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Thesis Proposal

Preliminary Proposal for the Investigation of Alternative Systems

Army National Guard

Readiness Center Addition

Arlington, Va.

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Executive Summary

The Army National Guard Readiness Center Addition (ArNG) will function as an administrative headquarters in conjunction with the existing complex on site. It mainly houses open office spaces and conference centers but will contain an auditorium and training facility as well. This building however deviates from a typical office building with its security and operations centers which have a higher concentration of computing equipment.

The most important aspects of the mechanical system design were to provide substantial thermal comfort as well as indoor air quality. This was of primary concern, but energy efficiency was greatly considered as well.

The ArNG building houses a hydronic HVAC system consisting of a heating and chilled water 4 pipe system. Variable Air Volume (VAV) terminals and Computer Room Cooling (CRAC) units condition the spaces where applicable. This type of system is easy to manage (common for this type of building), cheap to maintain, and fairly efficient.

Direct digital control is achieved through building automation systems (BAS) and building management systems. The BAS system controls all of the VAV terminals as well as damper systems.

The ArNG building contains over 126,000 square ft. of office space. This is roughly half of the total building area and as a result the largest area for potential improvement. To reduce loads to these spaces, a Dedicated Outdoor Air System (DOAS), will be analyzed. Other load reducing measures will be studied such as solar shading. With the loads successfully reduced, it is then possible to analyze alternatives such as a Combined Heat and Power (CHP cogeneration) system. A comparison will be conducted between the existing system and all alternatives.

The overall object of this proposal is to minimize energy consumption of the ArNG building thus making it less expensive in daily operations. Doing this will in effect reduce the carbon footprint of the building.

Several programs including Trane Trace will be utilized. Using the load data from the energy model it is possible to conclude which solution will provide the lowest initial cost with significant long term paybacks, while maintaining an ease of operation and efficiency.

System Description

Introduction

The ArNG building will function as an administrative headquarters in conjunction with the existing complex on site. It is an 8 story, 251,000 square foot facility which mainly houses open office spaces and conference centers but will contain an auditorium and training facility as well.

Design Objectives

When the designers sat down to analyze the future mechanical systems for the ArNG building there were two main focuses. Meeting and or exceeding the necessary ASHRAE standards while striving for an energy efficient design. This energy efficient design should warrant LEED points for the goal of being certified LEED Silver. From the ASHRAE standards the ArNG building must meet thermal comfort as well as IAQ stipulations. To meet these requirements a simple VAV system was specified to condition the spaces. These VAV systems are used in conjunction with high efficiency chillers with cooling towers, boilers, and efficient CRAC units for high demand spaces.

Site and Budget

The site of the ArNG building is located in Arlington, Virginia. The building is owned by the Army National Guard and the facility is to be an expansion of an existing facility on the site. The site is located on a very soft and spongy soil making it difficult for the foundation system. This is due to an unknown source of water entering the site from several sides. Current information is being obtained on budget information but the initial project budget was roughly $89 million with a budget of $9.7 million for the mechanical system. This is protected due to the government use of the building and that it is still under construction.

Equipment Summaries

The ArNG building houses a hydronic HVAC system consisting of a heating and chilled water 4 pipe system. This water is supplied to mechanical rooms on every floor containing AHU's as well as VAV terminals. There are a total of 17 AHU with one specified per tower level. The 3 underground levels hold the majority of the units and they range anywhere from 500 cfm to

4250 cfm. Typical unit size for the 5 tower levels is 1550 cfm. This system is supported through the use of CRAC units in spaces with higher thermal demands.

The AHU's and VAV terminals are supplied with chilled water by means of two 400 ton centrifugal water-cooled chillers specified in conjunction with two cooling towers. The cooling towers have a maximum flow rate of 1200 GPM with 25 HP fans. Heating is done through hot water which is supplied by five 930 MBH gas fired boilers which are 93% efficient.

The chilled water distribution system consists of three chilled water pumps with variable frequency controllers pumping chilled water through the evaporator of one or both chillers, the heat exchanger, and to the building loads. The system uses two pumps to achieve maximum flow with a third pump functioning as stand-by if needed. The required flow through the chilled water system is controlled by varying the speed of chilled water pumps and corresponding bypass valve. The flow to each chiller's evaporator is monitored by a flow sensor in the chilled water supply branch. The chilled water by-pass valve has the ability to modulate to maintain minimum chilled water flow to each active chiller. Finally the variable frequency controllers (VFC) modulate the speed of the chilled water pumps which maintain the differential pressure at a designated set point.

The heating water distribution system consists of two heating water pumps with variable frequency controllers pumping water through any one of the five boilers and heating coils throughout the building. The system uses 1 pump for system flow and the second as a stand-by if needed. The required flow through the heating water system is controlled by varying the speed of the heating water pumps. The VFC's are in place to modulate the speed of the pumps to maintain the differential pressure at a designated set point.

Mechanical System Evaluation

From an overall standpoint, the mechanical system of the ArNG building seems to be fairly typical. It is not only efficient, but it seems to have been implemented in a timely and cost effective manner. The specified VAV system in conjunction with high efficiency equipment can satisfy nearly any kind of load thrown at it, that is if it has been implemented in the correct fashion. Being that that this building will function as a multi-use administrative office building, a VAV system is a fairly common solution for the mechanical system.

The majority of the building is powered by delivered electricity, however there are several natural gas fired boilers on site. Although initial costs of the systems are still being explored, this system is fairly typical and should compare to a mid-rise multi use office building. The building utilizes 100% outdoor air (OA) which must be considered in these costs.

As for the total annual consumption for the ArNG building, it was found to be 4,664,299 kWh for electricity and 6,320,662 kBtu for gas. The majority of these values arise from space heating of the tower and lighting fixtures throughout the building. From the above energy consumption, it was determined that the ArNG building will require around $0.31/SF a year to operate. The cost/SF is currently under review. It has been established that this value is somewhat low and it should be reasonable to assume that it be around $1.00/SF or slightly more. The system is fairly common and thus typical building engineers will be familiar with its operation and maintenance. A VAV design is fairly simple and when in place with the BAS controls allow for high efficiency.

Proposed Alternative Systems

The ArNG mechanical system is sufficient for this type of building use. It meets the LEED certifications while complying with ASHRAE Standards 62.1 and 90.1. There is however always room for improvement. The folioing alternative solutions are intended to reduce operating costs which is directly tied to increasing efficiency. Areas for improvement are currently under review but will consist of DOAS and CHP.

Dedicated Outdoor Air System

The first alternative is known as a DOAS. With this type of system 100% outdoor air (OA) is used to ventilate a space. Because only OA is being used for ventilation, duct sizes can be significantly reduced in comparison to that of a standard VAV system. It is important to note that sensible and latent loads must be treated separately. This type of system is often coupled with fan-coil units, chilled beams, and other methods to meet remaining sensible loads within the space. Specifically, latent loads will be handled at the AHU.

The DOAS setup consists of the following: an enthalpy wheel, AHU's, coupled with some form of terminal units. With any system there needs to be some form of regulations and ASHRAE Standard 90.1 stipulates that preconditioning the air is a requirement. This system uses 100% OA for the supply and thus has no mixing requiring total heat recovery. A standard VAV system mixes OA with return air (RA) accomplishing preconditioning before the coils. The heat recovery unit utilized uses energy from within the building in a process with the OA.

Though more research is pending, utilizing a DOAS setup for the ArNG building should have substantial savings in energy in both fan and chiller energy. It is unreasonable to assume that this system wouldn't use more energy in some area. As a result, this along with the savings must both be accounted for in the comparison between DOAS and the specified VAV system.

Combined Heat and Power

The ArNG building with its high electrical and cooling demands could be a good candidate for Combined Heat and Power (CHP). The available utilities for the building are provided by Dominion Virginia Power, supplying an electricity and natural gas line. The buildings function as a Readiness Center will require round the clock usage allowing for a fairly level electrical load.

The benefit of CHP is its ability to generate on site electricity. To do this requires the use of prime movers of which there are several types. Specific prime movers are under review, but one candidate to use is a reciprocating internal combustion engine. One advantage of this engine is its high efficiency in electricity generation. Once a second prime mover is established, it will then be possible to compare the two for optimum performance for the ArNG building.

With this high efficiency, fuel utilization is optimized and keeps the building off the grid power. This arises from CHP's use of waste heat which is often discarded by a typical plant. Heat is produced in the electrical generation process and can be captured and used to run mechanical process within the building.

There is one major item that needs to be analyzed for viability of this system for the ArNG building. This item is known as the Spark Gap, the cost differential between electricity and natural gas. As this gap becomes larger, CHP becomes more applicable.

Breadth Topics

Architectural

The use of BIM technologies is growing significantly in the building industry. As a result, a study of the pros and cons of altering ceiling height would be interesting to conduct.

One of the open office spaces with a lot of mechanical and electrical congestion above the ceiling will be modeled with Revit. A rendering will be completed as designed in the building documentation. A second rendering will be created with the ceiling lowered. This would provide more room for the mechanical and electrical systems and warrant a potential redesign.

A comparison of the positives and negatives of changing the ceiling height could then be analyzed.

Construction Management

The proposed mechanical system alternatives will result in a new estimate for the mechanical design. As a result a CM breadth will be conducted to analyze this impact on initial cost and payback estimates. This is a preliminary idea and one which needs to be researched for future viability.

Tools for Analysis

Energy Modeling

One of the most influential tools at the disposal of a mechanical engineer is the ability to create energy models. With each potential alternative system, it is important to analyze all cost information as well as monthly and annual energy use. To generate the above information, energy modeling is a necessity. Trane TRACE, Energy Plus, and eQuest are all viable modeling software but each have their limitations. Though familiarity with Energy Plus and eQuest are limited, each alternative will be modeled using each software to determine which is most accurate.

Standards

The proposed alternatives will be compared with the ASHRAE Standards. The current system sufficiently handles the ventilation and thermal requirements. Any redesign must also meet and or exceed these standards. These standards will be referenced when evaluating DOAS as well as the CHP system.

Appendix A: Preliminary Research

DOAS

Mumma, PhD, PE, Stanley. “Dedicated Outdoor Air Systems.”February 2001. The Pennsylvania State University DOAS. 9 Dec. 2010. <http://doas.psu.edu>

The above page shows the advantages of DOAS over a VAV design.

Int-Hout,ChiefEngineer,Dan.“AReasonableAlternativetoChilledBeams-The DOAS Fan Powered Terminal Unit.”May 2009. Krueger HVAC. 9 Dec. 2010. <http://doas.psu.edu>

Chilled Beams are becoming a popular idea. This article shows the benefits of DOAS Fan Boxes over chilled beams.

CHP

"Combined Heat and Power Partnership." U.S. Environmental Protection Agency. 21 07 2009. U.S. Environmental Protection Agency, Web. 9 Dec 2010. <www.epa.gov/chp/basic/index.html>.

Basic information on benefits and applications of CHP systems are covered within this website.

Appendix B: Work Plan

The following schedule, if followed, should yield a successful analysis of the proposed alternative systems.

Week	Start Date	End Date	Acedemic	Mechanical	Architectural	Construction Management
1	10-Jan	17-Jan	Proposal Correction	**Learn Vital Programs**		
2	17-Jan	24-Jan	Finalized Proposal/Schedule	Revise/Correct current Energy Model		
3	24-Jan	31-Jan	Progress Schedule			
4	31-Jan	7-Feb	Meet with Consultant	DOAS/CHP Research	Generate Rendering 1	Cost estimation
5	7-Feb	14-Feb	Finalize Website Format			
6	14-Feb	21-Feb				
7	21-Feb	28-Feb		Model Alternative Systems	Generate Rendering 2	Cost Comparison
8	28-Feb	7-Mar				
9	7-Mar	14-Mar	Beggin Generating Presentation	Comparison of existing to alternatives		
10	14-Mar	21-Mar		Start Final Report	Start Final Report	Start Final Report
11	21-Mar	28-Mar	**Finalize CPEP STIE**	Organize Final Report	Organize Final Report	Organize Final Report
12	28-Mar	4-Apr		Arrange Final Report	Arrange Final Report	Arrange Final Report
13	4-Apr	11-Apr		**Final Report Due**		
14	11-Apr	18-Apr		Presentations		
15	18-Apr	25-Apr		Faculty Jury		