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Thesis Proposal Revision

Revised 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. When used in conjunction with Chilled Radiant Ceiling Panels (CRCP) or fan coil unit, this system should handle the latent and partial sensible loads of the building. With the loads reduced, they can be applied to a Ground-Source Heat Pump (GHSP) system as well as the existing hydronic system respectively.

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 following alternative solutions are intended to reduce operating costs which is directly tied to increasing efficiency. Load reduction with DOAS and implementation into a GSHP system can be compared with the current system showcasing the potential gains.

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.

There are many potential advantages, some of which have been touched on previously. First and for most, this type of system has the ability to increase a buildings overall efficiency. There are several was this is accomplished. Reduced supply air requirements and decoupling of heating and cooling from ventilation air provided substantial gains. This however is only the tip of DOAS. Indoor air quality can remain the same or even increase while downsizing ductwork and fans. The system specified currently generally uses more OA than is required by DOAS. The

VAV system can have trouble properly ventilating all spaces with fresh air, DOAS does not have this problem. This large amount of OA requires significant conditioning in both summer and winter which accounts for large energy consumption. Mechanical space requirements are reduced and impacts initial construction costs.

A DOAS system has the ability to achieve greater efficiency while treating 100% of the latent loads in the space. DOAS also handles 100% of the OA load requirements and a potentially large amount of the sensible loads.

This above system will be accompanied with the use of CRCP (chilled beams) and also fan coil units. With chilled beams there are two applications, passive and active and work by natural forces due from air temperature gradients. This allows for natural air movement and a reduction in fan energy.

Active chilled beams are connected to the DOAS for airflow from the unit. The beam itself activates air circulation after mixing with ventilation air.

Passive chilled beams do not provide the mixing with the ventilation air. The room air induction is for cooling purposes, the ventilation air is provided via alternative methods.

The major issues which can arise from the use of chilled beams is the general inexperience which contractors and maintenance workers. Also of significant importance is environment control to ensure condensation does not occur within the building and in possibly sensitive areas.

With chilled beams it can become an issue involving spaces which require both cooling and heating. Such spaces are often located around the buildings perimeter and would potentially require another technology in conjunction with the DOAS. This is a very simple solution using FCU's which can contain both a heating and cooling coil, non-condensing, within the unit itself. This type of technology is fairly typical and would have little installation and maintenance issues. These units can be placed where appropriate to cut down on zone load costs and handle more than one space at a time.

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, the above system can be compared with the specified VAV system in the areas of life cycle cost, payback, efficiency, IAQ and Thermal comfort.

Ground Source Heat Pump

The ArNG building site is of considerable size and currently has an adjoining property with an existing building and proposed parking structure. This area should provide ample space for the implementation of a GSHP. There are however several things which need to be considered. The GSHP system has significant first cost and significantly affects construction scheduling, both of which need to be analyzed. The savings with a GSHP come from the constant earth temperature in the region.

To determine the best design with respect to overall efficiency it will be necessary to analyze several varying systems. First the reduction in loads by the DOAS can be implemented into the GSHP system as well as the current hydronic VAV system. Specifically to determine the savings with the load reduction efforts, the GSHP system will be analyzed with the initial loads specified with the original system With these analyses it can be established which design offers the most significant savings and efficiency.

Breadth Topics

Acoustical

An interesting aspect of the ArNG building is directly tied to its function. It is an Army National Guard Readiness Center, as a result the building has some very distinct functions which require various considerations. One such function is that of its Joint Operations Center/Command Center. These areas are classified require very special care when it comes to privacy.

The building as a whole is mainly office spaces, but on the lowest level of the building these sensitive areas can be found. The function of these spaces are for conferencing between various government organizations and in an emergency will be used in a part, with other centers around the country, to run the United States. It is clear of the importance of these spaces and as a result they need to be heavily isolated from the spaces surrounding them.

From this it is proposed to conduct an acoustical analysis of these spaces. The current sound isolation measures which have been designed will be studied in an effort to determine possible room for improvement. From there it will be possible to propose alternative acoustical systems to either, provide better sound isolation from the corridors and other spaces or accomplish the same isolation with new materials in a more cost effective manner.

Construction Management

The proposed mechanical system alternatives will result in substantial scheduling issues and thus will impact costs. The GSHP which has been prescribed will be a very intriguing scheduling issue. This will depend on both the depth with which the bores will be made as well as the number of bores necessary. This will greatly affect construction times and will be determine continuation with construction. Cost estimation due to these schedule changes will also need to be analyzed in an effort to fully understand the impact such a system would induce.

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, Carrier's HAP, Energy Plus, and eQuest are all viable modeling software but each have their limitations. Though familiarity with Energy Plus and eQuest are limited they should be considered to determine which above program offers the best accuracy in modeling.

First it will be necessary to analyze and model the load reduction efforts. It is vital that this particular model be as accurate as possible, as this will determine the validity of the remainder of the new design efforts. Trane Trace will be my program of choice and I know it has the capability to model a DOAS design. If another program is used to model the same system, such as Carrier's HAP, it will be possible to compare the two programs results. Once this data is collected it will be cross-checked against know commercial buildings energy usage.

Finally these loads must be modeled again using the existing VAV system as well as the prescribed GSHP. Using both Trane Trace and another specified program will allow for comparisons and allow for validity in the calculations. Once again these findings will be compared against current building information.

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.

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.

GSHP

Kavanaugh, PhD, Steve. “Ground Source Heat Pumps.” ASHRAE Journal 40.10 (1998): 31-36.

The above article provides various GSHP construction methods and their costs. It goes into depth on potential designs and their capabilities.

Kavanaugh, PhD, Steve. “Ground Source Heat Pumps for Commercial Buildings.” September 2008. HPAC Engineering. 1 Jan. 2011. <http:///hpac.com>

Here the GSHP system’s operation is discussed, showing how it actually works. Also located within this article are comparisons between such a system and that of standard practices.

Appendix B: Work Plan

The following schedule is under revision to place it into the proper format, it will be uploaded upon completion and will yield the appropriate steps for success for the project at hand.

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		