



Thesis Proposal

Biobehavioral Health Building

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Thesis Proposal

Executive Summary

The Biobehavioral Health Building at The Pennsylvania State University will be connected to campus wide steam and chilled water loops to serve its heating and cooling needs. BBH as it stands is an energy efficient building that will achieve LEED Certification at a minimum, that being said there is still room for improvement in the over all energy efficiency of the building. Given Penn States stand on building a 100 year building, strategies will be employed to improve energy conservation and decrease seasonal energy use.

Decreasing the amount of energy used by BBH can be a challenging task, four tactics will be investigated; building thermal mass, heating and cooling distribution, heat recovery and a solar energy conversion system couple with a sorption cooling system.

The building thermal mass will be investigated to determine the optimal mass of the building that will provide the flattest heating and cooling load profiles thus reducing the size of mechanical equipment required.

Looking at alternative heating and cooling distribution systems may result in more efficient means of energy transportation throughout the building. This will further reduce the size of the mechanical system required, moreover reduce the amount of energy required by using a liquid to transfer energy around the building. An air ventilation system will still be required to maintain indoor air quality and provide dehumidification to prevent condensation on potential radiant cooling surfaces. Enthalpy wheels will also be included to help further reduce the amount of energy required for heating and cooling.

Finally, a solar thermal system will be designed to provide a portion of the heating in the winter and will be coupled with a sorption chiller to provide cooling in the summer. By including sorption cooling into the design, the solar thermal system will be able to operate year round and will not have to dump heat in the summer.

The addition of a solar thermal system will put an additional load on the roof which may alter its design and changing the mass of the building will also affect the design of the super structure. The difference in energy required by the mechanical system will affect the demand on the electrical system. These items will be explored in structural and electrical breadths.

Building and Mechanical System Description

The new Biobehavioral Health Building at the Pennsylvania State University was designed to provide space for classrooms, offices and research. The total building area is 93,500 SF, which is served by six air handling units with economizers. The air handlers are divided into zones as shown in Table 3.1. BBH also uses perimeter radiant heat beneath the windows.

Table 3.1: AHU Zones	
AHU	Zone
1 and 5	Core
2	Classrooms
3	South Offices
4	North Offices
6	Conference Rooms

BBH is fed off the campus steam and chilled water loops which provide all heating and cooling needs along with domestic hot water requirements. Steam from the campus loop is fed through a plate heat exchanger which transfers heat to the building hot water loops.

Mechanical Redesign Summary

Alterations of BBH's mechanical system will focus on reducing the energy required to heat and cool the building along with analyzing the distribution of the heating and cooling system. To achieve a reduction in energy costs, solar energy conversion systems, heat recovery wheels and combining radiant heating and cooling with the thermal mass of the building will be investigated.

Alternatives Considered

Thermal Mass

Coupling radiant heating and cooling with the thermal mass of a building can provide the ability to shave peak heating and cooling loads, reducing the size of the mechanical equipment required thus reducing upfront costs of the system. Using the thermal mass can allow a more flat load profile to downsize mechanical equipment and allow the equipment to run near full load more often.

Heating and Cooling Distribution

By altering the cooling and heating delivery method, significant energy can be saved switching from fan power to pump power. Radiant heating and cooling will be investigate in effort to reduce the energy required to move energy around the building. This can also reduce the space required for mechanical equipment which will allow for more room for additional equipment being proposed by the solar energy conversion system. An air ventilation system will still be employed to provide adequate ventilation for the building.

Heat Recovery Wheel

By incorporating a heat recovery system into the mechanical system of BBH, a reduction in energy consumption required to heat and cool the various spaces within the building can be achieved. By combining the savings of the heat recovery system and the ability of onsite energy generation the annual energy consumption can be reduced.

Solar Energy Conversion System

BBH is well oriented and suited for solar energy conversion systems along with having a roof height that is well above any surrounding building and vegetation. By implementing a solar energy conversion system consisting of solar thermal panels, the total energy demand from the campus chilled water and steam loops can be reduced.

Proposed Redesign

The internal thermal mass will be increased and a structural analysis of a typical floor will be conducted to account for the additional weight. The goal of increasing the thermal mass is to reduce the peak heating and cooling loads the building will see. By reducing the peak heating and cooling load, smaller mechanical equipment can be selected reducing the upfront costs and reducing the space required for the equipment.

A heat recovery wheel will be included in the design to reduce heating and cooling loads. To further reduce mechanical system loads, a solar energy conversion system will be incorporated into the design to reduce the energy demand from the heating and DHW loads. A sorption chiller will also be included to take advantage of the high useful solar gain in the summer and reduce the chilled water load from campus chilled water plants.

After modifying the mechanical system and the construction of the walls, the effects of these modifications will be explored in electrical and structural breadths.

Breadth Topics

Electrical

Reducing the electrical loads from motors for fans and the addition of a chiller and other pumps, will require altering the electrical system of the building. A study will be conducted to determine the change in the building electrical system by incorporating a lower electrical demand from the mechanical system. Switchgear will be resized when possible along with wire sizes and sub-distribution panels.

Structural

With the addition of solar energy conversion systems being installed on the roof of BBH, the extra weight on the solar panels will have to be considered when installing the system. The roof structure will be analyzed and modified if necessary to accommodate the extra load from the solar panels. A typical floor will also be analyzed to account for the additional weight of the internal thermal mass.

Tools and Methods

Extensive research will be done with the proposed alternatives being considered to ensure a proper understand of each element. Tools such as Excel, DesignBuilder with EnergyPlus, EcoTect, System Advisor Model (SAM), STADD and other innovative tools will be used throughout the research and design process.

DesignBuilder with EnergyPlus will be used to first obtain reasonably accurate cooling, heating and electrical loads. The affects of increased thermal mass will be explored then the addition of heat recovery systems will be implemented into the model and the changes in energy required will be observed and compared.

EcoTect will be used to perform a solar analysis of the site to help determine the proper location and orientation of a solar energy conversion system to maximize solar utility for the given local. SAM will be used as a financial model to determine how financially viable installing a solar energy conversion system is and how long its payback period will be.

Excel will be used for detailed design calculations of the solar energy conversion system. A PV array is desired to run various pump loads in the building and needs to sized according. A solar thermal system needs to be size to provide the proper amount of hot water that is required for various building processes.

STADD will be used to analyze the roof structure and to reinforce the existing roof design or help design a new roof system if necessary due to the extra load of a solar energy conversion system.

Preliminary Research

Braun, James E. "Load Control Using Building Thermal Mass." Diss. Purdue University, 2003. Web.

Duffie, John A., and William A. Beckman. Solar Engineering of Thermal Processes. 3. Hoboken: John Wiley & Sons, Inc, 2006. 238-321, 324-373, 483-545, 579-605. Print.

Goodheart, Kevin A. "Low Firing Temperature Absorption Chiller System." MS thesis. University of Wisconsin, 2000. Web.

Kalogirou, Soteris A. Solar Energy Engineering Process and Systems. 1. Burlington: Elsevier Inc., 2009. 121-314, 315-386. Print.

Stein, Benjamin, John S. Reynolds, Walter T. Grondzik, and Alison G. Kwok. Mechanical and Electrical Equipment for Buildings. 10. Hoboken: John Wiley & Sons, Inc., 2006. 137-139,369-455. Print.

Sumathy, K. Solar Absorption Cooling with Low Grade Heat Source - A Strategy of Development in South China. . University of Hong Kong, 2001. Web.

Tentative Work Schedule

