Mechanical Thesis Proposal

National Rural Utilities Cooperative Finance Corporation (NRUCFC) Headquarters Building
Sterling, VA

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Executive Summary

The purpose of the Thesis Proposal is to propose alternative mechanical systems to be used in National Rural Utilities Cooperative Finance Corporation (NRUCFC) as well as two proposed breadth topics. The new headquarters building is 120,000 square foot office building that will also house a fitness center, café, and executive lounge. The three-story above grade building is located on a 42-acre lot in Sterling, VA, about 10 miles north of the Dulles International Airport, at the intersection of Route 28 & 7. The headquarters is LEED® Gold certified.

The alternative proposed systems include a solar thermal system, a dedicated outdoor air system with chilled beams, and the use of passive solar heating. The breadths include a study of the control systems and an architectural study.

The solar thermal systems will include solar collectors, storage tanks, and distribution equipment. The advantage of this system is that it will reduce the demand on the current heating system, reduce the carbon footprint of the building and reduce operating costs.

The second alternative design will utilize chilled beams which will reduce the fan power needed to cool the space, saving again in operating costs and create a more uniform distribution of air within the spaces.

Thirdly, the use of passive heating in the atrium is being considered to reduce the heating load during the day.

The breadth topics will include a study of the control systems and a plan as to how to maximize the efficiency of the controls to make the building systems more efficient and an architectural study to see how the additional on the proposed alternative systems will impact the façade and envelope.

Existing Mechanical Systems Overview

Existing Systems

Primary Cooling

Two 210 ton electric centrifugal chillers are located in the first floor central plant. They incorporate oil-free compressors to increase part-load efficiency. Six "ice on coil" storage tanks will circulate 25% ethylene glycol solution through the chillers. Two induced draft cooling towers are located on the roof. The central plant and piping has been configured to allow for future expansion and serve as the central plant for other buildings.

Primary Heating

Two high efficiency natural gas-fired condensing boilers are located in the mechanical penthouse and serve as the primary heating source. They will circulate water to the terminal units with a hot water heat feature. The heating plant is also configured for future expansion.

Atrium Heating and Cooling

A combination of radiant flooring and ventilation units serve as the heating and cooling for the three story atrium. A water to water heat pump serves the radiant flooring while three ground source heat pumps ventilate the space. Both systems are connected to the geothermal well located in the parking lot.

Office Space Heating and Cooling

Four central air handling units, located on the roof, serve as the heating and cooling for the office spaces, supplying to the zones shown in Figure 1. The perimeter spaces are ventilated by fan powered boxes with a hot water coil. Interior spaces are ventilated by VAV boxes.

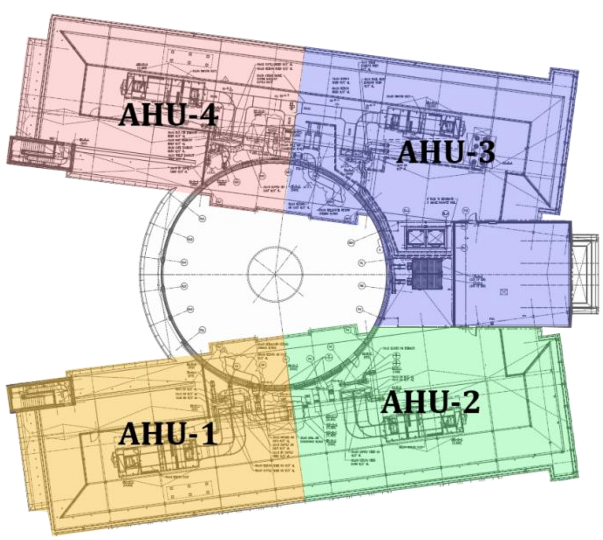


Figure 1 | AHU Zones

Design Objectives and Requirements

The National Rural Utilities Cooperative Finance Corporation Headquarters building was designed to exemplify the CFC as an industry leader in environmental stewardship and "make a positive environmental impact, be cleaner, healthier, more efficient, and project an image of openness and accessibility, yet be a secure and safe workplace for our staff and visitors." The design objectives included receiving LEED Gold Certification while selecting cost effective systems based on life cycle cost. The owner wished the building be redundant and efficient.

Design Conditions

The design conditions were taken from weather data provided in the ASHRAE Handbook of Fundamentals for Washington D.C. and experiences similar weather as Sterling, VA. The values in Table 1 below were used when calculating the design loads and energy use.

Table 1 | ASHRAE Weather Data | Washington, D.C.

ASHRAE Values	Outdoor DB (^oF)	Outdoor WB (^oF)	Design Indoor DB (^oF)
Summer Design Cooling (0.4%)	93.2	75.1	75.2
Winter Design Heating (99.6%)	9.6	-	71.8

Mechanical System Evaluation

Overall the NRUCFC Headquarters facility is designed as an efficient and redundant system. A VAV system coupled with efficient chillers and boilers along with utilizing other technologies like geothermal heat pumps and radiant flooring has led to this efficient design. The aesthetics and function of the building lend towards achieving the goals that the CFC wished to accomplish coming into this project.

The CFC went above and beyond to ensure that if there was a failure a back-up system would be able to handle the load and things would run smoothly. Most of the major equipment is located in either the central plant on the first floor, the mechanical penthouse or mounted on the roof. The vertical mechanical shaft space takes up little of the floor area. Centralizing a majority of the equipment leads to easy of maintainability.

As shown in the LEED assessment, an effort was made to make the building more energy efficient, have less of an impact on the environment, and have a high air quality. The LEED Gold certification was achieved due to the great efforts of the design team.

While the mechanical system is designed to be efficient, the complicated nature of the system could be investigated to see if a less complicated and redundant system could be used to achieve the same energy efficiency and quality.

Proposed Alternative Systems

While the NRUCFC Headquarters building is designed to be energy efficient and sustainable, there are other technologies that could be investigated to see if they would be more cost efficient and more energy efficient. The following is a proposal for the redesign of current systems and an investigation into the feasibility of the additional system redesign.

Depth Topics

Solar Thermal System

A solar thermal system uses the heat from the sun collected through solar thermal panels to heat the building and is an effective way to offset space heating energy use. It can also be used to heat domestic hot water. While there is currently a small photovoltaic panel located on the north side of the building, it contributes very little energy to the building load. Solar thermal panels would alleviate more of a load on the building. The proposed system will assist the existing natural gas boilers. The building location is a large flat site and has room to place the collectors in a number of locations as to not be blocked by the sun. A solar analysis will be performed to determine the best location to maximize the amount of energy that can be collected. The type of collector and water system will have to be investigated to determine the best design for the new headquarters.

Dedicated Outdoor Air System (DOAS) with Chilled Beams

A DOAS uses 100% outdoor air to ventilate a building and provide fixed quantities of ventilation air directly to each occupied space. The use of chilled beams will reduce fan power and thus reduce the electrical load and operating costs. Chilled beams provide uniform conditions throughout a space because they distribute air at a low velocity and they are very quiet. A drawback of using chilled beams is that water temperature can't get too low or condensation on the beam with form and "rain". They are best used for cooling and can be supplemented with other heating devices.

Passive Solar Heating

A study will be conducted to see if the atrium, with 3 stories of glazing, can be passively heating during certain times of the year. The glazing used can be investigated to determine the best material. There is a marble floor in the atrium that can be used as a thermal mass. This proposed system can supplement the radiant flooring and geothermal heat pump that is currently used to heat the atrium.

Breadth Topics

System Integration Maximization

Currently the systems and their controls are very complex. There are several modes that the building can operate in. A study can be done of the controls to determine if they can be maximized to see if in these modes, the equipment is running at its most efficient. If the controls are maximized, the equipment will be operating at their highest efficiency and therefore enhance the efficiency of the entire building.

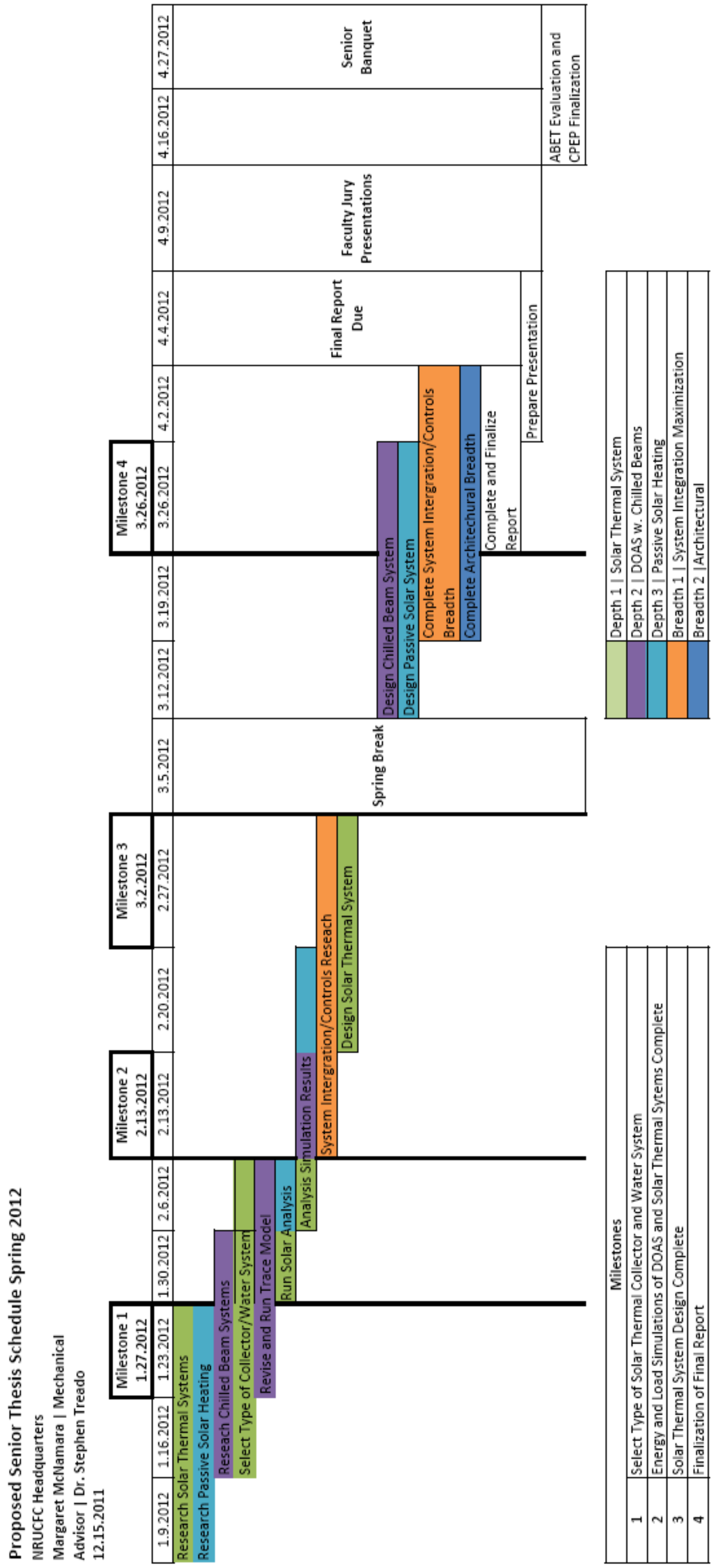
Architectural

The utilization of solar thermal panels could potentially be incorporated into the architecture of the building, if it was decided to add the panels to the exterior of the building. Also, using passive solar heating, there may need to be minor changes to the windows and orientation of the building. There made also need to be the addition of shading.

Tools and Methods

TRANE Trace will be used to determine the new loads and energy use from the new system redesign. Autodesk Ecotect Analysis software be used for determine the amount of usable energy that will hit the solar collectors. For some spaces, Design Builder and EnergyPlus will be used to show the energy simulation. Excel will be used to for necessary calculations and to organize data. Autodesk AutoCAD will be used to show the proposed new layout of the terminal boxes and solar collectors. ASHRAE Standards and Virginia Building Codes will be used to ensure that the new designs comply.

Proposed Spring 2012 Schedule



Resources

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