Nathaniel Mooney | Mechanical | Dr. William Bahnfleth | 12/12/2012

Broad Institute Expansion: 75 Ames Street

Cambridge, Massachusetts

Mechanical Thesis Proposal

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Executive Summary

This proposal is for changes to 75 Ames Street, Cambridge Ma. This report contains two proposed changes for current mechanical systems and two breadth changes. The two proposed changes for the mechanical system are for changing offices from a VAV system to active chilled beams and adding an air quality monitoring system to each lab space. Chilled beams will cool and heat the load dependent room's t directly and thus only the air required for ventilation will be needed, lowering the supply air needed and wasted energy. The air quality monitoring system also lowers the supply air by only using the ventilation needed due to contaminants in the space, not a pre-assigned schedule. Both the chilled beams and air quality monitoring system will ultimately allow for better use of energy and save on operating costs. These savings will be shown through the energy modeling software TRANE TRACE.

For the first breadth study 75 Ames shall be taken off the grid and instead use a combined heat and power system. There is a great deal of waste in the grid and by generating one's own electricity the waste created, heat, usually lost in the processed, can be harnessed for use with in the building. In this study the savings from emissions and power shall be analyzed to determine the effectiveness of adding such a system. The second breadth shall determine the time added to the construction process though changes to the schedule by adding both the air quality monitoring system as well as the chilled beams.

Also included in this proposal is a building overview, mechanical system overview, any alternate depth considerations, and a schedule of progress for the spring semester. The schedule of progress has been included to show when activities shall be performed, and important dates to maintain good progress throughout the semester. Activities include both research and analysis for the depths and breadths as well as when writing of reports shall begin.

Building Overview

75 Ames Street is a new 250,000 sq. ft., 15-story high-rise addition to Kendal Square in Cambridge, Massachusetts (figure1 below). This building is designed to bring together the multiple Broad institute offices around the Cambridge area into one location attached to their main office at 7 Cambridge Center.

This structure is set to finish the Ames Street frontage and add to the current pedestrian walk space. This is done with a new pedestrian entrance to a 5-floor garage attached to Ames Street as well as 4000 sq. ft. of retail and restaurant space on the ground floor. The primary design is for offices and research & development labs, which use a majority of the area. Some other notable areas of the 75 Ames are a vivarium on the 12th floor and 3 mechanical rooms making up the penthouse.

The exterior is mainly composed of a mixture of stone, terra cotta, Viracon vision glass and spandrel glass. The penthouse is primarily constructed of aluminum louvers and metal panels. The front façade adds to the vibrant community on Ames Street while the other three facades connect 75 Ames to the current Broad Institute main office next door at 7 Cambridge Center.

Figure 1: A look at the location of 75 Ames Street in Cambridge (courtesy of ELKUS|MANFREDI ARCHITECTS)

Mechanical System Overview

Level M2 hosts the heating plant consisting of two 500 BHP preheat fire tube boilers, four 120 BHP Reheats with one standby, two 215 BHP MPS boilers for humidification and process steam loads, and finally a pressure reducing LPS for humidifiers. Also on M2 is the chiller plant consisting of three 1000-ton chillers for cooling air handing units 1 through 4. Two 450-ton chillers to serve vivarium (AHU-5) and fan coil units, which serve freezer rooms, tell/data, electrical, and the penthouse for spot cooling. Each chiller has a corresponding cooling tower located on the roof.

The ducting on each floor was taken with future floor plan changes in mind. In order to achieve this, air-handling units 1 through 4 each connect to a main ring on each floor. This can be seen in the following figures 2 & 3, which show the supply and exhaust duct respectively. These rings then supply air to each zone on their floor. Since they are serving both labs and offices together return air cannot be utilized since labs call for 100 % outside air. The only return air used in this building is 16000 CFM of air from the connector of 75 Ames Street to 7 Cambridge Center to level M1.

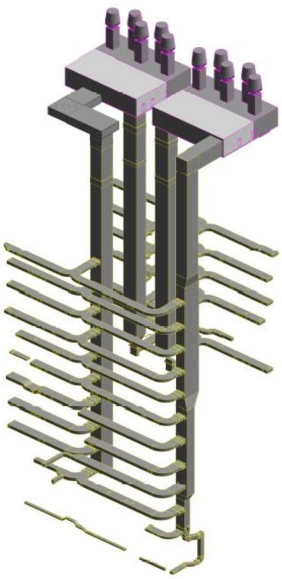


Figure 2

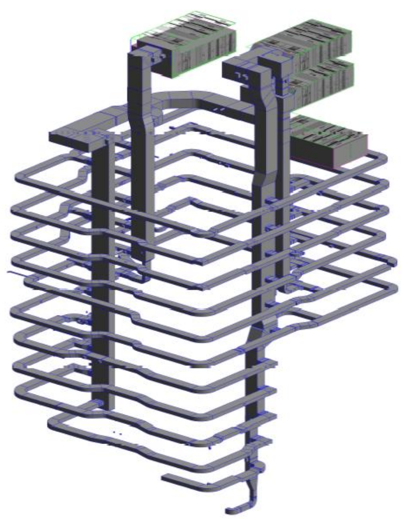


Figure 3

Mechanical System Design Objectives

This section is an in depth report of the mechanical design objectives, requirements and modeled conditions for 75 Ames Street. It will also look into energy usage and costs for these conditions.

Design Objectives

75 Ames's mechanical design objective is to build a state of the art facility incorporating sustainable design principals of energy conservation that will achieve a United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Silver Certification. The HVAC system must be designed and built to support the present building program but maintain flexibility for changes of this program in the future. Spaces to be supported are chemistry wet labs, tissue culture spaces, sequencing spaces, a vivarium on level 12, administration areas, restaurant tenant on level one, and positions of possible future vivarium expansion.

All systems will be designed in accordance with Massachusetts State Building Code, City of Cambridge Ordinances, ASHRAE and other recognized standards, NFPA Standards and good engineering practices. As well an effort shall be put forward to design, layout and place equipment in areas of easy access to encourage routine maintenance. The use of isolation valves shall be implemented to enable easy servicing as well as expansion or renovation of any part of the existing facility without interrupting adjacent areas. Air Handling unit cross connection, ring duct or ganged duct, are used to provide redundancy throughout the facility to ensure environmental comfort to each space with in the building

Alternatives Considered

In preparation for the proposal several different ideas where considered to minimize operating costs and improve the reliability of the system. Below you will find the Ideas considered and a brief explanation of them.

Solar Thermal Heating

A solar thermal system could be placed on the roof of the building to utilize solar energy for hot water heating. This could then lessen the heating bill and carbon footprint of the buildings. One barrier to consider is the amount of heating available depends upon the area available for the collectors and the clearness index of the area. Since 75 Ames is a 250,000 SF building using 348.500 therms of natural gas costing $5.57K annually this could be a potential cost saver, but there does seem to be a lack of space for the collectors.

Rain Water Collection

A rainwater harvesting system could help 75 Ames become a more sustainable building. By collecting rain for use in toilet flushing for example, a great deal of clean water can be saved. There is a roof area of roughly 29,000 SF that could be utilized for rain water collection.

Return Air from offices to be used.

75 Ames was designed for future renovations and it is because of this all areas are 100% outside air and no return air is utilized for any spaces. There is a large potential for energy savings here. In designing two separate systems, one for labs and one for administration, although the mechanical design will not be as flexible, it will be more efficient.

Mechanical Proposal

Supply/Exhaust Redesign: Chilled Beams & Aircuity

75 Ames is a 100% outdoor air building. Because of this there is a lot of energy going into heating and cooling the minimum supply air required for the spaces. By using chilled beams in spaces that are load dependent there is a high potential for savings.

Chilled beams use natural convection in a room to cool air which falls, forcing the warmer air up. If the chilled beams are chosen to heat as well a supplementary heating system may need to be investigated. There are two primary types of chilled beams active and passive. For this project active chilled beams are chosen meaning a pretreated primary air is used to provide ventilation to the room (Seen in figure 4) The first costs of active chilled beams tend to be higher than variable air volume systems, but the operating costs are far lower resulting significant energy savings though lower air handling unit horse power and increased chiller EER. Chilled beams should not be used in any places with ceiling heights of 14', high latent loads, uncontrolled humidity and restrictions on recirculated air.

An investigation into supplying each non lab area with chilled beams shall be investigated in this depth. Potential savings in cost and energy shall be modeled in Trace.

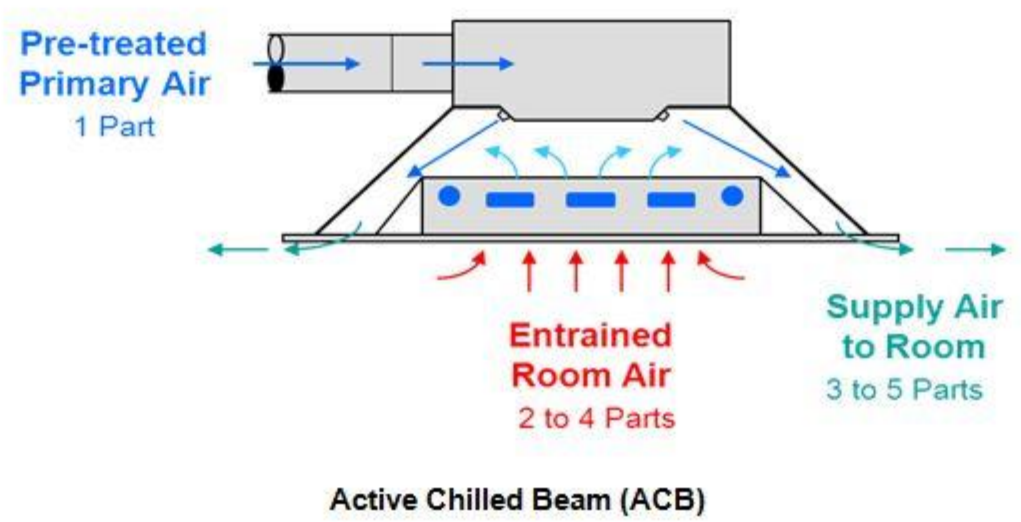


Figure 4

Labs are to be equipped with Aircuity Optinet air sensors which can control the total air changes per hour based on current room conditions and not a preset value. Optinet systems take air samples for a space and by measuring the contaminants in each sample can determine the adequate ventilation rates and can provide an intelligent system for energy efficiency and indoor environment quality.

The cost of installation and equipment shall be investigated. These will be measured against the savings in cost and energy, calculated in Trane Trace, to determine if this system makes sense for the project.

Breadth Topics

Construction Management: Scheduling

A construction management breadth will be investigated into the scheduling changes to 75 Ames with the installation of the chilled beams and Aircuity Optinet system. Due to these extra systems being added the construction time may be elongated costing even more time in labor.

Electrical: Cogeneration

75 Ames Street has been modeled to spend roughly $1.8 million dollars on electricity annually for roughly $9 million kWh of electricity and $557K for 249K of natural gas for heating. In this traditional system electricity comes from the power plant and heat coms from the boiler in the mechanical room. This method yields only 45% efficiency.

There is a better far more efficient method of energy generation and that is the use of a combined heat and power plant, which range from 65-75% efficient.

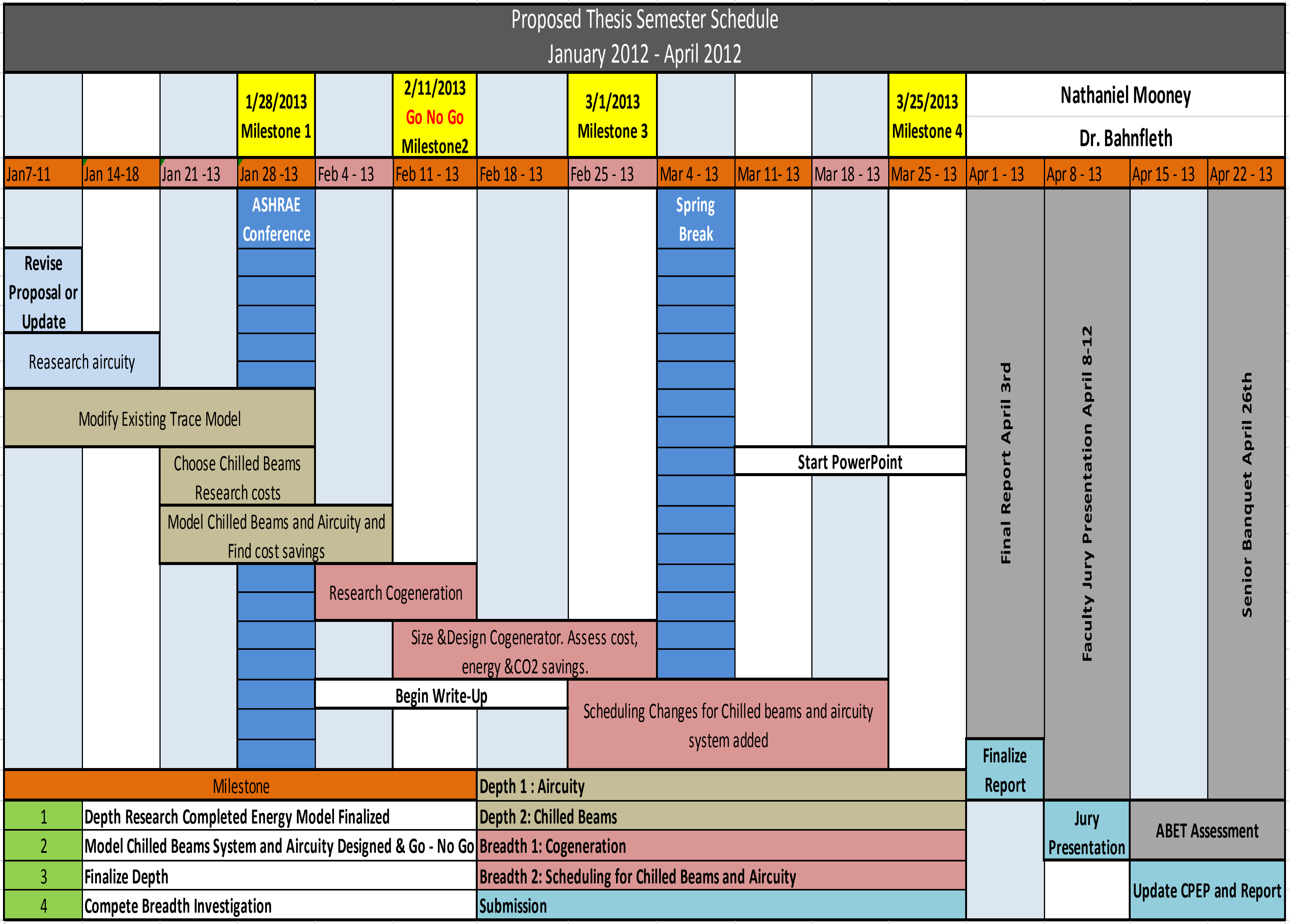
Combined heat and power systems achieve this efficiency by taking themselves off of the grid and producing their own electricity and using the heat created in the process for heating. There are many benefits of switching to such a system such as reduced energy cost. A study will need to be done for the capital, fuel and maintenance cost of a CHP system to that of the purchased power and thermal energy system to determine the economic benefits of such a system. A CHP system also has an advantage of offsetting capital costs of boilers or chillers.

Project Methods

Two alternate mechanical designs as well as two breadth designs in electrical and construction management have been proposed. During the beginning of the spring semester research shall be performed on chilled beams and Aircuity Optinet systems. After the researching a product shall be chosen and effects shall be modeled in Trane Trace, an energy modeling software. A cost analysis shall be performed for this additions versus the old system to determine payback times and savings.

Once the mechanical depth has been performed the Depth analysis will begin for a Cogeneration system. The depth study will start with research into systems, looking at case studies and products. Trace can be used to determine the amount of electricity used in the building to size the generator and understand the heating the building needs. This depth study will determine the economics of adding a combined heat and power system, looking at possible offset first costs, rate of return and simple payback. Emissions shall be compared for this system versus energy supplied from the grid to determine the environmental effects. Economics and emissions shall be calculated in Excel.

Lastly the construction management breadth shall begin. For this the original schedule shall be obtained and through research into chilled beams and Aircuity Optinet the installation times shall be determined. Faculty Consultants shall be utilized throughout the research and analysis of both the depths and breadth to ensure correct reliable data is given.


Proposed Thesis Semester Schedule
January 2012 - April 2012
1/28/2013
Milestone 1
2/11/2013
Go No Go
Milestone2
3/1/2013
Milestone 3
3/25/2013
Milestone 4
Nathaniel Mooney
Dr. Bahnfleth
Jan7-11
Jan 14-18
Jan 21 -13
Jan 28 -13
Feb 4 - 13
Feb 11 - 13
Feb 18 - 13
Feb 25 - 13
Mar 4 - 13
Mar 11- 13
Mar 18 - 13
Mar 25 - 13
Apr 1 - 13
Apr 8 - 13
Apr 15 - 13
Apr 22 - 13
ASHRAE Conference
Spring Break
Revise Proposal or Update
Reasearch aircuity
Modify Existing Trace Model
Choose Chilled Beams Research costs
Model Chilled Beams and Aircuity and Find cost savings
Research Cogeneration
Size &Design Cogenerator. Assess cost, energy &CO2 savings.
Begin Write-Up
Scheduling Changes for Chilled beams and aircuity system added
Start PowerPoint
Final Report April 3rd
Faculty Jury Presentation April 8-12
Senior Banquet April 26th
Finalize Report
Jury Presentation
ABET Assessment
Update CPEP and Report
Milestone
1 Depth Research Completed Energy Model Finalized
2 Model Chilled Beams System and Aircuity Designed & Go - No Go
3 Finalize Depth
4 Compete Breadth Investigation
Depth 1 : Aircuity
Depth 2: Chilled Beams
Breadth 1: Cogeneration
Breadth 2: Scheduling for Chilled Beams and Aircuity
Submission

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