Senior Thesis Capstone Project
Treado

Thesis Proposal

Interdisciplinary Science and Engineering Building

University of Delaware
Newark, DE 19716

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Executive Summary

The fallowing proposal is for the redesign of the University of Delaware's newly designed Interdisciplinary Science and Engineering building (ISEB). The building will be built on university property, will be approximately 194,000 square feet, and is scheduled for completion in Fall 2013. The building will facilitate both research labs and educational/office spaces.

The presence of labs in buildings is synonymous with energy consumption. High outdoor-air rates, possibly large process heat loads, and continuous hours of operation, all contribute to make the average laboratory space an energy hog. These energy concerns also offer the opportunity for innovative design.

The current air side system of ISEB consists of two AHU types, 100% outdoor air and re-circulation. The re-circulation type systems consist of VAV AHU's that re-circulate air through the spaces, bringing in outdoor air to meet ventilation requirements or if running in economizer mode. These systems supply conditioned air to zone terminal boxes that are equipped with hot water reheat coils. The 100% outdoor air AHUs supply VAV zone terminal boxes equipped with hot water reheat. Each lab contains variable volume fume hoods that exhaust 6-12 ACH/hr and feed "high-plume", constant flow, exhaust fans on the roof. These units are equipped with either enthalpy wheel or heat pipe energy recovery from exhaust air, depending on contamination requirements.

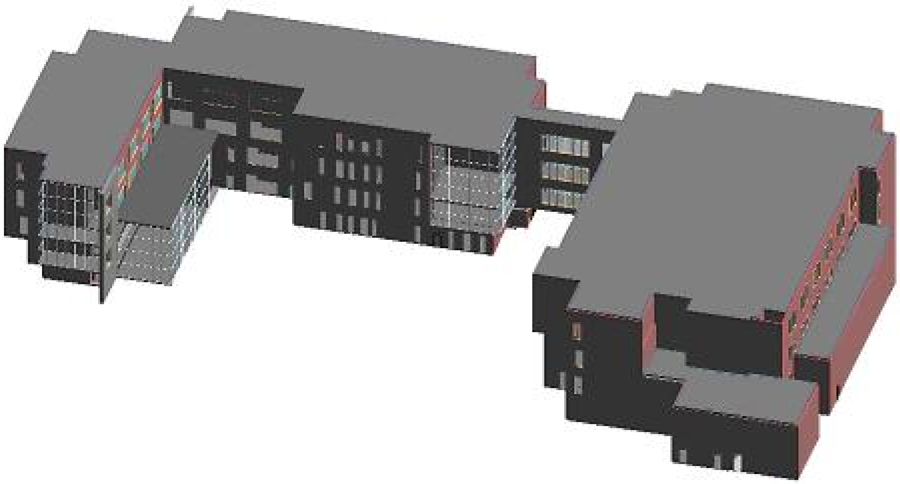
The proposed redesign presented in this document will aim at reducing the energy consumption of ISEB on a holistic basis. First, two different methods of handling the exhaust air to the labs will be compared to the current design. A large portion of the heating/cooling load on the building is due to the large amounts of ventilation air required by the labs, so reducing the amount of and implementing ways of conserving the ventilation air could result in large energy savings.

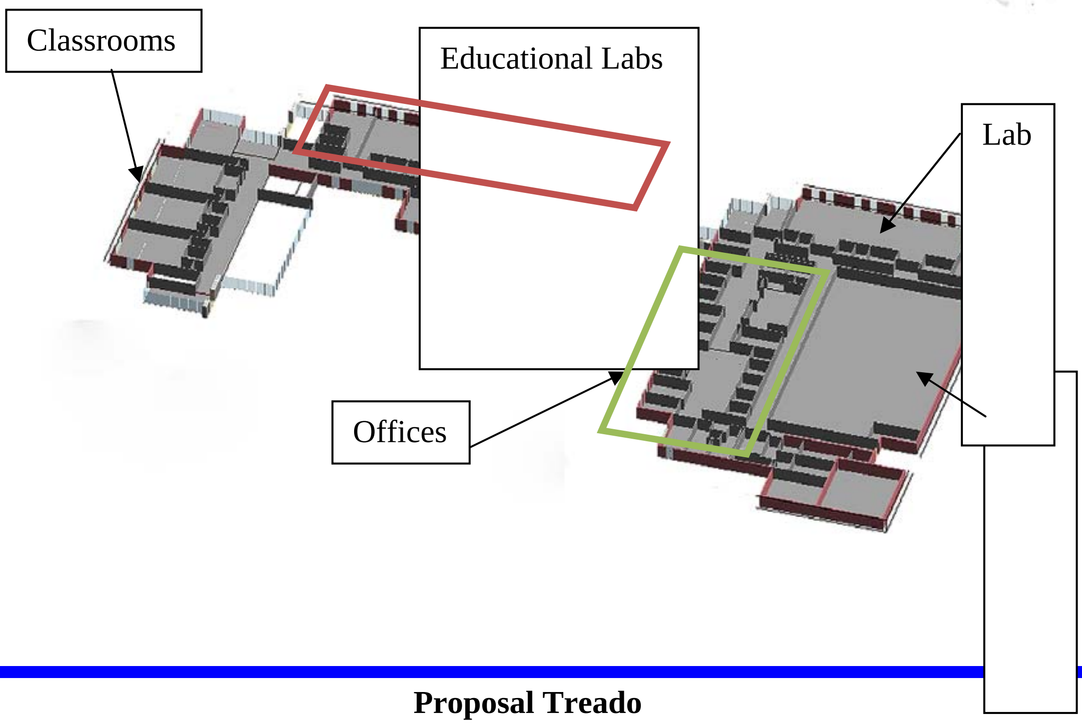
The redesign will also look at recovering energy that is wasted in the pressure reducing station that receives the high-pressure campus steam serving the building's heating needs, by implementing a steam turbine generator. The electrical design and integration of this turbine generator into the building's electrical system will act as an electrical breadth topic.

Reducing the amount of ventilation air brought into the building and recovering unused energy from steam entering the building are two potential ways of greatly reducing the energy consumption of ISEB, but reducing heat gain and loss through the building shell can also prove to be effective. Continuing with the holistic approach to reducing energy consumption, a heat gain/loss analysis will be conducted on the current building facade and compared with alternatives. Energy efficient façade strategies that will be investigated include, but are not limited to, double skinned facades for the curtain wall systems of ISEB and light shelf implementation for glazing in lab areas.

Building Overview

ISEB is a unique building due to its mixed use. It contains strictly controlled laboratory spaces with stringent environmental requirements, as well as classrooms and office areas that deal with large occupant fluctuations. All of the educational related spaces, as well as the office spaces, are supplied by any one of the three recirculating type AHU's. The lab and lab support spaces require 100% outdoor air and are supplied by any one of the seven 100% outdoor air AHU's. Each wing of the building contains both lab and non-lab spaces. (Typical floor shown below)





Mechanical Redesign

Lab Exhaust Redesign

Method 1:

One area that has been identified as wasting energy is in the non-lab spaces that are served by 100% outdoor air units. This method will implement chilled beams in these spaces along with any lab space that has a cooling load that dictates, in order to reduce the air change rate, and in turn reducing the amount of conditioned air that is thrown away. This method will also implement Aircuity's Optinet air sensor controls in order to control the amount of outdoor air brought into the air handling units based on current air conditions, not a set schedule. Bringing in outdoor air based on demand and not on preset accepted lab ACH/hr. values should reduce the amount of ventilation air brought into the building.

Method 2:

The multi use of ISEB results in some tricky design situations from a ventilation standpoint, but if addressed carefully can result in some energy conservation solutions as well. In many hours of the year the non-lab spaces require ventilation air that is in excess of the amount needed to pressurize the building. When this occurs, this excess ventilation air can be ducted as "return air" to the lab AHU's for reuse. This transfer air system is possible because although it is often thought that lab air requirements call for 100% outdoor air, the actual requirement is no re-circulation of lab air. The current design of AHU's 5 and 9 implement heat pipe energy recovery because they serve clean rooms that have high contamination restrictions. This redesign method will replace these heat pipes with 3 angstrom enthalpy wheels to improve energy recovery.

Electrical Breadth

Steam Turbine Generator Electrical Integration

The estimated steam heating load for ISEB is 19,000 PPH. This heating load includes domestic water heating and steam-to-steam humidifiers, therefore there will be a significant steam load year round. In the current design, steam enters the building from the campus steam loop at 100 psi before it enters a 2-stage pressure reducing station, dropping the pressure from 60 psi and then to 15 psi to be used in the building. Instead of wasting this steam energy by throttling it through valves, this re-design will use this energy in a steam powered turbine to feed electricity back into the buildings electrical system, while reducing the high pressure steam to an acceptable level (15psi) to be used in the building heating system. This turbine generator will be integrated into the current electrical system and its impact on the current electrical system will be analyzed. Also, the electrical energy savings that is seen from this turbine will be analyzed.

Architectural Breadth

Building Enclosure Thermal Performance

Putting a highly efficient mechanical system in a building with a thermally poor building envelope is like putting a Ferrari engine in a lawn mower, it may be well designed but it will never live up to its full potential. So in order to take a holistic approach to cutting energy use of this building, the building's current façade will be compared to several energy efficient alternatives. More research will be conducted in order to determine sufficient alternatives, but at the time that this report was written double skin walls and solar shading were the front runners. Also, building orientation will be analyzed in order to determine the best possible site orientation to prevent excess heat gain and loss.

MAE Connection

The redesign of the exhaust system will incorporate hydronic cooling systems. This will include chilled water pumping to the chilled beams along with fan energy needed for the ventilation systems. These topics will make use of material covered in master level courses AE 557, central cooling systems. The steam turbine and pressure reduction station redesign will require information on steam systems, turbine generation, and heat exchangers, which is covered in the AE558, central heating systems.

Tools for Analysis

Mechanical System Redesign

In order to compare the different alternative methods suggested in this report to the current design energy simulation software must be used. Trane's TRACE 700 software will be used to conduct load calculations and run energy simulations. For the design of the Aircuity's Optinet system, a control writing software will be required. Automated Logic's Control Spec Builder will be used to show how this system will be implemented and how it will communicate with the building's ALC system.

Electrical Breadth

The concept of steam turbine electrical generation requires complex calculations. This will require the use of EES software along with Excel spreadsheets in order to determine the electrical power that is attainable from a given amount of steam. This relation can be linked to the heat load (steam load) throughout the year and then a yearly electrical generation number can be attained.

Architectural Breadth

Running load calculations and energy simulations for different building materials will require the use of Trane's TRACE 700 software. U-values and R-values can be obtained and input for simulations.

Preliminary Research

1. Johnson, Gregory R. "HVAC Design for Sustainable Labs." *ASHRAE* 50 (2008): 24-34. Print.

This article was used to get ideas for energy saving areas present in labs. This is where the preliminary research was done for the transfer exhaust and ventilation reduction methods.

2. "Energy Savings Turbine over Prv." *Steam Turbines*. Web. 09 Dec. 2010. <http://www.nestco1.com/energy_savings_turbine_over_prv.htm>.

This website was used to do the preliminary research for the steam powered turbine in lieu of a pressure reducing station.

3. "Aircuity OptiNet Components Evaluate Indoor Environmental Quality | Aircuity." *Aircuity - Indoor Environmental Quality Solutions (IEQ)*. Web. 09 Dec. 2010. <http://www.aircuity.com/technology/optinet-components/>.

This is the site for the manufacturer of the ventilation control method presented in this report. Preliminary feasibility research was done by visiting this site.

4. Poirazis, Harris. *Double Skin Façades for Office Buildings*. Rep. Lund University, 2004. Print.

This article reviews several other articles and journals on double skin facades. It gives a description of different types of double skin systems, the history of this type of façade, and how they work.

5. Hock, Lindsay. "Airing Out Laboratory HVAC." *R&D* 10 Aug. 2010: 20-24. Print.

This article was used to get an idea of how different laboratory exhaust and ventilation systems work. It also inspired further research into lab energy conservation.

6. Loudermilk, P.E., Ken. "Designing Chilled Beams For Thermal Comfort." *ASHRAE October* (2009): 58-62. Print.

This article lays out design guidelines for the use of chilled beams in many situations in order to provide adequate thermal comfort. It is in reference to both sensible comfort and humidity control.

7. Barnet, P.E., Barry M. "Chilled Beams for Labs." *ASHRAE December* (2008): 28-37. Print.

This article focuses on the use of chilled beams in a laboratory space. It discusses the use of chilled beams for sensible load with the use of energy recovery for the exhaust of the lab.

Preliminary Work Plan

Week	Start Date	End Date	Mechanical	Turbine Generator	Architectural
1	10-Jan	17-Jan	Load/Energy anlysis current design & Sensible Loads/Vent Rates for Spaces	Research Turbine PRV	Research Facades
2	17-Jan	24-Jan		Determine Steam load variation	Review previous Trane simulation from tech 2
3	24-Jan	31-Jan	Determine min. vent rate for pressurization & hrs excess vent		Run Trane simulation for alternative systems
4	31-Jan	7-Feb		Calculate Kwh from steam load	
5	7-Feb	14-Feb	Research Acuity, Control Spec Builder, 3 angstrom wheel	Integrate into electrical system	
6	14-Feb	21-Feb	Input Acuity into control spec blder		Re-run simulation for different orientations
7	21-Feb	28-Feb		Cost/energy/CO2 Savings	
8	28-Feb	7-Mar	Compare Alternatives		Energy Savings Compare
9	7-Mar	14-Mar	Calculate Cost/energy savings		Compare Cost of ea. System to current
10	14-Mar	21-Mar	Start Final Report	Start Final Report	Start Final Report
11	21-Mar	28-Mar	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	Present		
15	18-Apr	25-Apr	Faculty Jurry		