Thesis Proposal

Mechanical Project Proposal for AE482

The Hershey Press Building
Hershey, PA

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Table of Contents

Executive Summary

The Hershey Press building uses terminal water to air heat pumps to serve a variety of zones and spaces. A boiler plant and fluid cooler is used for heat reject and absorption from the water source heat pump loop. While many of the original building objectives are being met, there is a variety of possible sustainable alternatives that could enrich the system. A mechanical study has been developed to address any issues and give the mechanical system a sustainable retrofit design.

The mechanical retrofit redesign will focus on three major areas associated with sustainability, including water efficiency, energy efficiency and indoor environment quality. In each area, three to six alternatives will be evaluated. With each alternative, key factors will be evaluated in terms of cost and constructability. These factors will need to be addressed and researched, prior to any sustainable alternative suggestions.

Two breadth alternatives will also be analyzed to supplement the mechanical proposal. The first area includes a possible architecture redesign of the building envelope in order for the building to become more energy efficiency. These include improvements to the roof, wall, and windows. The second area will provide a construction management analysis which will include cost and schedule impacts due to alternatives. The mechanical designer and contractor are from the same company, design/build, estimation and installation challenges can be predicted and later evaluated.

In order to adequately research these areas, a spring semester schedule and research methodology was developed. The spring semester schedule, which focuses on more weekly workload initiatives, can be found in Appendix A. This detailed schedule takes in to account holidays, overflow weekends, and two day work options.

For calculations and data, various methods and tools will be used. Trane Trace software will be used for energy modeling. Energy costs will be estimated using utility rates from local utility plants. Costs for new materials will be estimated using R.S. Means or past numbers used on McClure Company projects. McClure Company is a design/build mechanical contractor that has completed all four tenant fit-out projects at the Hershey Press Building. Scheduling data will also be supplied by McClure Company, generated from similar project data. Indoor air quality analysis will utilize ASHRAE Standard 62-2007 with possible Computational Fluid Dynamics (CFD) analysis.

Key research tools and software to be utilized will include: Trane TRACE, ASHRAE journals, and engineering website. Some other resources will include McClure Company engineers and Penn State Architectural Engineering Professors. This will allow for a highly accessible wealth of knowledge to be utilized and applied to the sustainable retrofit proposal for the Hershey Press Building.

Building Summary

The Hershey Press building is a three story, 75,000 square foot, mixed use facility located on in Hershey, Pennsylvania. With the town's main amusement attraction, Hershey Park, located directly behind the facility, and an up-and-coming historical museum being constructed next door, the building is a popular eatery and office complex. The 1915 original construction, renovated in 2005, preserved this historical building and stands as a monument on the corner of Park and Chocolate Avenue. See Figure 3-1 for the site building layout and location on site.

Figure 3-2: Hershey Press Building - First Floor Tenant Spaces

From 2003-2005, this unoccupied building received a complete interior and exterior renovation for a core and shell design for the first floor. For the next 5 years, the first floor was fitted-out by the three first floor tenant seen in Figure 3-2 below. The building currently has two restaurant tenants on the first floor. Houlihan's, opened in 2006, has indoor and outdoor seating facing Chocolate Avenue. Devon's Seafood Grille will be finished with construction in spring 2009. Jack Gaughen Realty office space is the third tenant on the first floor, containing private offices, open offices and conference rooms.

Figure 3-2: Hershey Press Building - First Floor Tenant Spaces

The second and the third floor spaces house the owner of the building, Hershey Entertainment and Resorts (HE&R). This conglomerate owns many of the entertainment facilities located in Hershey, including: Hershey Park, Giant Center, Hershey Arena & Stadium, Zoo America, and many other popular attractions. Call reservation centers, conference rooms, open offices, private offices, and a gym facility are a few spaces are located on these floors. The chic interior design of the office spaces, mixed with local materials and historical columns, give this office facility a high-end, personal look.

Existing Mechanical System

The Hershey Press building's mechanical system utilizes ninety-four terminal air-to-water ceiling-mounted heat pumps are located in the spacious ceiling plenums created by fifteen foot floor to floor heights. Within these plenums, return air and outside air from energy recovery ventilators are supplied or drawn into the plenum and is directly ducted to the spaces by the heat pumps. These energy recovery ventilators serve each floor plenum from the roof in order to provide the necessary outside air requirements to all three floors and basement, serving as dedicated outside air units for the facility. Exhaust air, providing relief for the ERV's, flows over silica gel heat exchangers to temper the outside air before it is discharged to the plenums. The water source heat pump hydronic loop, tempered by three natural gas boilers and closed-loop fluid cooler tower temper the loop at the proper temperature for the heat pumps. Make-up air units and kitchen grease exhausts provide proper ventilation and exhaust of equipment without cross-contaminating the building's plenums'.

For the mechanical system, a list of project objectives was created. By identifying objectives prior to design, enhanced design decisions could be made in order to meet the final requirements. These objectives included:

- Multiple zone temperature control with the ability heat and cool zones simultaneously
- Energy efficiency and life cycle cost optimization
- Simplicity of control and control reliability
- Integration with existing architecture and structural systems

The design also utilized a direct digital control/automatic control system that provided temperature control, scheduling, energy management, alarm, monitoring and trending functions. The computer workstation with graphical interface was also installed with modem remote monitoring capabilities.

The designers used ASHRAE 62.1-2007 to calculate the minimum outside air requirements for the spaces. Based on occupancy, population, and area, the minimum ventilation rates were calculated and compared to the original minimum outside air volumetric flow rate found. The results proved that indeed the Hershey Press Building had the proper amount of outside air being distributed to the system.

Seven sections of ASHRAE Standard 90.1-2007 were also evaluated. The building envelope did not meet all the standards required by this standard, namely the walls and glazing fell short of expectations. In the heating, ventilating and air conditioning section, it meets most of the standards except for the heat rejection equipment, the fluid cooler, needs to be more efficient in order to meet the standard. The service water heating, gas-fired domestic water heaters of the space met the criterion of this section. As did the power requirements in the power section. Section nine, lighting, was one section that the Hershey Press Building failed to meet miserably. The lighting power density for the facility greatly exceeded the maximum allowable, and therefore failed the building's ability to be lighting efficient. In the other equipment section, the press building redeemed itself to an extent, by meeting all the efficiencies in the motor requirements.

The Hershey Press Building has gone through an extensive design process and energy analysis. The mechanical design was chosen based on many factors, including system control in multiple zones, integration of the structural, mechanical and architectural systems, as well as energy efficiency and life cycle cost. Overall, the choice for water source heat pumps was an energy-efficient choice, taking advantage of the large 3-8' high plenum spaces. While the McClure Company chose an extensive, logical design, there are still some alternatives to be discussed. These include strategies to optimize first cost, construction cost, and overall, energy lifecycle costs.

From a renovation standpoint, the Hershey Press Building was a large demolition "gut" of the interior spaces of the building, leaving on the core and shell to remain. With limited shaft and mechanical room space, designers needed to choose an efficient design with minimum duct space.

Using energy recovery ventilators as dedicated outside air units, the shafts provide the vertical space necessary for ventilation air to be distributed to each floor. An enthalpy wheel also improves the efficiency of keeping the ambient temperature necessary required for the plenum. Once the air is blown into the open plenum, the ventilations air mixes with the return air that flow through the grilles in the ceiling through negative pressurized plenum. Hypothetically, the two streams are mixed and are drawn through the heat pumps. While it becomes hard to prove if the actual adequate ventilation is being distributed to each space, a computational fluid dynamics model could be created. With this tool, a model could be created of the plenum space to see if the system is working effectively.

The heat pumps, one in each zone, provide thermal control and comfort for variances in occupancy and schedule. A difficult aspect of the current design is maintenance and filer changes. With the heat pumps located sporadically around the building, it could become difficult to locate and access each heat pump easily. While much of the design allows for access door and removable ceiling tiles, an overall maintenance and filter change plan could be created for the entire building, once the Devon Seafood space's design is finalized. With this plan, preventative care and increased indoor air quality can be met for each of the 94 heat pumps.

The two-pipe heat pump water loop provides the perfect heat absorption/rejection mechanism necessary for the refrigeration cycle for each heat pump. The loop is kept at a temperature necessary for the loop by a natural gas boiler and fluid cooler. The small pipes are also run through the small vertical shafts between floors. One possible evaluation for improvement is the control sequence between the pumps and the heat pumps. The pumps are utilized at full output continuously. If the pumps could be ramped back by a variable frequency drive while reconfiguring each controller for the heat pump terminal units, an efficient pumping system could be satisfied. This could lead to potential energy cost savings.

Another positive design principal was the recovery of the rejected walk-in freezer heat from each of Devon Seafood's walk-in coolers. This provides a helpful boost to the heat pump loop's temperature during the winter months. Harvesting this heat in the summer, however, could decrease the fluid cooler's ability to cool the loop to the necessary temperature. In order to improve this design, special consideration to cost and benefit would have to be considered to take off the walk-in freezers rejected heat off the loop and utilize more efficiently somewhere else in the design.

Fans and make-up air units are also used to exhaust both kitchen spaces. The make-up air unit supplies the air each exhaust fan removes from the space. The unit also requires the conditioned air to provide back to the space, relying on gas heat and economizer cooling to temperate the incoming air. This process could be improved by recovering the heat from the exhaust and replacing back into the make-up unit, similar to the energy recovery ventilator. Through further investigation, a cost saving and a more thermally comfortable scenario could be developed.

A few benefits of this system include occupant control and energy efficiency. The terminal heat pumps can provide simultaneous heating and cooling to the occupants based on temperature set points and scheduled occupancy. The energy recovery unit, utilizing a silica gel enthalpy wheel for the exhaust and outside air, provides an efficient dedicated outdoor air unit serving the facility.

Some drawbacks from the current system include an uncertain ventilation strategy and considerable energy consumption. With the outside air being supplied to an open ceiling plenum, it is difficult to assess if the ventilation requirements, ASHRAE Standard 62.1-2007, are being met. The building could improve upon its current design in order to be more sustainable to the environment. The building is also limited by the shaft and mechanical spaces.

Overall, the system at Hershey Press building's mechanical design met objectives while not breaking the budget. However, opportunities exist to improve the Indoor air quality and thermal comfort of kitchen zones of the Hershey Press Building could improve while maximizing energy efficiency and energy usage while minimizing water usage. This would provide a more sustainable design and the building could potentially receive recognition for its efforts. This proposal describes alternatives that will be considered to achieve these goals.

The Hershey Press Building's mechanical system was designed to meet the design objectives of the owner and design team. The use of water source heat pumps provided controllability and energy efficiency. With any design, however, there can be drawbacks and new goals for the design can be created.

The following is a retrofit design proposal, with a focus of sustainable ideas for the Press building. With proper research and development, these ideas could be initiated with the intent to receive a LEED rating. Three major areas for sustainability will be studied including water efficiency, indoor air quality, and energy efficiency.

Water Efficiency

With three million gallons of on-site water used annually on site, water conservation should become a priority. While water is often treated as an infinite resource, possibly due to its inexpensiveness, but it is actually not an infinite resource and has been under restrictions a number of times. By reducing the water usage in the fluid cooler, landscaping and plumbing systems, a sustainable water system could be initiated.

During the summer months, the fluid cooler, used for water source heat pump heat rejection, utilizes the fresh water supply for its cooling purposes. An estimated 5,000 gallons per day is used by the fluid cooler on a typical day in July. A proposed alternative is to use treated building water for the fluid cooler instead of fresh water.

A second alternative to water efficiency to the building would include water efficient landscaping. By studying the amount currently used, a redesign of irrigation treated building water.

Treated building water could be taken from the following systems:

- Condensate Water Loop: The condensate water from the water source heat pumps could be used to supplement the fluid cooler. A pump would have to purchased and installed in order to supply the water. Grey water, including dishwasher water and sink water, could be treated and supplied to the fluid cooler as well. The condensing boiler condensation, in the winter time especially, could also be used for excess water. By conducting research in three areas, a water conservation method can be concluded and a possible water reduction scenario could be initiated.
- Rainwater: By redirecting this water from a drain and into a storage tank, this rainwater could be redirected during times of almost drought conditions, to water the shrubbery and landscape surrounding the building. A pump would also have to be installed to take the water from collection to the exterior of the building; however, water usage for landscaping could also be reduced through this method.

A third alternative for water reduction for the Hershey Press Building includes water efficiency methods in the building's daily plumbing use. Low to no flow lavatory and sink fixtures could be installed. This would reduce the plumbing system water use. Also, lavatory and sink fixtures should be supplied with sensors for automatic shut off after a timed use.

Energy Efficiency

With an estimated two million kWh energy demand usage for electricity annually, it becomes necessary to research alternatives for energy use and reduction. Energy savings can occur by discovering ways to reduce energy usage. Combining domestic water heating and water source heating is one possible way. Others include reducing and improving boiler usage, implementing variable frequency drives on the pumps, and impacting the system architecture and building envelope. Further analysis is needed to guarantee energy savings and rapid payback of instituted systems.

One way to possibly reduce energy use is to initiate combined heating for the heat pump loop and domestic water heating. Instead of using dedicated systems for both, the efficient condensing boilers could be used to provide the heating for both. A storage tank for the hot water supply would have to be installed for this system to operate. Also, attention to loop temperatures and dish washing temperatures would have to be investigated. Use of the auxiliary boiler or addition of a boiler may be an end result of this analysis; in order to ensure neither the water loop system or domestic water heating system is compromised.

Another way to improving energy efficiency for the site is to find ways to improve or reduce the load on the boiler and its gas consumption. One way is to improve the boiler to a variable load or pulse boiler. Another way is to use geothermal system or ground source heat pump to reduce the boiler overall consumption. A third method is to initiate micro turbines for combined heat and power for the mechanical system. While the during the winter months, the mechanical system would use the excess heat to supplement the boilers in the water loop heating requirements, the summer would present a challenge for the excess heat use. Domestic water heating in the summer, however, could be impacted by this heat excess to even further the reduction of boiler requirement during these months.

A third energy reduction technique that could be implemented is the use of variable frequency drives on the water loop pumps. While this method would require a reconfiguration of controls for all heat pumps as well as on the pump itself. This would allow the pump to run on a schedule rather than continuously. The lead and lag pump would still remain on a biweekly usage. A possible energy savings and pay back could be determined for this measure.

A few architectural changes could also improve the energy efficiency by providing a better exterior building envelope. Improvement of glass, wall, and roof are three possibilities for a more efficient thermal, moisture, and air barrier. These improvements will be easier to recognize one a base system analysis has taken place. Alternatives to consider include: improved u-value glass replacement, white roof installation, overhang installments, increased insulation, and many more.

By analyzing the effectiveness and application of all of these ideas, one can determine which should be suggested for implementation. Energy savings and annual payback can then be calculated. This information will then be added to the energy savings of the entire building.

Other LEED points in the energy efficiency area include third party commissioning, refrigerant management, and green power. The refrigerant atmospheric impact can also be analyzed by researching what type of refrigerants the water source heat pumps use. As long as the refrigerants used are not HCFC's, then the system is good for the environment. Also, if a renovation would take place in the future, a 3rd party commissioning agent could be used to ensure system optimization and an additional LEED point. Green power can also be researched for cost and availability.

Indoor Environmental Quality

While overall the ventilation flow rates for the building appears meet ASHRAE Standard 62.1-2007, the distribution of this air through a combined supply/return plenum makes it unclear whether each heat pump will receive the proper amount of outside air for the zone it serves. By developing methods for proper ventilation air distribution, coupled with improved kitchen ventilation, the indoor environmental quality can be optimized.

One way to ensure proper delivery of ventilation air is to directly duct the outside air into the spaces. This can be done a number of ways. One way is to institute ductwork directly from the ERV ductwork into each heat pump supply. This would increase the amount of sheet metal used on the project as well as labor. Another method would be to install separate diffusers in each room for ventilation. While this method would require separate outside air conditioning methods and additional materials and labor, it would prevent any disturbances and changes to the current system.

Carbon dioxide monitors could also be installed in high occupancy spaces to manage the amount of ventilation required for each space. Not only would this increase the efficiency of the ventilation system, it would also give the owner a measurement and verification method to ensure proper ventilation of spaces and optimized indoor air quality.

With the increase of return air circulation into the spaces, filters place in the return air grilles could be used to remove contaminants from the populated spaces. This would improve the cleanliness of the plenum spaces as well as reduce the amount of filtering done at the heat pump level. In turn, this could reduce the amount of filter changes for the heat pumps, which is quite a feat due to the quantity and locations of multiple terminal units.

A second way to improve the indoor environments air quality is to tackle the kitchen make-up air and exhaust. Since the same plenum is used for all first floor inhabitants, kitchen and dining rooms alike, certain precautions have to take place to ensure the pressurization of the plenum is optimized. It is also necessary to use hoods to exhaust the kitchen spaces of harmful air contaminants.

A possible solution would be to separate the kitchens from the central heat pump system and provide commercial kitchen ventilation system that would solve kitchen comfort problems as well as a dedicated system that will not affect the office and dining systems. A dedicated outdoor air system (DOAS) could be installed to take care of both the conditioning and make-up air required for the system. Load will also be taken from the central heat pump loop and therefore, the conditioning of this load on the loop would be reduced significantly. The control sequence for the DOAS unit and the hoods will need to be highly coordinated in order for the energy efficiency and spatial comfort to be optimized. Further research and calculations will have to take place in order to properly demonstrate the beneficial effects this system could offer.

Sustainable Results and Life Cycle Analysis

With the research and compilation of sustainable theories and data, the final results of the study can be determined. A few of the more plausible and rapid payback theories will be determined and recommendations for a sustainable retrofit will be concluded. These recommendations will be assessed base on the cost, indoor air quality, energy efficiency, and feasibility impact it will have on the building and the building system.

The building will also undergo a second LEED assessment to monitor any point increases the building would gain for the retrofit recommendations. This would only add to the incentive the building would have towards having a sustainable, recognized facility. Other assessments could also be considered, including Energy Star rating and Architecture 2030 assessment.

While doing the mechanical system sustainability research, it is also necessary to research how these implementations will affect the other building systems and execution of such. These areas will be covered in the sustainable breadth topics with focus on two major topics: construction management and architecture. Below are the proposed areas and the description of how each will be achieved.

Architecture

In order to improve the energy and water efficiency, changes in architecture may need to take place. Solar shades, improved glass and insulation, efficient water landscaping and other architectural impacts may need to take place to save energy and reduce the water consumption.

This research will be concluded by choosing landscape that does not require a lot of water to sustain while not comprising the overall landscape aesthetics of the building. Shading of the building façade over the 53% glass makeup, or installing new glass, will help reduce the thermal loads of the spaces, therefore reducing the size and requirements of the present system.

Construction Management

The mechanical system has been design/build for all four phases of the construction process; it is possible to assume a retrofit will be constructed in the same way. Special research and adjustment will need to be taken into account for the cost, schedule and commissioning for any adjustment or addition to the mechanical system.

This will be accomplished by analyzing previous construction schedules and costs for similar systems and comparing it to the current system. A schedule can then be created for the retrofit timeline and crew sizes. Also, a compilation of costs and payback can also be determined by using previous data. This will provide raw data for the owner to use to decide if any of the recommendations should be implemented based on time and cost.

With the study of these two breadth topics, a more accurate alternative suggestion for the Hershey Building sustainable retrofit can be made.

With the research and development of sustainable retrofit options, it is necessary to create a schedule and research methodology to carry out the extensive task. For a schedule of fourth month task to take place during the spring semester, please see Appendix A. Notice that many of tasks are during the weekday periods, since weekends are used for studying and other activities. Also, spring trips and activities are also blocked off from being assigned work. The days that are left will be used for research, calculations, reporting, and miscellaneous activities. Four to eight hours per day will be put aside for thesis work, especially during non-class days including Monday, Wednesday and Friday. Tuesday and Thursdays can be used for overflow work and miscellaneous activities. Weekends will also be used sporadically for make-up work and additional unforeseen conditions.

As for research and calculations, extensive background investigation needs to occur into which systems would be the most sensible and cost effective. One way to do that is to break it up by category and study each alternative separately. These categories and alternatives are below, including the method of research and calculation planning to be used:

- Water Efficiency
  - Fluid Cooler + Condensate Water: Calculate the amount of condensate water generated by each heat pump on a typical summer day and the amount of condensate water from the condensing boiler during the fall and spring. Calculate the amount of water a fluid cooler uses. Compare. If adequate, design a condensate water supply system. Estimate design/build cost and schedule.
  - Fluid Cooler + Grey Water: Calculate the amount of grey water created daily by estimating sink water use (both by lavatory sinks and kitchen sinks). Estimate the amount a fluid cooler would use during peak hours. Compare. If adequate, size a storage tank and pump that would be able to meet that fluid cooler capacity. Estimate design/build cost and schedule.
  - Landscape + Rain Water: Calculate the amount of rain water that could be collected during the summer months. Calculate the amount of watering the building's landscape normally undergoes during these months. If necessary, research similar landscaping plants that utilize less water. Decide the amount of water necessary for all plants during dry weeks or weeks without rain. Size a tank and pump for excess storm water to be collected in and serve landscaping. Estimate design/build cost and schedule.
  - Plumbing: Research existing plumbing fixtures in all four tenant spaces. Make recommendations for low and no flow water fixtures, as well as sensors, and estimate the cost and schedule for the entire plumbing reduction retrofit.
- Energy Efficiency
  - Boiler + Domestic Water Heater: Calculate peak boiler required capacity, required temperature and capability. Next, calculate domestic water heater peak required capacity, temperature, and capability. Compare if two could be integrated. Research if domestic heating could be met by boiler during summer seasons. If necessary, redesign

boiler and domestic water heater systems to integrate both systems together. Size pumps and storage tanks if required. Ensure redundancy and backup system is also designed. Calculate energy savings and payback. If adequate, estimate design/build cost and schedule.

- Boiler Replacement/Alternatives: Research alternative boiler types. Compare the consumption per output of each type. Compare to current condensing boilers. Also, research the feasibility of boiler alternatives including geothermal systems, ground source heat pump systems, and micro turbines. If any are feasible, research the cost and implementation of these systems and the annual paybacks.
- Variable Frequency Drives + Pumps: Estimate the current energy consumed daily by a pump. Next, estimate the amount the pump would be required to operate if not continuous and at what capacity (nearest quarter horsepower). Next, estimate the cost to reconfigure controls for all heat pumps and heat pump water loop. Compare. If necessary, design variable frequency drives system and schedule. Calculate energy savings and payback. If adequate, estimate design/build cost and schedule.
- Architecture Replacement/Alternatives: Research energy saving alternatives for existing concrete structures. Calculate the cost required to mitigate the solar impact. Compare to a better efficiency glass with LOE and Argon. Calculate savings based on energy versus the cost of installation and materials of new glass. Also, calculate the cost for solar shades and reduction cost of doing so. Also, research methods for better wall insulation and look at energy savings. Compare roof to a typical white roof and conclude savings. Choose the highest energy savings to the lowest installation cost. Choose which should be initiated. Calculate final energy savings and payback. If adequate, estimate design/build cost and schedule.
- LEED Energy Requirements: Research what type of refrigerant Florida Water Source Heat pumps used inside their terminal units. Next, locate and price a local third party commissioning agent in the central Pennsylvania region. Finally, locate and price green power and find out if it is available through the PPL utility.

- Indoor Environmental Quality
  - Ventilation Distribution: Research the best way to distribute the ventilation directly into the room. Compare direct duct versus entrance to ERV supply duct. Choose the most cost effective choice without comprising distribution priorities. Design system. Estimate the design/build cost and schedule to implement new system. Record any energy or equipment effects.
  - Carbon Dioxide Sensors: Choose which rooms would benefit from the carbon monoxide sensors. Estimate the energy savings that would occur from installment. Estimate the cost per each sensor and the payback for the total installation. Estimate the design/build cost and schedule to implement.
  - Return Grille Filters: Research a filter to use over the return grilles with low pressure affects that could be used for a plenum water source heat pump system. Estimate the number of filters required for the entire building. Estimate the cost and installation of each filter. Estimate the savings generated by less filter changes per heat pump.

- Dedicated Kitchen Air System: Research DOAS for kitchen conditioning and ventilation. If feasible, design a new system, eliminating the make-up air unit. Size the DOAS unit as well as any additional ductwork and materials. Estimate the cost and energy savings on the dedicated system and the entire building system. Research and estimate if any additional materials are needed to separate the kitchens from the other zones. Record energy or equipment effects caused by rezoning.

- Sustainable Results & LEED Assessment
  - Results: For each area researched, rate each system (1-5, 1 being the best) based on cost, indoor air quality (if applicable), energy efficiency, and the construction feasibility. This score will be divided by the applicable maximum score. Once each method is rated, an overall score can be used to rank the most effective improvements to the least for the sustainable retrofit.
  - Assessment: Each alternative will also be used to assess the building based on LEED, Energy Star and Architecture 2030 analysis. This will rank the building in terms of sustainability.

For research, many journals and websites have provided helpful resources for proposal alternatives. Interviews with McClure engineers and Penn State professors will provide a secondary research into design and implementation. See the next section titles “References” for a list of materials that were used during the research.

For calculations and data, various methods and tools will be used. Trane Trace software will be used for energy modeling. Energy costs will be estimated using utility rates from local utility plants. Costs for new materials will be estimated using R.S. Means or past numbers used on McClure Company projects. McClure Company is a design/build mechanical contractor that has completed all four tenant fit-out projects at the Hershey Press Building. Scheduling data will also be supplied by McClure Company, generated from similar project data. Indoor air quality analysis will utilize ASHRAE Standard 62-2007 with possible Computational Fluid Dynamics (CFD) analysis.

References

ANSI/ASHRAE, 2007, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA, 2007.

ANSI/ASHRAE/IENSA, 2007, Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA, 2007.

ASHRAE Handbook, Fundamentals. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2005.

ASHRAE Handbook, HVAC Applications. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2003.

ASHRAE Handbook, HVAC Systems and Equipment. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2004.

Barfield, Albert R. "Hybrid Geothermal for Hotel". ASHARE Journal June 2008: 48-50.

Brown, Stephen L. "Dedicated Outdoor Air System for Commercial Kitchen Ventilation". ASHRAE Journal July 2007: 24-35.

Dedicated Outdoor Air Systems (DOAS). Dr. Stanley A. Mumma. 1 Dec. 2008. <http://doas.psu.edu>

LEED. 2005, LEED 2005 Green Building Rating System For New Construction & Major Renovations. Leadership in Energy & Environmental Design, Washington, DC. 2005.

Lstiburek, Joseph W. "A Cup in the Rain". ASHRAE Journal April 2008: 54-58.

Lstiburek, Joseph W. "The Perfect Wall." ASHRAE Journal May 2007: 74-78.McClure Company. 2006. Mechanical Documents. McClure Company, Harrisburg, Pennsylvania. 2008.

Rate GS-3 2008 Calculation Form. PPL Corporation. 20 Oct. 2008. <http://www.pplweb.com>

Stensrud, Bryan. "Advances in plumbing technology help builders add LEED points". San Antonio Business Journal September 2006: <http://sanantonio.bizjournals.com/ >

Trace 700. Computer Software. C.D.S. Applications, 2008.

January 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 **New Year's Day**	2	3
4	5	6	7	8	9	10
11	12 Research Cooling Tower Consumption **Classes Begin**	13	14 Estimate Rainwater/ Month and Compare	15	16 Research Water Treatment and design Tie-in	17
18	19 Plumbing Study MLK Day – No Classes	20	21 Summarize Water Efficiency Results	22	23 **ASHRAE Trip**	24 **ASHRAE Trip**
25 **ASHRAE Trip**	**26 Complete Water Efficiency Research** **ASHRAE Trip**	**27** **ASHRAE Trip**	**28** **ASHRAE Trip**	**29**	**30 Boiler + DHWH Study & Evaluation**	**31 Possible Overflow Work Weekend**

February 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 Possible Overflow Work Weekend	2 Boiler Alternatives – Water to Water Heat Pump Boiler	3	4 Conduct VFD/Pumps Study & Feasibility	5	6 Finish Research on Energy Study – Summarize Results	7
8	9 **Complete Energy Efficiency Study**	10 Architecture Breadth Study – Windows	11	12 Architecture Breadth Study – Building Envelope/Misc	13	14 Additional LEED Study - Summarize Energy Efficiency Results
15	16 Run TRACE model for Energy Changes & Calculate Savings	17	18 IEQ – O/A Direct Duct Research	19	20 IEQ – O/A ERV Duct Approach Study & Comparison **THON**	21 **THON**
22 **THON**	23 **Complete Arch. Breadth**	24 IEQ – O/A Redesign and Cost/ Schedule Estimate	25	26 Kitchen Make-Up Air Unit/DOAS Study	27	28 Overflow Work Weekend

March 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 **MCAA Trip to Scottsdale, AZ**	2 **MCAA Trip to Scottsdale, AZ**	3 **MCAA Trip to Scottsdale, AZ**	4 **MCAA Trip to Scottsdale, AZ**	5 **MCAA Trip to Scottsdale, AZ**	6 **Spring Break Cabo w/AEs**	7 **Spring Break**
8 **Spring Break**	9 **Spring Break**	10 **Spring Break**	11 **Spring Break**	12 **Spring Break**	13 **Spring Break**	14 Overflow Work Weekend
15 CO2 Sensor and Return Filter Study - Summarize IEQ results	16 CM Breadth Schedules and Cost Estimates **Complete IAQ Study**	17	18 Finish CM Breadth Schedule and Cost Estimate Study	19	20 Conduct Sustainable Assessments	21 Possible Overflow Work Weekend
22 Possible Overflow Work Weekend	23 Compile Final Report/ Create Tables & Figures **Complete CM Breadth Study**	24	25 Organize Final Report/ Outline	26	27 Begin Final Report	28 Final Report
29 Final Report	30 Final Report	31				

April 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 Final Report	2	3 Proofread and Fix Changes	4
5	6 Create Presentation	7	8 Finish Presentation FINAL REPORTS DUE	9 Practice Presentation	10 Practice Presentation	11 Practice Presentation
12 Practice Presentation	13 FACULTY JURY PRESENTATION	14 FACULTY JURY PRESENTATION	15 FACULTY JURY PRESENTATION	16 FACULTY JURY PRESENTATION	17 FACULTY JURY PRESENTATION	18
19	20	21	22	23	24	25
26	27	28	29			