Thesis Proposal

Freetown Elementary School

Glen Burnie, MD

Matthew R. Buda

The Pennsylvania State University

Architectural Engineering – Mechanical Option

Advisor: Dr. Treado

Table of Contents

Executive Summary	**2**
Overview	**3**
Design Objectives and Requirements	**3**
Mechanical Systems	**3**
Overall Evaluation	**4**
Proposed Alternative Designs	**4**
Breadth Topics	**5**
Software and Tools for Analysis	**6**
Resources	**7**

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 addition of a ground source heat pump will be made. A solar system located on the roof will be installed to look at the benefits of "free energy" from the sun. The other analysis will provide information on installing indoor environment quality sensors into key areas of the building to apply ventilation rates as needed. Advantages and disadvantages to all of these additions will be looked at. The ground source heat pump and the solar addition will be modeled to determine the energy and cost savings.

Breadth topics that are being discussed are of the lighting and the structure. The lighting/electrical breadth will look at the installation of occupancy sensors for a better control of lighting throughout the day. The structural breadth will be in conjunction with the solar system addition. An analysis of the roof, joists, columns, and foundation will be done to determine the upsize in structure to accommodate the weight of the solar system.

In conclusion, advantages and disadvantages will be made for each selection. Keeping in mind cost savings, energy savings and the indoor environment will determine whether or not these systems are feasible with this type of building in this location.

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

Install Ground Source Heat Pump

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.

Solar System

A solar system will be added to the mechanical system in order to decrease energy use. A solar panel will be chosen and the number of panels will be determined based on the heating load of the building. An analysis of cost, savings, and payback will be done. The location of the solar panels will be modeled to show the altered view on the roof. Panel care and maintenance will also be analyzed to determine the life span of the solar panels.

Install Indoor Environment Quality Sensors

This study will install indoor air quality sensors to control the ventilation 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 improvement on indoor air quality.

Breadth Topics

Lighting/Electrical

Occupancy sensors for lighting will be installed in conjunction with the indoor environment quality sensors to reduce electric consumption. The use of occupancy sensors will eliminate the lighting that is not needed at certain times. Different variations will be looked at including infrared, ultrasonic, and a hybrid sensor. Room layouts will be displayed to show the best location of the sensor and the coverage in the room. In addition to the responding occupancy sensor, the sensor will also be programmed to adjust to natural lighting from the sun. A dimmer will be used to dim the lights closest to the windows to help save on energy. The cost of the sensors will be displayed and the potential savings.

Sustainability

An addition of a rainwater collection system will benefit the school because of the reuse of rainwater. Instead of draining the water away, this water can be used to circulate throughout the building. Components that will benefit from this will be the usage of water in toilets and sinks.

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.

TRNSED will be used as the energy modeling software for the addition of solar panels to the roof. This program calculates the overall energy use for a solar system. Then by using the natural gas or electricity rates, the decision can be made for the auxiliary energy source.

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.