Rami Moussa
Mechanical Option
Advisor: Professor Treado
1/14/11

Peirce Hall, Kenyon College

Senior Thesis Proposal

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Executive Summary

The purpose of this proposal is to describe the studies that will be performed to complete the Architectural Engineering Senior Thesis Project in the spring 2011 academic semester. The following proposed thesis will explore possible modifications and additions to Peirce Hall and its building systems to address areas of incompliance and attempt to exceed requirements of ASHRAE Standard 90.1 Section G with intent to approach LEED Certified status.

Peirce Hall of Kenyon College in Gambier, Ohio underwent a major renovation, expansion, and addition project beginning in 2006. The intention of the project was to accommodate an increased demand on the facility and replace the outdated building systems with more efficient, economical, reliable, flexible, and maintainable systems. This goal was achieved in many aspects such as the new chiller plant and air distribution system. However, the previously existing campus steam supply was used to provide heat and power is still purchased from a local provider. Steam production is fueled by natural gas and distributed throughout the campus. The heating demand dominates the energy use of the facility due to the local weather conditions of Gambier, Ohio and the uses of the building. These areas appear to be the most capable of significant efficiency and performance improvements.

In order to receive the most benefits of having an energy efficient facility as possible, improvements of the building systems and spaces will be geared toward satisfying ASHRAE Standard 90.1 Section G which coincides with LEED certification requirements. There is an added bonus for having a system that exceeds requirements of Standard 90.1. Therefore the main study of this thesis will be to investigate possibilities of reducing the dependence of Peirce Hall on campus steam and purchased power by designing a combined heat and power (CHP) plant and investigate the necessity of a connected hot water thermal energy storage system.

An acoustic breadth study will be conducted to determine a location for the CHP plant that emits the least possible noise pollution. A second breadth study will address the facilities incompliance with current lighting power densities in the Great Hall as required by ASHRAE Standard 90.1 that pertain to satisfying Section G requirements. This study will include a lighting redesign to replace the current luminaires that draw 1200 and 1500 Watts each.

Energy analyses will primarily use Trane Trace 700 for modeling and calculation purposes. Acoustic analysis will make use of hand calculations as well as a possible EASE model. Lighting levels will be analyzed with AGi32.

Background

Peirce Hall, shown in Figure 1 is one of the most recognizable landmarks on the Kenyon College campus located in Gambier, Ohio. The 66,640 square foot facility is one of the campus's signature buildings and holds campus-wide known spaces such as the Great Hall shown in Figure 2, a 4,150 square foot dining hall with a 40 foot 8 inch high ceiling. Peirce Hall was originally built in 1929 and added onto in 1964 with the Dempsey Hall to accommodate the growing campus's needs.

Figure 1

In 2006-2008 an 18 million dollar renovation, addition, and expansion project was conducted. About half of the original structure was removed, the interior building systems with the exception of the structure were gutted and redesigned, and additions were constructed expanding the building to the South and East. The building primarily functions as a dining facility for students at the college. There are also administrative offices, student organization and lounge spaces, a classroom, and computer lab.

Figure 2

Peirce Hall holds walls as much as 80 years old, and was a facility that could not easily be modernized as a result. The Peirce Hall renovation, addition, and expansion project was intended to make the facility a more useful, comfortable, and better performing building. This goal was attempted by the use of efficient equipment design and intelligent controls. Of the building systems added during the renovation period, a 3.3 million dollar mechanical system was installed. This system serves as the primary means for heating, cooling, and ventilation.

The control system for the heating, cooling, and ventilation systems is the strongest part of the design. By means of a BACnet building automation system (BAS), facility managers can monitor and control, via a direct digital control (DDC) system, every feature necessary such as differential pressures and valve positions. This makes way for extremely efficient scheduling and operation of the building systems.

Mechanical rooms have been well placed in the facility allowing for the most practical distribution schemes. Space was used well such as the utilization of the attics for mechanical space and good plenum design. Even though the facility had no centralized chilled water plant prior to the renovation, one was created with marginal success. In order to fit the necessary chiller into the designed mechanical room, a scroll type modular chiller with five, three foot wide sections was selected to provide a 241 ton capacity. Maintenance of the systems is reasonably simple, with all access door requirements of ASHRAE Standard 62.1 satisfied and well-designed mechanical room layouts.

Kenyon College uses centralized steam production and distributes it through the campus. The previous Peirce Hall mechanical system tapped into this steam distribution and currently supplies medium pressure (26 PSI) steam. Steam is directly used to supply coils in air handlers, some unit heaters, and dishwashers in kitchens. Other components of the heating system are supplied with hot water. The steam to hot water converters that were previously installed in Peirce Hall were consolidated and upgraded in the renovation process. Hot water is supplied at 190°F to scattered unit and cabinet unit heaters, convectors, and a radiant floor system.

Since Gambier, Ohio is only 55 miles Northeast of Columbus, Ohio, yearly weather data from Columbus was used to approximate the exterior environmental conditions of Peirce Hall. As such, the conditions used for analysis were the 0.4% and 99.6% cooling and heating conditions shown in I-P units in Table 1.

Heating DB	Cooling DB/MCWB		Evaporation WB/MCDB		Dehumidification DP/HR/MCDB		
99.6%	0.4%		0.4%		0.4%		
3.2	91.1	73.8	76.7	86.8	73.6	129.0	81.2

Table 1. Yearly Weather Data for Columbus, Ohio

Problem Statement

One of the advantages of having an efficiently performing building is the opportunity to receive funding from both government and private sources. However, to benefit from these sources through federal tax incentives, energy programs funded by energy providers, and similar programs, a building must be certified by a specified rating system. One rating system that is widely recognized is the LEED certification system developed by the United States Green Building Council. To benefit from the LEED certification system a building must satisfy a list of minimum requirements. Once minimum requirements have been met, a building must use enough energy and resource saving methods which have been given weighted credit values. Once a specified number of credits have been accumulated, a building can be labeled as LEED Certified. However, satisfying the minimum requirements demands a high level of performance in itself. One of the requirements for this is to satisfy base requirements of ASHRAE Standard 90.1 Section G, which provides means to assess individual components of building systems.

The following proposed thesis will explore possible modifications and additions to Peirce Hall and its building systems to address areas of incompliance and exceed requirements of ASHRAE Standard 90.1 Section G with intent to approach LEED Certified status.

Proposed System Modifications

Depth Study: Combined Heat and Power Plant with Thermal Energy Storage

Description:

The possibility of a combined heat and power (CHP) plant addition will be explored in an attempt to provide Peirce Hall with heat more efficiently and reduce the necessity for purchased power from the local provider. Heating loads are much more prominent in the facility than loads requiring cooling, as can be gathered from the local weather data. Hence a modification of the heating system will be the main focus of the study rather than a cooling system modification. The CHP system will provide power, steam and hot water to be supplied to the appropriate components of the Peirce Hall building systems.

Current distribution of steam and hot water to system components will be maintained, however the need for a new steam to hot water heat exchanger will be investigated. The steam produced by the CHP system will be tied into the existing building's main steam supply. The existing system supplied steam at 26 psi however the maximum pressure required by system components was 15 psi.

The necessity of a hot water storage system to operate in tandem with the CHP system will be investigated. During times when little power generation is required from the CHP system, hot water will still be available from the storage system if necessary.

Location:

The CHP equipment will be located, as shown in Figure 3, outside of the facility in the highlighted area, but with the most convenient access to the current main steam supply entrance marked by the green arrow and the current main electrical service entrance marked by the blue arrow. The system cannot be located inside the facility because space for additional mechanical equipment inside of the facility is extremely limited. Both the CHP and hot water storage systems will be planned to be located partially underground to limit zoning issues and ambient noise levels created by the generator.

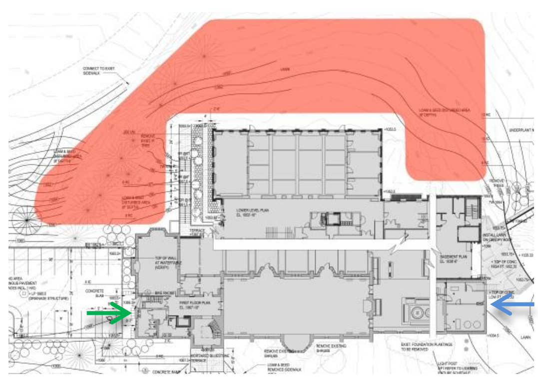

Figure 3

Tools and Methods:

The main tool that will be used to measure the effectiveness of the CHP and TES systems will be the energy modeling software Trane Trace. This program will allow integration of the two systems into the existing model, but like any simulation program the result will be approximate values. Recommendations from the ASHRAE HVAC Systems and Equipment Handbook will be used as guidelines.

Breadth Study 1: CHP Plant Acoustic Analysis

Description:

When designing a combined heat and power plant, various prime movers can be used such as reciprocating engines and turbines. These different methods of producing heat and power produce a variety of different noise levels and profiles. Noise profiles for the proposed CHP plant design schemes will be examined to ensure noise levels in the surrounding areas are minimized and local zoning noise pollution requirements are satisfied.

Tools and Methods:

Hand calculations will be the main form of justification; however an EASE model may also be considered.

Breadth Study 2: ASHRAE Standard 90.1 Section G Compliance

Description:

A minimum requirement to become LEED Certified is to comply with the base requirements of ASHRAE Standard 90.1 Section G. This section requires an energy model to determine whether the proposed design conforms to base standards. In addition, sections 5.4, 6.4, 7.4, 8.4, 9.4, 10.4 must be satisfied. Peirce Hall does not incorporate all requirements of these sections as determined in Technical Report One.

A new lighting design will be developed to determine substitute luminaires for the existing chandeliers in the Great Hall and other dining areas to conform to recommended lighting power densities. Current luminaires draw 1200 and 1500 Watts each, creating the largest issues for Peirce Hall when trying to satisfy recommended lighting power density levels. In the design, proper illumination levels and light quality will be applied to satisfy values recommended by The Illuminating Engineering Society of North America (IESNA).

Tools and Methods:

A new lighting scheme will be explored using AGi32 to create a similar environment in terms of color temperature and light intensity.

Appendix

A.1 References

1. *ASHRAE Handbook: HVAC Systems and Equipment*; Owen, Mark S., Ed.; The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.: Atlanta, GA, 2008.

   This handbook, provided by The American Society of Heating, Refrigerating, and Air-Conditioning Engineers provides information on functions, components, and design methods of CHP and TES systems. Also included are feasibility analysis methods and design strategies to maximize performance of the systems.

2. United Stated Green Building Council. LEED 2009 Minimum Program Requirements. 2009. 28 Nov. 2010 <www.usgbc.org>

   LEED 2009 Minimum Program Requirements provides the base requirements for buildings that intend to apply for LEED certification. These requirements include all areas of a building from the interior systems to site considerations.

3. United Stated Green Building Council. LEED 2009 for New Construction and Major Renovations. 2009. 28 Nov. 2010 <www.usgbc.org>

   LEED 2009 for New Construction and Major Renovations is the LEED rating system for newly constructed or significantly modified commercial buildings including offices, institutional buildings, hotels, and residential buildings with four or more habitable stories. The rating system encourages green building practices organized into five environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality.

4. "Energy Storage." *District Energy*. University of Rochester. June 2000. Web. 9 Dec. 2010 <www.energy.rochester.edu/storage/>

   The University of Rochester produced a website called the District Energy Library that contains information on various energy production and saving methods. The site provides access to information, case studies, and examples of CHP and TES projects from different sources around the country such as universities and the US Department of Energy.

A.2 Spring 2011 Work Plan

(Located on next page)

Spring 2011 Senior Thesis Work Plan
Rami Moussa
Mechanical Option

Peirce Hall, Kenyon College
Gambier Ohio
Advisor: Prof Treado

1/14/2011

- Go/No-Go dates
- Depth Study
- Breadth Study 1
- Breadth Study 2