Thesis Proposal

Mechanical

Proposed Mechanical Revisions for Twin Rivers Elementary/Intermediate

Author:
Tessa Bauman

technical consultant:
Laura Miller, Ph.D, P.E.

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Executive Summary

This is the thesis proposal to be completed in Spring 2014. The contents include a summary of the building and the mechanical spaces, alternative ideas taken into consideration for the proposal, mechanical depth proposal and the two breadths.

The mechanical depth proposes inclusion of a solar hot water system to provide auxiliary heat into the existing geothermal system and provide heating for the domestic hot water. This would remove an existing boiler and one of the current water heaters, both located in the mechanical space on the first floor. Both of the original systems used natural gas to introduce heat into the respective water lines. An optocaloric panel would decrease cost of fuel by eliminating most of the systems that require natural gas.

The breadth analysis concentrate on acoustics and structural topics. The acoustics breadth will take into consideration the storefront glazing that surrounds a portion of the mechanical and electrical rooms. A closer look will be taken to ensure that the core learning areas will not be affected by the HVAC equipment. The structural depth will consider the effect of the additional load added to the cafeteria roof. The solar panels proposed in the mechanical depth will increase the roof load and had not been taken into consideration during the first load calculations.

Building and Mechanical Systems Summary

The Twin Rivers Elementary/Intermediate School will house 800 students of the Mckeesport Area School District. It is a two story building of 127,000 sq. ft. The Mechanical system is designed to save 30% of energy when compared to ASHRAE standard 90.1-2007 requirements. ASHRAEs Advanced Energy Design Guide for K-12 School Buildings also had a major impact on the design. The building has many different rooms with different functions, including the following types of areas:

- Cafeteria
- Classroom
- Computer Lab
- Corridor
- Gymnasium
- Kitchen
- Library
- Mechanical & Electrical
- Nurse's area
- Offices
- Water Closets

The main heating and cooling will come from a geothermal heat pump system. This will be an earth coupled water loop directly connected to water-to-air heat pumps. There will be 2 well fields located slightly north of the building's foundation. The earth coupled water loop will also be connected to a chiller, serving air handling units, variable volume reheat boxes, and radiant floor systems for the kindergarten, pre-school rooms, and library story room.

The ventilation system consists of 2 dedicated outside air systems (DOAS) which serve the classrooms and most of the building. The library, cafeteria, gymnasium, and offices each have individual air handling units (AHU). The library and office AHUs will have zone reheat coils. The gym and cafeteria AHUs will consist of just a single zone.

Design Objectives

Twin Rivers Elementary/Intermediate was designed to be a state of the art educational building. It is to be a example for other school districts in the area to follow. LEED considerations heavily influenced the design. Once completed, the school is to be LEED Silver certified. The HVAC design references the following standards:ASHRAE 15-2010,62-2007,90.1-2007, and 55-2004,and uses ASHRAEs 2006 Advanced Energy Design Guide for K-12 School Building as a guideline.

Ventilation

Two DOAS's, four AHU's supply the building, one kitchen make-up air unit, and one fan coil unit provide the building with the appropriate ventilation as required by ASHREA Standard

62.1.

The DOAS's return air, including that from the restrooms and from the classrooms, is used within the DOAS for heat recovery. It is then exhausted out of the system near the outside air intake. Since restroom exhaust is considered a Class 2 exhaust, it is allowed to be recirculated into the system. The AHU supplying the cafeteria and support area is placed at least 18 feet away from the kitchen exhaust. This is more than the 15 feet required for a Class 3 exhaust. The Kitchen will have specific exhausts to the rooftop. Because of this, there is a kitchen makeup air unit.

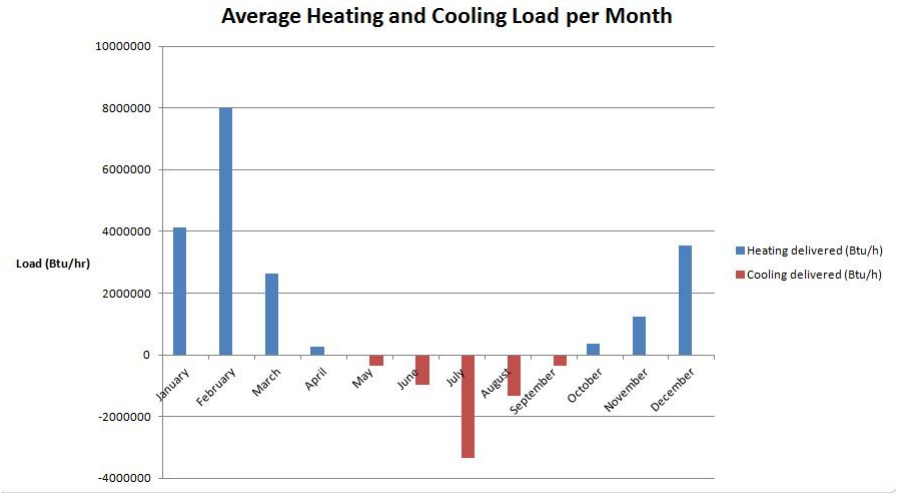
A ventilation calculation was performed in order to determine outdoor air intake flow for optimal ventilation system for breathing zone. All systems met the required outdoor air minimums.

Heating and Cooling Loads

Twin Rivers Elementary/Intermediate is designed for 99.6% winter conditions due to the lack of occupancy during the summer months. This means that most of the load is for heating purposes.

A Load simulation was preformed in the TRANE Trace program. To do this, a block load energy analysis was applied. Within Trace, templates for different zone types were created. A block load analysis is for simplicity and estimation.

The following graph is the load for each month of the year. February has the highest average load due to extreme winter conditions. December and January do not have a high load as it may be expected. This is because these months have school holidays that lessen the load needed during those times. The peak heating load is 10,998 MBh. This is typical for western Pennsylvania design conditions.



Alternative Designs

Many ideas for improving the mechanical system were considered. The following are proposed design revisions to lower the life time cost of the building and utilize on site energy sources. Among the most prominent ideas were waste heat recovery from existing sanitary tank and Chilled beams to replace office and library reheat units.

Waste Heat Recovery Auxilary

By implementing a waste heat recovery system, the auxilary boiler to the geothermal heat pump system could be eliminated. A waste heat recovery system would provide the option to reduce the number of wells of the bore field from 102 to a more reasonable number. However, The nearest sewage tank is far from the building. This would require the installation of a new tank. This would most likely remove the benefit of drilling less wells.

Chilled Beams

There are currently 24 variable volume reheat units extending from air handling units 2 (supplies library) and 4 (supplies offices). If these were to be replaced by chilled beams, there would be future savings in maintenance, the room would not have nearly as much HVAC noise which is important in these areas, and they would reduce the necessary fan usage. However, since there are only 24 units, the benefits would most likely fall short of the overall impact on the project.

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Solar Thermal Auxiliary

The most likely solution to extracting on-site energy would be to involve a optocaloric auxiliary system. This would work in a similar manner to the waste heat recovery system mentioned above. The proposed renovation would connect the solar thermal energy into the heat pump water system and remove the currently scheduled auxiliary boiler. This could reduce the number of wells needed to be drilled, reducing the initial cost of the geothermal system. There is adequate space available on top of the cafeteria roof, which are in close proximity to the mechanical spaces on the first floor. The solar thermal system should be able to provide enough auxiliary heat to the heat pump system and also have additional heat when auxiliary heat is not need. The proposed system could look similar to this diagram.

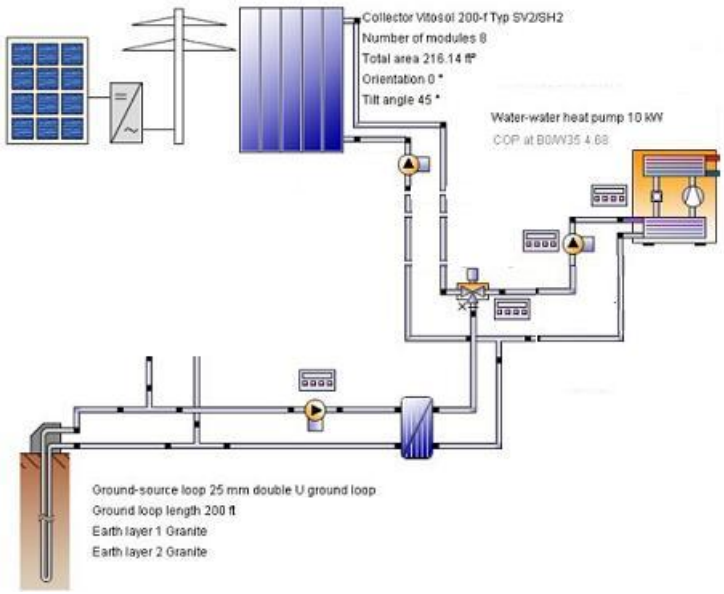


Figure 1: Geothermal heat pump system with auxiliary solar energy system

Currently there are two 125 gallon domestic water heaters serving hot water to the building. It is possible to replace one or both of these with the excess energy produced by the optocaloric panels, depending on their efficiency and size. This would be an additional benefit for installing the solar-based system.

The initial cost of the system may be high but natural gas fuel savings could make the installation of a solar energy system worthwhile. A appropriate life cycle cost evaluation must be done to determine if the project is cost efficient idea.

Breadth Topics

Acoustics Breadth Evaluation

The current design has the mechanical room encased by a exposing glass wall. This was decided so that students of Twin Rivers Elementary/Intermediate would have a clearer understanding on mechanical and electrical systems at a young age. However, This proposed wall system could lead to loud HVAC noise entering the corridor and other adjacent spaces. 28% of the mechanical space perimeter wall is constructed of of an interior storefront glazing. A full acoustic evaluation of machinery and transmission loss of the glazing would determine if the hvac noise is too loud for core learning spaces.

Structural Load Breadth Evaluation of Collectors

The suggested placement of the collector is to be on the cafeteria roof. This is a large enough area but, the roof is not designed to hold the extra weight that a solar collectors would entail. A load analysis will be preformed to ensure that the building is adequately strong. Recommendations will be given to increase strengths of materials to ensure building safety.

Tools and Methods

Complete Solar Analysis

In order to have necessary information for the proposed optocaloric panel, A solar analysis must be completed. This includes, but not limited to: solar shading analysis, optimum tilt analysis, type of panel research.

Trane Trace 700

The load evaluation in TRACE preformed for technical assignment 2 would be adapted to include a optocaloric panel. The load analysis would determine how much thermal energy must be entered into the geothermal heat pump system.

SAM

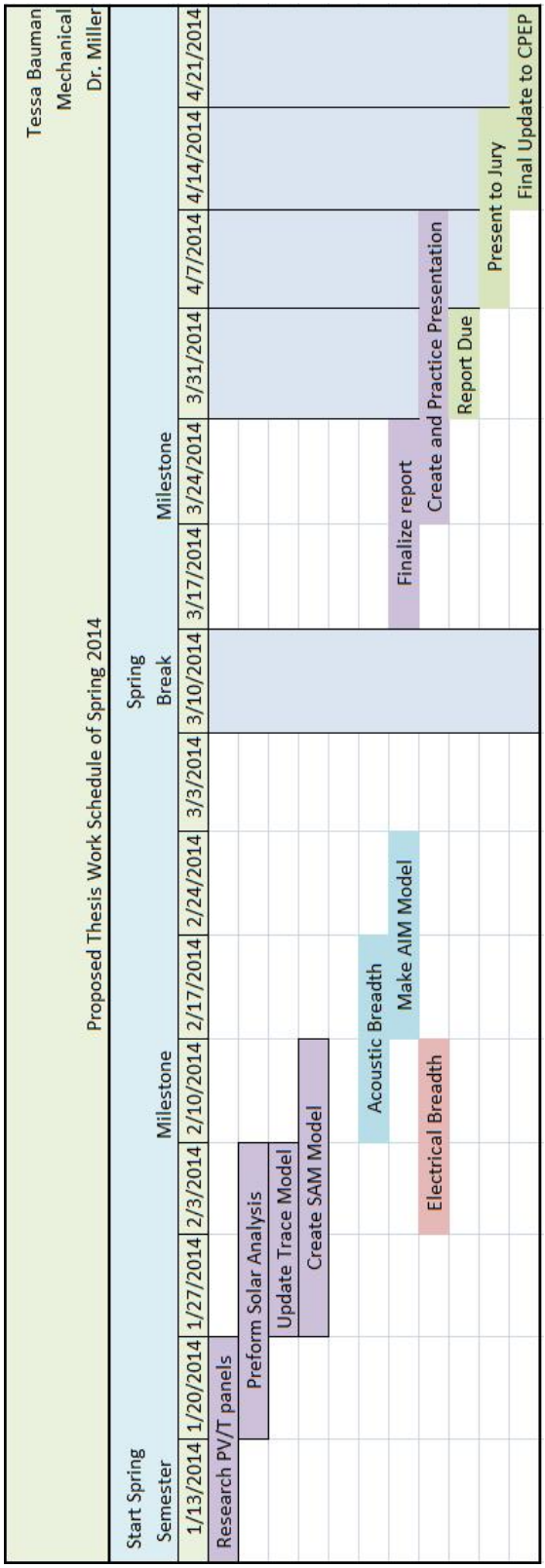
SAM(System Advisor Model) is a program that will calculate the life cycle cost of the optocaloric and the geothermal system. This will produce results that will help determine if a solar energy panel would be useful in this particular project.

AIM

Dynasonics' program AIM(Acoustic Information Model) will provide an adequate evaluation of noise entering the mechanical room's adjacent spaces. The program will be used for the Acoustics breadth.

Load Calculations with STAAD The program will help assess the load added to the cafeteria roof.

Schedule of Work



References

ASHRAE. Standard 62.1-2007, . Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc

ASHRAE. Stanard 90.1-2007, Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

Design by J C Pierce, Architects with help from the following engineering firms

- Phillips & Associates, Inc
- Loftus Engineers
- American Geosciences, Inc.