Thesis Proposal

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Executive Summary

Penn State promotes sustainability in its construction projects. There are many potential sustainable applications for the Whitmore Laboratory Renovation Project. This proposal suggests ideas that will make significant difference in the demolition, construction, and operation performance of Whitmore Laboratory Renovation Project. Regarding the main concerns of a laboratory building such as: energy saving, schedule acceleration, and sustainability, the following analysis will be conducted during the Spring semester:

1. **Analysis I: Installation of Evacuated Tubes System (Solar Collectors)**

A considerable amount of hot water is consumed in the labs. The consumption of the building utilities peaks during the working hours (8:00 AM - 5:00 PM) when most classes take place. The amount of hot water consumed during the day is manageable and can be heated by the Solar Collector system. The system is expected to be able to substitute the water heater in the building during the day.

2. **Analysis II: Installation of Aquatherm Pipes**

The plumbing network in the Whitmore Laboratory Building is intense and complicated. In pursuing of schedule acceleration, Aquatherm pipes become handy since they are lighter in weight and have faster, easier and safer installation. Therefore installing aquatherm pipes instead of copper pipes will bring many advantages to the project and the facility.

3. **Analysis III: Recycling the Demolished Materials**

There is a sizeable amount of demolished materials from the lab including toxic refrigerant. These materials need to be disposed safely by specialties. There are many recycling facilities can be found to recycle the fume hoods, lab casework, pipes, light fixtures and others. These options are discussed briefly.

4. **Analysis IV: Lean Thinking: Implementing First Run Studies**

The actual construction is scheduled to complete within 12 months. And there is no tolerance for delay because the building has to be turned over before Classes start in Fall 2016. To tackle the tight schedule, lean construction technique should be implemented. First Run Studies is advised for this particular project.

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Project Background

Whitmore Laboratory is a four-story building: three stories above grade and one ground floor. It is occupied by Elberly College of Science in University Park, PA 16802. The building is a mix use of teaching and research labs. The renovation project includes upgrade to the mechanical, fire protection, portion of the electrical, lab casework and roofing systems plus replacing the windows and interior doors. Design-Bid-Build delivery method is used in this project. Whitmore Laboratory renovations will be phased into two phases to allow continuous operation of the building. Construction started at the end of July 2015 and is expected to finish in August 2016. Project cost is $24.5 M for both phases.

The building has a footprint of 23,000 SQFT and is oriented northwest. The building being located in University Park allows it to be exposed to the sunlight all day long because the buildings height in campus is limited to 90 ft. Therefore; the roof of the Whitmore Laboratory is not blocked by the surrounding buildings allowing it to receive the sunlight all day long.

Penn State strives to employ sustainability techniques in campus and this paper proposes some ideas to help Penn State in accomplishing its goal. The suggested analyses help improvong sustainability during demolition, construction and operation processes.

Analysis I: Installing Evacuated Tubes

Problem Statement

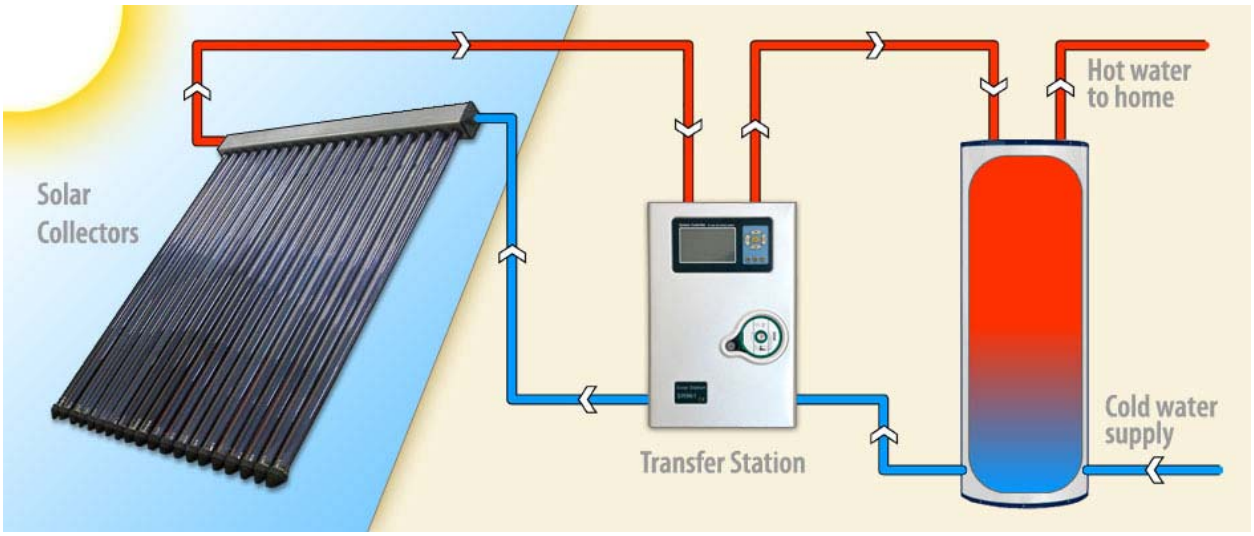
The HVAC system in the building is required by code to supply 100% fresh air since it is serving a laboratory building. The building having 116 fume hoods with face velocity of 75 exhausts a tremendous amount of air. That air is replaced with fresh air from the outside. Heating up that amount of outside air requires a significant amount of energy. Besides, a considerable amount of hot water is used in the labs. The peak use of the building happens during the working hours (8:00 AM - 5:00 PM) when most classes take place.

Background Research

The evacuated tubes (solar collectors) absorb the electromagnetic waves emitted by the sun and transfer it to heat energy. The average energy coming from the sun is 1,000 watts per square meter[1]. The number varies depending on the geographical location, time of the year, time of the day, and weather conditions. However, the low temperature does not impact the system efficiency making it functional all year long as long as the sunlight is present. There are two types of solar collectors, flat and concentrated. For residential and commercial building, commonly flat solar collectors are used.

Potential Solution

In order to heat the supply air using the evacuated tubes, a very large array of evacuated tubes is



needed to supply the necessary energy. That being said, the system requires: large area, additional

[1] https://en.wikipedia.org/wiki/Solar_thermal_collector

Figure 1- Evacuated tubes System Diagram

structural support (if installed in the roof), prior planning and budget. So it is impractical for this project to install an evacuated tubes system for the supply air. On the other side, the amount of hot water consumed during the day is manageable and can be heated by the evacuated tubes system. The system is expected to be able to substitute the water heater in the building during the sunny and overcast days. For the rainy days, the collected energy is reduced requiring other energy input such as: electricity or propane. The system is automated so, thus the hot water will be continuously available.

Analysis Procedure

The analysis will focus on the design of the evacuated tubes system, constructability and feasibility following this procedure:

1. Determine the consumption of the hot water in the building based on statistics from Penn State or other similar buildings. The data can be obtained from Penn State Libraries but not limited to that.
2. Determine how many panels are needed to satisfy the load consulting a guide that comes with the solar collectors array.
3. Find the gravitational load and check if it can be supported by the roof structural system. (The structural breadth analyzes the evacuated tubes system load and check if the roof sustains the load. If not, a new structural roof design will be suggested)
4. Calculate the energy cost saving and the payback period.
5. Analyze the feasibility of the system.

Resources:

1. Literature
2. Apricus Solar Hot Water
3. PVWatts Calculator
4. Lecture materials from the passed years

Expected outcome:

A complete analysis of the evacuated tubes system, which shows the long-term savings versus the front cost. In the breadth studies, a structural analysis will be conducted. In addition, the mechanical breadth will explain how this system ties to the existing water heater.

Analysis II: Using Aquatherm Pipes for the Domestic Cold Water Distribution

Opportunity Statement

The plumbing network in the Whitmore Laboratory Building is intense and complicated. In pursuing of schedule acceleration, Aquatherm pipes become handy since they are lighter in weight and have faster, easier and safer installation. Aquatherm pipes do not need insulation if installed for the cold water because they have an R-value of 1.

Background Research

Aquatherm pipes are German manufactured by mbH on the basis of polypropylene. They resist high -pressure stream. The pipes can be used for cold or hot water (up to 90 C). They come in different sizes; and the different colors identify the designated use of the pipe. For the connections and fittings, a method called heat-fusion is utilized.

Potential opportunity

Installing aquatherm pipes instead of copper will bring many advantages to the project and the facility including:

- No need for insulation
- Lighter in weight leading to easier and safer handling
- Faster installation
- Compatible with hot or cold water

That is being said, there is potential cost saving and schedule acceleration.

Analysis Procedure

The analysis will focus on the two aspects: schedule acceleration and cost saving and that can be examined following these steps:

1. Collect the necessary data required for the analysis
2. Estimate the linear footage of the cold water pipes in the building
3. Estimate the cost and time required for copper pipes
4. Estimate the cost and time required for aquatherm pipes
5. Compare the two alternatives and calculate time and cost savings

Resources:

1. Aquatherm State of the Pipe
2. RSMeans Plumbing Cost Data
3. Project Manager and Plumbing subcontractor

Expected Outcome

This analysis will mainly compare the aquatherm pipes with the copper pipes considering several attributes. At the end of the analysis, the best alternative will be selected with accompanying calculation of cost saving and schedule acceleration.

Analysis III: Recycling the Demolished Materials

Problem Statement

There is a sizeable amount of demolished materials from the existing building including toxic refrigerant. These materials need to be disposed safely by specialists. Also, the demolished HVAC, Electrical, and plumbing materials contain value, which should not be ignored.

Background Research

There are many recycling options can be found to recycle the fume hoods, lab casework, pipes, light fixtures and others. One option is to send the large equipment such as the fume hoods, cooling towers and air handler to a recycling facility. They will take the responsibility of recycling these materials or disposing them responsibly. Another option is Bounty Program where the utility company would buy the appliances if they meet certain specifications.

Potential Solution

For the refrigerant, the local Hazardous Waste Facility should be consulted to find the best refrigerant removal option. Concerning other materials, there are potential buyers such as: manufacturers and recycling facilities. Selling the scrap materials to the corresponding will ensure safer environment. Also the owner can get some cash value back from the demolished materials.

Analysis Procedure

This analysis studies the process of recycling from the moment of demolishing to the moment when the buyer receives the shipment. Also potential buyers will be identified.

1. Determine what systems are demolished partially or completely
2. Categorize the materials based on the major constituent
3. Look for a recycling facility for each category
4. Calculate the value earned from the process

Expected Outcome

This analysis will focus on building a detailed process map with explanation on how to recycle the demolished materials from this project. And estimate of how much value can be earned back from selling the scrap materials.

Analysis IV: Lean Thinking – First Run Studies

Problem Statement

The actual construction (phase i + phase ii) is scheduled to complete within 12 months. And there is no tolerance for delay because the project has to finish on time and be ready for occupants. Some classes have to be offered during the Fall semester for students in order to graduate on time.

Potential Solution

To tackle the tight schedule, lean construction technique should be implemented. Whitmore Laboratory has 11 labs, 116 fume hoods and a lot of lab casework. So there is repetitive work in this project. Using First Run Studies Tool will help ensure the project progresses as efficient as possible. The focus will be on the installation of the fume hoods since they need coordination with HVAC, plumbing, electrical and casework subcontractors.

Research Procedure

1. Standardize the work process (process of installing one fume hood)
2. Provide detailed implementation guide on how to implement First Run Studies in this project
3. List the benefits of First Run Studies
4. Compare this project with other case studies

Resources

1. Site Implementation and Assessment of Lean Construction Techniques
2. Lean Construction: From Theory to Implement
3. Lean Construction Institute (LCI) Web
4. The Use of First Run Studies to Develop Standard Work in Liquefied Natural Gas Plant Refurbishment

Expected Outcome

This research focuses on the installation of the fumes hoods. The research will include: introduction, implementation guide and a case study.

Conclusion

To participate with Penn State in building sustainable practices in campus, this paper studies the potential sustainable methods that can be implemented in the Whitmore Laboratory Renovation Project. There are many sustainable ideas for the Whitmore. This proposal suggests ideas that will make significant difference in the demolition, construction, and operation performance. Regarding the primary concerns of a laboratory building such as: energy saving, schedule acceleration, and sustainability, four analysis proposed including: installation of Solar Collectors, Installation of Aquatherm Pipes, Recycling the Demolished materials, and Implementing First Run Studies.

Appendix I – Breadth Studies

Structural Breadth

Regarding the first analysis, the suggested system carries a considerable gravitational load that need to be included in the design of the roof structural system. This breadth will study the willingness of the existing roof structural system to take the load of the solar collectors. In case the existing system does not support the solar collector system, a new roof structural design will be developed and compared with the existing system cost wise.

Mechanical

Regarding the first analysis in this paper, the solar collector system needs to be integrated in the existing water heating system. This breadth will provide explanation on how to tie the solar collector system with the existing system along with diagrams.