Thesis Proposal

Freetown Elementary School

Glen Burnie, MD

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Architectural Engineering – Mechanical Option

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Table of Contents

Executive Summary

In evaluating Freetown Elementary School, it was observed that the school is a simple design with room for improving sustainable features. The school already captures sustainability through its energy management system and two energy recovery units for the classroom wings, although it will be beneficial to look at other modes of energy reduction.

In this proposal, an in-depth analysis will be broken down into different sections. An analysis of an addition of a ground source heat pump will be made along with the construction management aspects of cost and time of installation. The other analysis will provide information on installing CO_2 occupancy sensors into key areas of the building to apply building loads as needed. A breakdown of cost and time for installation will also be including when determining the advantages and disadvantages of this system.

The final option for the depth of this proposal will include an alternative system comparing a four pipe system to the already installed two pipe system. Advantages and disadvantages will be looked at and discussed as to why each system is pertinent to this elementary school.

Breadth topics that are being discussed are of architecture and of construction management options. The architecture breadth will include a look at the façade of the building to increase the amount of daylight inside the spaces. The construction management breadth will document the time and cost associated with the addition of all of the systems.

Freetown Elementary School Overview

Freetown Elementary School is a two-story building located in Glen Burnie, MD just south of Baltimore. A new building was made in place of the old school to update systems and to provide a better learning environment for the students. The building is approximately 83,000 square feet and is made up of 31 classrooms, also equipped with two music rooms, an art room with a kiln, a computer room, a media center, a cafeteria and a gymnasium. The school was designed with two wings each of two-stories and contains all of the classrooms. An addition was made near the entrance to house an extended day care program. All of the administrative personnel offices are located in the front near the entrance of the building.

Design Objectives and Requirements

Freetown Elementary School was designed following the ASHRAE Standards. In Technical Report #1, an analysis can be found of the ventilation rates of the building and how they compare with the standard. Freetown Elementary School was not designed with LEED aspirations although an analysis of the LEED certification requirements can be found in Technical Report #3.

Mechanical Systems

The main mechanical room is located in the southwest corner of the building along the perimeter. Two natural gas boilers and an air cooled chiller outside control the loads in the building. Freetown Elementary School is based off a 2 pipe system and has controls set up for changeover from heating to cooling and vice versa. Six rooftop air handling units serve the music rooms, gymnasium, cafeteria, administration offices and the media center. Two energy recovery units serve each of the classroom wings. In addition to the air handling units are six ductless split system units serving smaller rooms such as electrical closets. An air source heat pump is responsible for the extended day program located in the north end of the building near the entrance.

RAHU-1, RAHU-2, RAHU-3, and RAHU-4A are constant volume serving spaces such as the music rooms and the cafeteria/gymnasium. RAHU-5 serves the administration section of the school and is a variable volume unit with reheat capabilities. RAHU-6 serves the Media Center and is a constant volume unit with a return air fan. Two variable frequency drive pumps serve the chilled/heating cycle for pumps P-1 and P-2.

Sustainability

Two Energy Recovery Units serve the east and west classroom wings. These units allow for energy savings through reusing the warm temperature exhaust air to heat up the incoming cold air. These units have DX cooling and contain an air cooled condensing unit. The mechanical system is saving energy on the heating coil loads by using of this waste heat from the building.

An energy management system was also in mind when designing. Boiler rotation is monthly and is adjusted by the owner. Independent schedules of operation for each zone listed in the auto-occupied-unoccupied sequence are for energy management. A master schedule for control of all zones (except RAHU-5) in the event of a snow day is also accounted for.

Overall Evaluation

In conclusion of analyzing Freetown Elementary School and progressing towards alternative designs to improve on the buildings energy use and efficiency, there are certain aspects of the building that could be altered with a chance of more sustainability.

Although the building energy sources could not be obtained to this point, it will be important to look further into how the building gets its energy. Freetown Elementary School does not have many sustainability features so researching to include various systems to the building could benefit the overall performance.

Proposed Alternative Designs

Ground Source Heat Pump with thermal storage

In order to take advantage of the earth's constant temperature, a ground source heat pump will be researched and modeled to look at advantages and disadvantages of installation. A ground source heat pump could be integrated into the mechanical system to lower the energy use of the building in the extreme months in the summer and in the winter so the air handlers will not have to work as hard. Copper piping in the ground source heat pump is a large determining factor since the price is high for copper.

This system will reduce environmental noise because there is no need for compressors outside. The importance of this is vital because the elementary school is located in the middle of a residential area.

The location of installing a ground source heat pump will be looked into as well as the cost and schedule aspects. Since there is adequate space for installation because of many athletic fields surrounding the school. This study will be a reasonable option.

Ground source heat pumps are the most energy-efficient, environmentally clean, and cost-effective space conditioning systems available according to the US Environmental Protection Agency. Heat pumps also offer reduction of emissions, which is better for the environment.

Install CO_2 Occupancy Sensors

This study will install occupancy sensors to control the ventilation as well as lighting within a space. These sensors will have an effect on the amount of outdoor air and amount of return air that could be used. If less people are in the space, less outdoor air would have to be brought in resulting in energy savings because of the reuse of return air that is already conditioned. An analysis will be made for cost and length of time for installation.

Four Pipe System

Currently, Freetown Elementary School is a two pipe system that needs to be switched over from heating to cooling or from cooling to heating. One pipe is dedicated to supply and one pipe is dedicated to return depending if the spaces are calling for heating or cooling.

A four pipe system will be researched and modeled to determine the advantages and disadvantages of the system. In a four pipe system, two pipes are dedicated to supply chilled water and hot water and two pipes are dedicated to return chilled water and hot water.

A four pipe system will make available chilled water or hot water at all times. The computer room air needs to be controlled usually at a cooler temperature because of the chance of overheating the computers and equipment. This system could also be used for rare hot days in the typical cooler months or cold days in the warmer months.

Breadth Topics

Architecture

An addition of glazing on the exterior façade will be analyzed for the advantages and disadvantages in hopes of increasing the day-lighting within spaces on the north side of the building. A new model will be made in analyzing this concept. Improving the amount of natural light that gets into the building can help reduce the electricity costs.

Construction Management

If the ground source heat pump or occupancy sensors are installed, changes in the schedule and costs related to the extra time will be associated with the installation. A crew will be assembled for this work which will add in this extra time. This will affect the decision for installing either of

these items. An analysis will be done to check on equipment needed for installation as well as other items needed. A new schedule will be implemented and a change order will be prescribed along with a site map of where the ground source heat pump will be located in comparison to the building.

Software and Tools for Analysis

Energy Modeling Software

Trane Trace 700 will be used as the energy modeling software. The original model will be altered in Revit Architecture 2010, which was used to build the model in three dimensions in Technical Report #2. The current energy model will be revised to better reflect the building loads and operation. The energy recovery units serving the classroom wings will be of interest in altering the system to be more accurate.

Microsoft Excel

Design problems that cannot be solved or modeled will be evaluated in Excel. Excel will help organize all of the data and can be easily changed if other options are explored.

Resources

ASHRAE (2005). *Handbook – Fundamentals*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Council, U.S. (2009). LEED 2009 for New Construction and Major Renovations. Washington, D.C: United States Green Building Council, Inc.

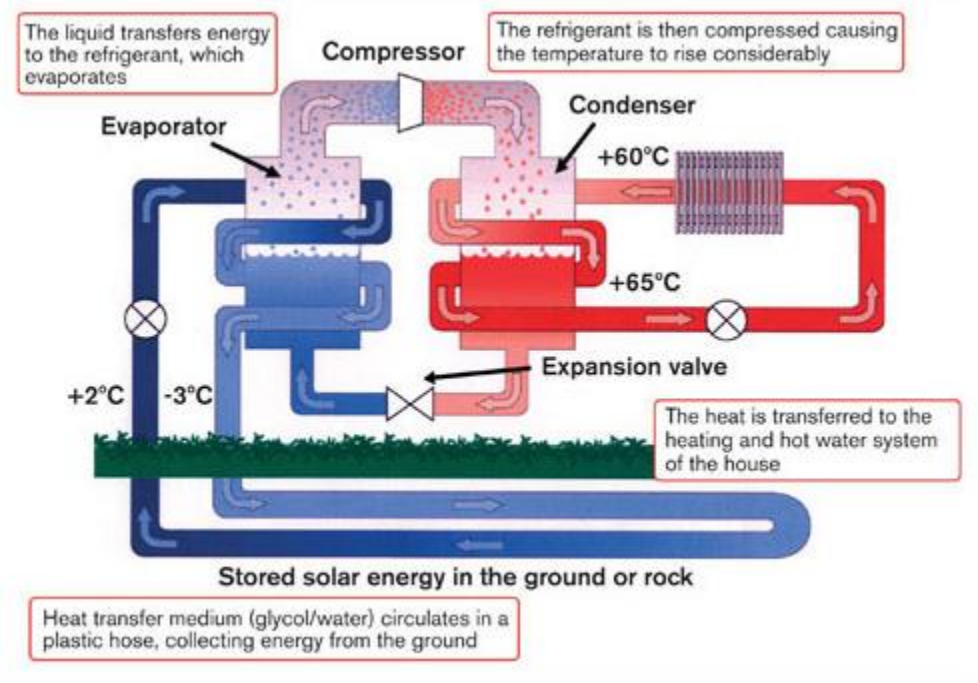
"Ground Source Heat Pumps in Schools. - ASHRAE Journal | HighBeam Research - FREE Trial." Research - Articles - Journals | Find Research Fast at HighBeam Research. Web. 10 Dec. 2010. <http://www.highbeam.com/doc/1G1-169458063.html>.

James Posey Associates. 2008. MEP Construction Documents. James Posey Associates, Baltimore, MD. 2008.

"RJS Heating Renewable Energy." *RJS Heating*. Web. 10 Dec. 2010. <http://www.rjsheating.co.uk/renewable.php>.

Rubeling Associates, Inc. 2008. Architectural Construction Documents. Rubeling Associates, Inc., Towson, MD. 2008.

Appendix A: Preliminary Research



According to the US Department of Energy, schools that have ground source heat pumps reduce energy use between 25% and 50%. A typical payback period is of two to eight years. The only drawback is the unfamiliarity of the technology used in creating ground source heat pumps.

Appendix B: Proposed Schedule for Spring Semester