steam basin heater to prevent spray water from freezing.

Mechanical System Critique

Air Distribution Critique

The air distribution of the HSS River Building can be seen as a satisfactory system. The system does not use more space and materials than conventional AHU return systems where either a ducted return or open plenum is required to bring all the return air back to the AHU. The air distribution also does decently at isolating serving zones from each other, which is important in an acute medical procedure building to prevent cross contaminants as each return air is re-circulated in each zone. But on the contrary, the mixture of outdoor air and room air is never exhausted in each serving zone but rather at negative pressure zones such as restrooms, lockers and the rehabilitation gym. This creates a positive pressure for every zone, possibly resulting in cross contamination into the negative pressure zones.

Another questionable design is the absence of heat recovery from the 100% OA AHU. As of now, the AHU is being conditioned by the heat pump source loop, but it can be conditioned by the exhaust air from the building with a heat recovery wheel. This topic will be discussed in the proposal.

Heat Pump System Critique

The heat pump system in the HSS River Building is an effective system. The heat pump system requires less space and energy to heat and cool the space. It also allows for simultaneous cooling or heating in different zones of the building at the same time as the terminal heat pump simply reverses its refrigerant flow cycle to allow this. This is a great advantage dealing with the diversity in the building as it contains fully exposed ceiling to floor glass on every floor on the North, East and South side. This is a great feature for providing control for the occupants. Even though the heat pump system is very delicate in its coordination of temperatures with the water-to-water heat pump serving the AHU and the water-to-air heat pumps serving each zone, the balance is maintained through controls and the cooling tower for heat rejection and heat exchangers for additional heat. A potential concern of this system is the numerous amounts of terminal heat pumps concealed in the plenum on each floor that would need to be maintained throughout the year. This process will have to be done on premium time on weekends in order not to disturb the doctors and patients on the weekdays.

Mechanical Proposed Redesign

The mechanical system for the HSS River Building was designed adequately for its purpose of reducing the spread of contaminates, providing controllability to the user, and reducing energy use. But as with any system, there can be alternative designs for improvement. The following proposal for redesign of the air distribution and heat pump system will be the topics of study for the spring 2008 thesis. Below are the proposed topics and a description of how to approach each redesign.

Air Distribution System

The HSS River Building provides its occupants with a supply air that is made up of the minimum required outdoor air mixed with the existing room air. This outdoor air is brought in by the 100% OA AHU on the rooftop that uses energy to condition harsh winter and summer outdoor air to ideal comfort room temperatures. The River Building also contains (6) exhaust fans, exhausting conditioned air out of the building. This being said, the proposed alternative redesign is to provide conditioning to the outdoor air temperatures by heat recovery from the exhaust. This system is commonly used with systems that use 100% OA AHUs.

This heat recovery process can be achieved by using an enthalpy wheel which conditions the outdoor air by using the heat of the exhaust air. The enthalpy wheel contains a heat conducting material and an optional discussant material to recover both sensible and latent heat energy. The functionality of the system is simple: a huge wheel rotates, capturing heat energy from the exhaust air and transferring it over to the outdoor air coming in. Figure 3 shows an image of how a heat recovery wheel works.

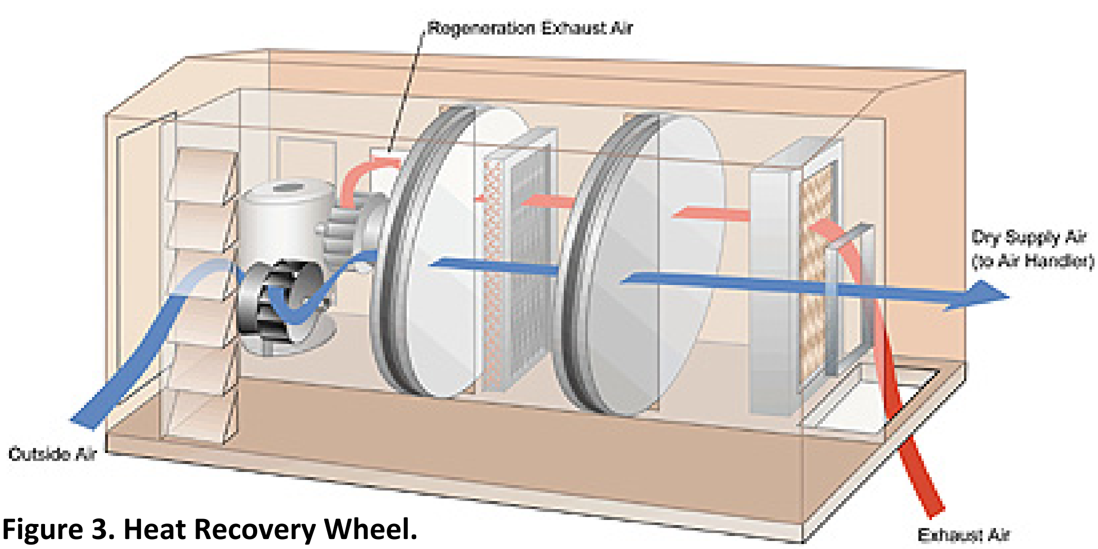


Figure 3. Heat Recovery Wheel.

Heat Pump System

The heat pump system in the HSS River Building provides simultaneous cooling and heating in occupant spaces depending on the needs of the occupant. In order to do so, the heat pump loop maintains a delicate temperature range by rejecting or absorbing heat from a cooling tower and heat exchanger respectively. The current method of heat rejection is by a cooling tower on the roof spraying water and blasting air in order to bring down the temperature to that of the loops. This method requires intense energy use by pumps and fans. The River Building is also being built next to the East River, a tidal strait with a semi constant water temperature. With this being said, the proposed alternative redesign is to take advantage of the site and use the river as a heat rejection source rather than a cooling tower, reducing energy costs and equipments.

The system for using natural bodies of constant temperature for heat rejection is common in heat pump systems. Besides rivers, other thermal bodies such as underground soil, lakes, and ponds can be used as a heat rejection and absorption source. This can be achieved as the thermal body acts as a reservoir to supply or absorb the energy coming from the heat pump loop. **Figure 4** shows how a body of water can act as a heat absorber.

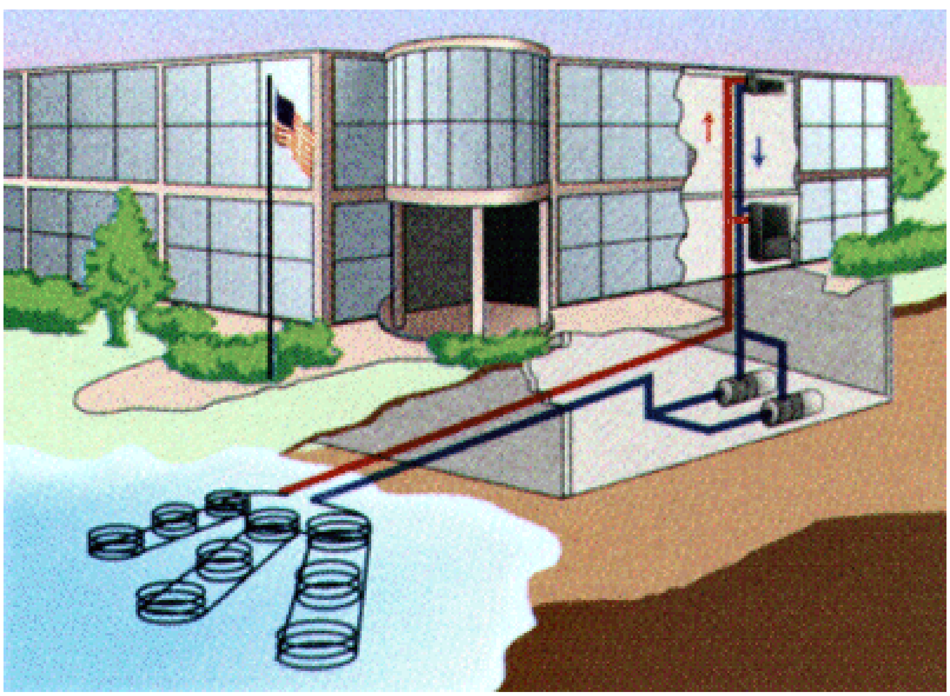


Figure 4. Heat pump system using a pond as a source of heat rejection.

Proposal Breadth Topics

Along with the redesign of mechanical systems in the building, many other building systems are affected by the change. The proposal breadth topics will investigate the structural and architectural systems that will be affected by the mechanical design. Below are the proposed areas of breadth topics and a description of how each will be approached.

Structural Proposal

By changing the 100% OA AHU and providing a heat recovery wheel, many mechanical equipments will be changed and even be removed from the schedule. Due to this alteration, the total weight of the penthouse will be changed and will perhaps reduce the amount of steel needed for support.

This will be accomplished with hand calculations and also the help of RAM, structural engineering software that will model the building's structural system with the given structural plans provided by Cannon Design.

Architectural Proposal

The HSS River Building façade contains over 60% of glass as analyzed in *Technical Assignment 2 – Building and Plant Energy Analysis Report*. This high percentage of glass will increase solar heat gain and heat loss during the summer and winter times respectively. A breadth analysis will determine whether or not the aid of solar shades or a façade with a different material will reduce internal loads, reducing the amount of energy needed to condition the building.

This will be accomplished by researching different solar shade products available on the market today and also by researching other materials that will decrease the heat transfer of the glass. This modeling will be performed on Trane Trace, a building energy modeling software that will calculate the new facades impact on internal loads. Also, Adobe Photoshop and Autodesk Revit will help provide renderings and models of the new façade appearance.

Finally, these two breadth proposals will be analyzed with their associated costs and it will be determined whether or not significant savings will occur or if the additional cost is worth the alterations.

Project Methods

Two alternative mechanical designs have been developed along with two breadth topics in the structural and architectural sides for the proposal. In order to analyze and determine the results, a well organized method needs to be developed for the spring 2008 semester.

In the time span of four months, the mechanical proposal will be carefully examined first by researching product designs and previous research and job projects relating to the topic. After the research, a thorough analysis and modeling will be pursued by hand calculations and the aid of Trane Trace, an energy modeling software. This method will be used to analyze the proposed heat recovery wheel and heat rejection to the East River proposals.

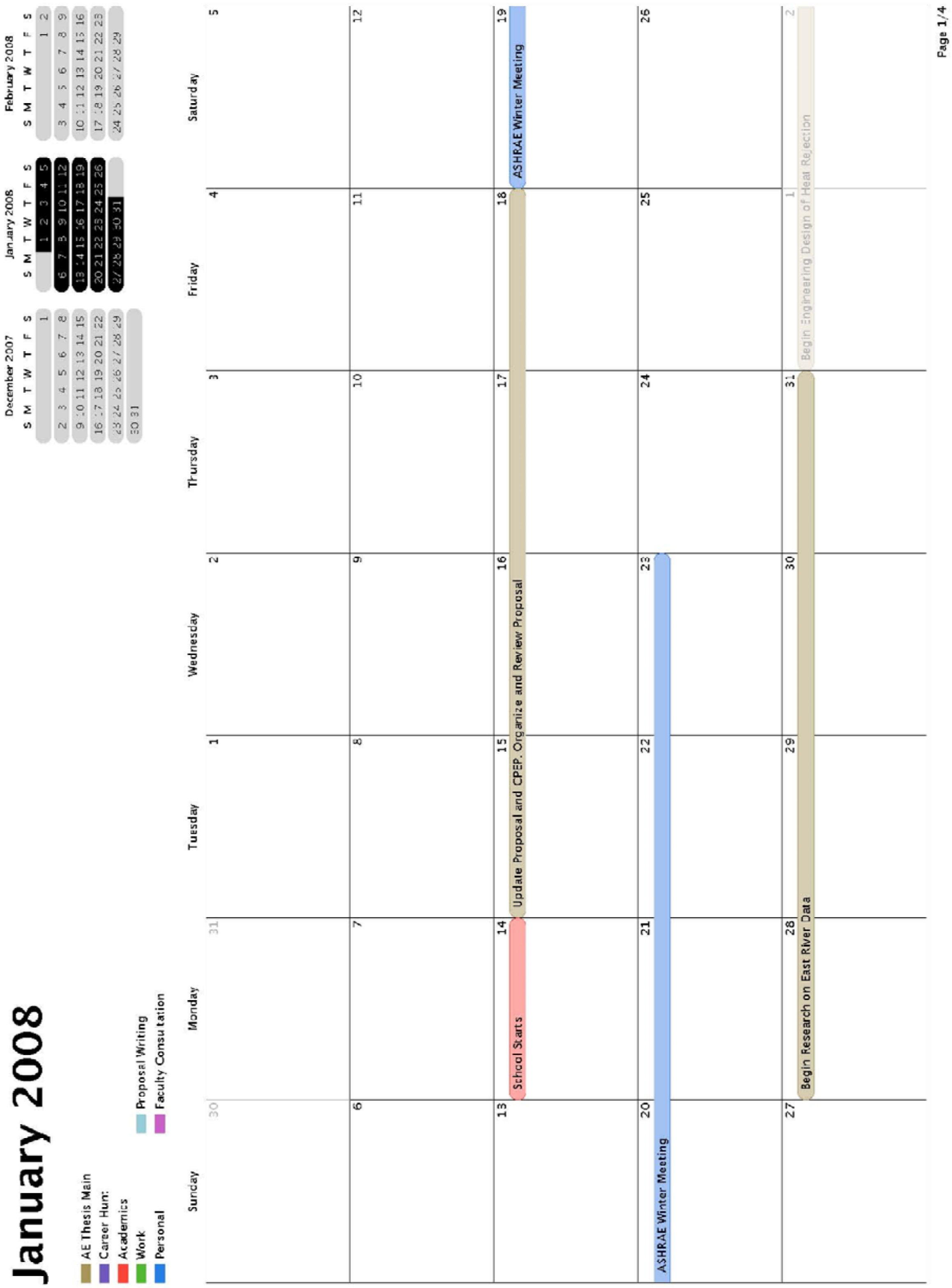
Once the mechanical redesign has been developed and written, a careful study of the breadth topics will be reviewed. Using the same approach as with the mechanical redesign, the breadth topics will first involve research in products available and previous research and jobs on the topics. Then, a thorough analysis and modeling will be performed by hand calculations and the aid of Trane Trace. For the structural breadth, RAM, a structural design software, will be used to help calculate the new building load. And lastly for the architectural breadth, Adobe Photoshop and Autodesk Revit will be used for renderings and models of the new façade along with Trane Trace for load calculations.

Throughout both the mechanical and breadth proposal analysis, a faculty consultation will occur during the later phase of the design portion. This is to ensure that the design analysis is as accurate as possible and also provide helpful feedback to the redesign. After the meeting takes place, several days will be designated for incorporating the feedback into the design.

Lastly, for all proposals a careful life cycle cost analysis will be performed. This will determine whether or not if the redesign is economically feasible or not.

Spring Semester Proposed Schedule

The following calendars are the proposed schedule that will be followed for the redesign of the mechanical system and the breadth topics. This is only an estimate and does not contain daily details but rather how long each phase of the project will last. Modifications may occur due to unforeseen academic course load or personal events.


January 2008
AE Thesis Main
Career Hunt
Academics
Work
Personal
Proposal Writing
Faculty Consultation
December 2007
January 2008
February 2008
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
School Starts
Update Proposal and CPEP. Organize and Review Proposal
ASHRAE Winter Meeting
ASHRAE Winter Meeting
Begin Research on East River Data
Begin Engineering Design of Heat Rejection
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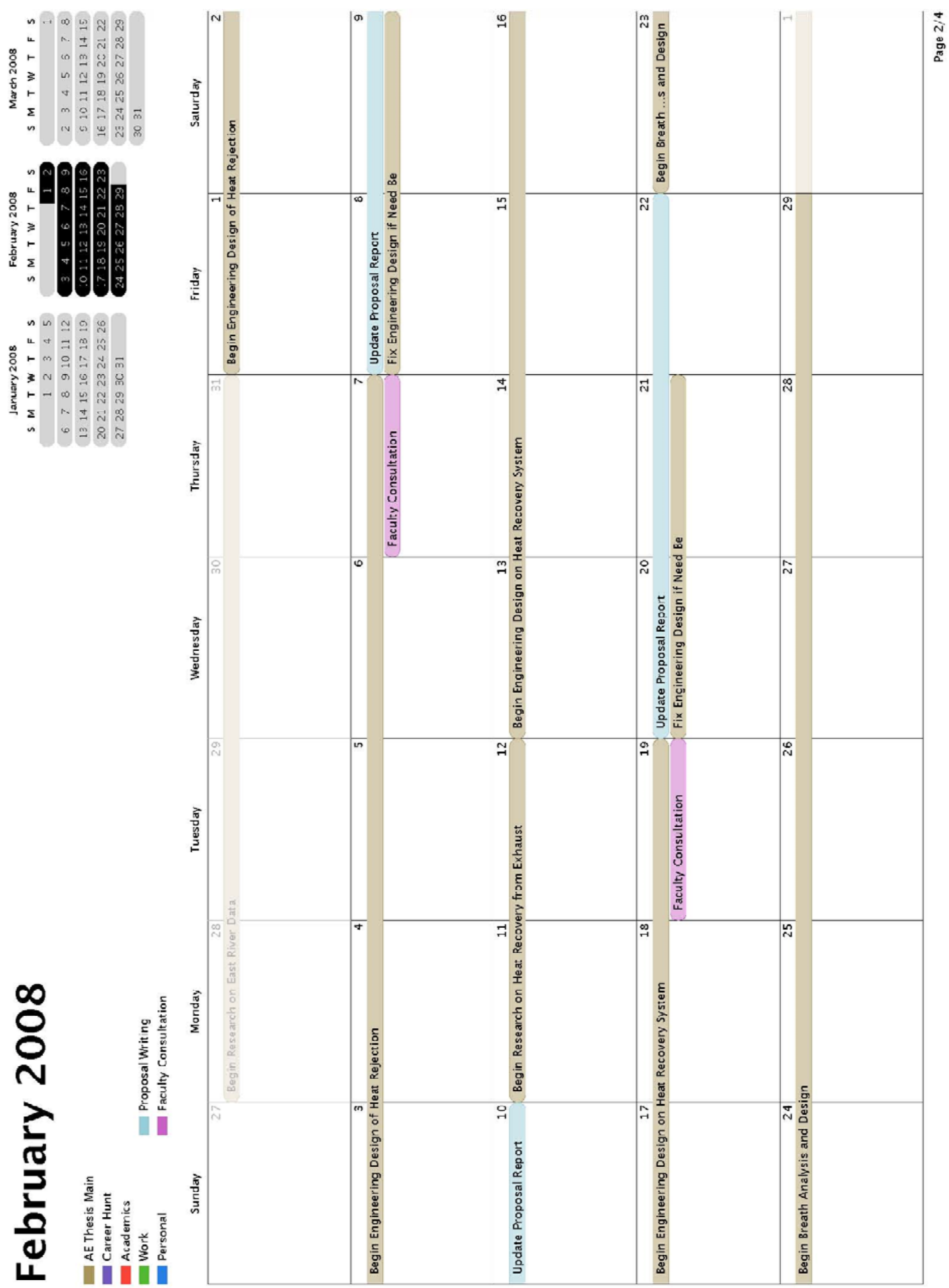
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Begin Research on East River Data
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Faculty Consultation
Update Proposal Report
Fix Engineering Design if Need Be
Update Proposal Report
Begin Research on Heat Recovery from Exhaust
Begin Engineering Design on Heat Recovery System
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Begin Breath Analysis and Design
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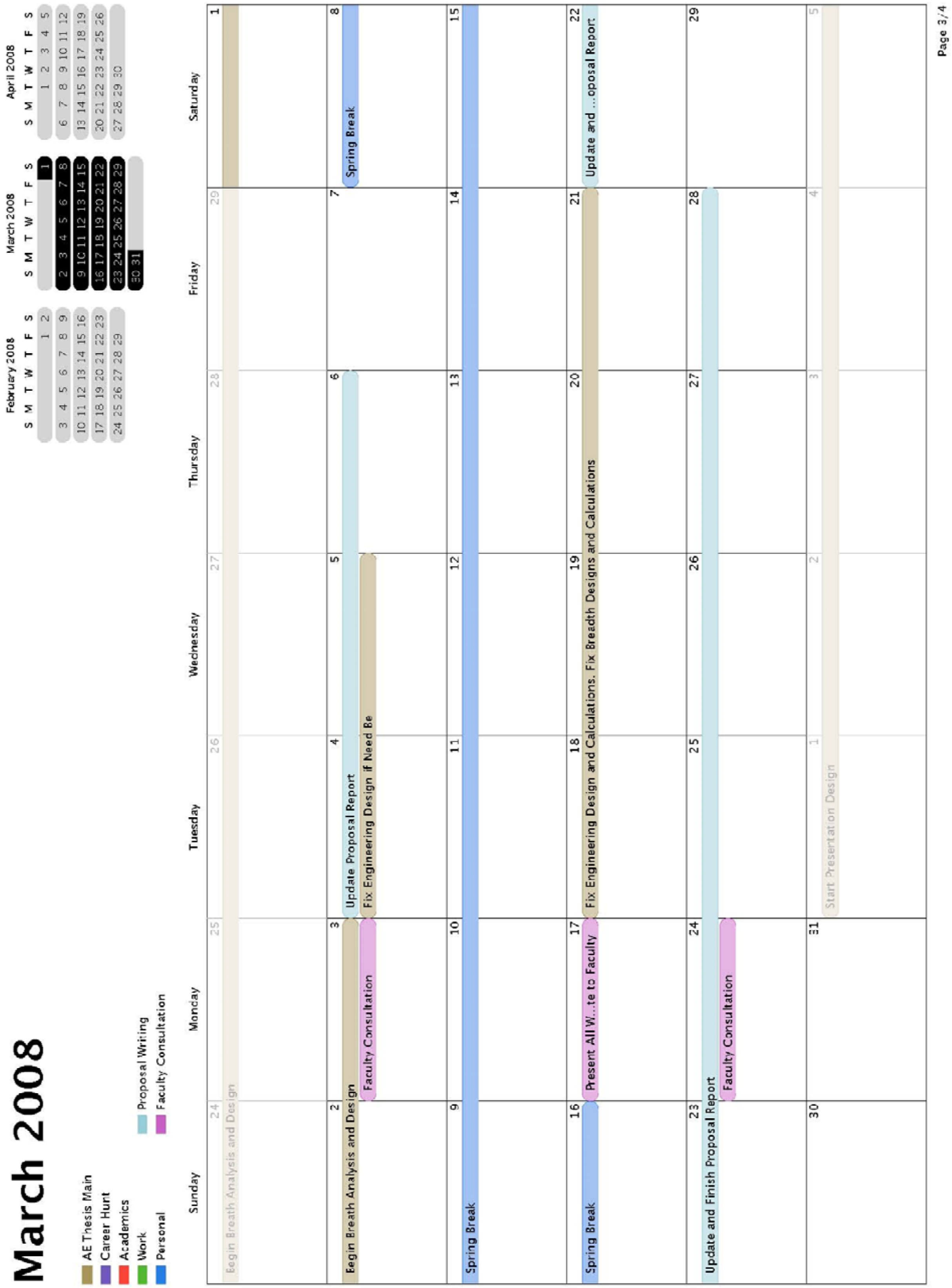
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Update Proposal Report
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Spring Break
Present All W...te to Faculty
Fix Engineering Design and Calculations. Fix Breadth Designs and Calculations
Update and ...oposal Report
Update and Finish Proposal Report
Faculty Consultation
Start Presentation Design
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April 2008

- AE Thesis Main
- Career Hunt
- Academics
- Work
- Personal
- Proposal Writing
- Faculty Consultation

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	31	1 Start Presentation Design	2	3	4	5
6 Start Presentation Design	7 THESIS REPORT DUE	8	9	10	11	12
13	14 Thesis Presentation	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3

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