

# Mechanical Thesis Proposal

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



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Revised 1.13.2012**

## Table of Contents

Executive Summary.....	3
Existing Mechanical Systems Overview .....	4
Existing Systems.....	4
Design Objectives and Requirements .....	5
Design Conditions .....	5
Mechanical System Evaluation .....	5
Proposed Alternative Systems .....	6
Depth Topics .....	6
Hybrid Solar System .....	6
Dedicated Outdoor Air System (DOAS) with Chilled Beams .....	6
Breadth Topics .....	6
Electrical.....	6
Architectural .....	6
Tools and Methods .....	7
Proposed Spring 2012 Schedule .....	8
Resources.....	9

## 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 hybrid solar system and a dedicated outdoor air system with chilled beams. The breadths include a study of the electrical system and an architectural study.

The solar thermal systems will include hybrid solar thermal/PV collectors, storage tanks, and distribution equipment. The advantage of this system is that it will reduce the demand on the current heating and cooling systems and electrical 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.

The breadth topics will include a study of the electrical study to see the impact of using the hybrid solar system and an architectural study to see how the addition of these new systems will impact the building façade.

## 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.

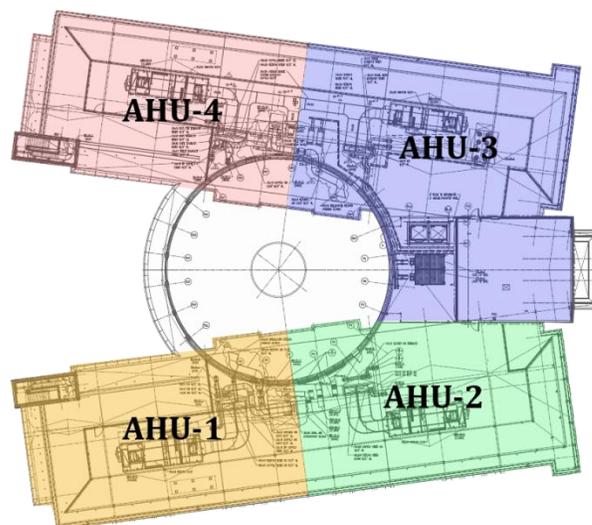


Figure 1 | AHU Zones

## 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 (°F)	Outdoor WB (°F)	Design Indoor DB (°F)
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

#### Hybrid Solar System

A hybrid solar system uses the solar photovoltaic panels with thermal modules attached to convert the solar energy into both usable electric and thermal energy. The thermal energy can be used to heat domestic hot water as well as space heating and cooling. The electric energy can be used to supplement the load on the grid from the building. 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 during peak hours. 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. A study will be performed to see if the panels are able to reduce the load on the building and make it more efficient.

#### 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.

### Breadth Topics

#### Electrical

Using the hybrid solar system, an electrical analysis will be performed to determine the existing electrical loads and then see if the new system was cost efficient in alleviating some of load during peak times from the grid. The study will also look at the impact of using a DOAS system instead of the existing system.

#### 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. The panels can sometimes be large in size and therefore impeded on the architecture. To show the new façade and impact of the new systems on the architecture, a Revit or Google Sketch-up model will be used.

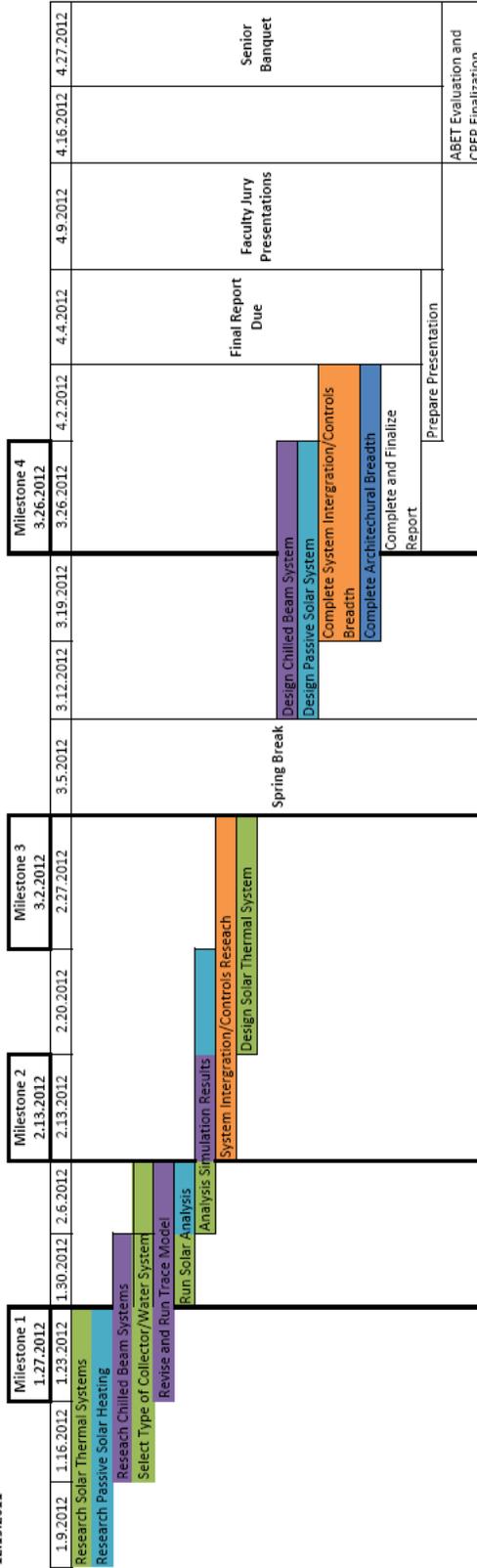
## **Tools and Methods**

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

## Proposed Senior Thesis Schedule Spring 2012

NRUCFC Headquarters  
 Margaret McNamara | Mechanical  
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 12.15.2011



Milestones
1   Select Type of Solar Thermal Collector and Water System
2   Energy and Load Simulations of DOAS and Solar Thermal Systems Complete
3   Solar Thermal System Design Complete
4   Finalization of Final Report

Milestones
Depth 1   Solar Thermal System
Depth 2   DOAS w. Chilled Beams
Depth 3   Passive Solar Heating
Breadth 1   System Integration Maximization
Breadth 2   Architectural

## Resources

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