The Eberly Campus Community Center
Uniontown, PA

Building Systems Renovation Proposal

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Executive Summary

In direct response to a number of observed problems within the Eberly Campus Community Center, a series of building renovations have been proposed. These problems include excess humidity and moisture, mold growth, underutilization of the building, and a lack of energy efficiency. The proposed renovation ideas have been divided into seven distinct sections to facilitate owner understanding and to supply a variety of different renovation options to the owner team without enforcing the use of all of the ideas. The proposed renovation work is detailed below.

Alternative 1 includes the most basic remediation efforts to fix the most prominent problems. Solved here will be the excess moisture, the possibility of retaining of mold after removal of the visible contaminant, and administrative solutions to the underutilization problem.

Alternative 2 provides a full mechanical system redesign that will increase energy efficiency and actively counteract the underutilization problem that affects the mechanical system.

Alternative 3 manages the building water use within the plumbing system.

Alternative 4, renewable energy sources, suggests some common site energy production methods that may be employed in Pennsylvania, the location of the project.

Alternative 5 addresses the possibility of a LEED EB certification and the requisite actions that must be followed to attain the certification.

Alternative 6 is the calculation of the carbon use of the facility, with a goal to achieve a building that is at least 50% carbon neutral through the previously suggested alternatives.

Finally, Alternative 7 contains the proposed acoustical and lighting analysis to provide a better interior environment as well as possible electricity savings.

Through the seven alternatives suggested above, it is possible for this previously unremarkable building to become a showcase for green and sustainable renovation. Not only will the building energy use be deflated, but the interior built environment will improve and the building will become more appealing to its occupants. These alternatives, once implemented, will create a sustainable and functional building for the entire course of the building life cycle.

Breadth Executive Summary

A thorough knowledge of all of the building systems must be demonstrated through this proposed building redesign. While the main focus shall be upon the building mechanical systems, several other systems will be analyzed to provide breadth to the redesign.

The proposed breadth alternative is incorporated within Alternative 7, as mentioned in the Executive Summary. This alternative includes an acoustical and lighting analysis of key spaces within the building. The acoustical analysis shall be performed through hand calculations as well as the application of the free ESP-r software available through the U.S. Department of Energy. To complete the lighting analysis, the lighting power density shall be analyzed and the fixtures will possibly be redesigned to operate with less energy use. The redesign of the lighting system shall be accompanied by consultations with available lighting professionals.

However, Alternative 7 is not the only section of the proposed building renovation that will provide experience in other building systems. The renewable energy alternative provides experience with power and electrical distribution systems. Also contributing to the breadth of experiences is the LEED EB evaluation. To achieve a LEED certification, all of the building systems must be analyzed, and experience will range from construction management to electrical and lighting, to architecture and the use of materials. Finally, the first alternative requires a close inspection of the building site and its programming, which will provide additional experience with architecture and possibly construction management.

As these proposed renovations reach completion, a wide variety of skills and knowledge must be used. A breadth of knowledge will be demonstrated within the architecture, acoustical, electrical, and construction management areas of expertise. This is an unusual diversity of applicable skills that is not often encountered within the design of a single consultant. The completion of this redesign project will provide an integrated look at the existing and proposed building systems through the eyes of several disciplines, and hopefully provide the best solution for the current problems.

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1. Existing Conditions

The Eberly Campus Community Center is an existing building that has been in operation for about three years. For an existing building, any redesign of the building systems requires an evaluation of the installed systems as well as its operating history. Therefore knowledge of the existing systems and their operating characteristics is the first step in the building renovation process.

1.1: Heating

The heating system is currently a water based system powered by two cast iron 2498 MBH natural gas fired boilers. Most of the heating loads are met by the application of radiation equipment and radiant panels located along the perimeters of the spaces, though a few of the heating loads are served only by the system supply air.

1.2: Cooling

Most of the building cooling loads are served by the cooling coils on the space air handling units, though some small split system DX units are employed in the server rooms where no ventilation is required. Besides the DX units, all of the cooling is served on a water based system with the chilled water supply provided by a 225 ton air-cooled screw type water chiller.

1.3: Building Envelope and Foundations

The building wall system is a basic cavity wall with 12” CMU base wall and 4” face brick with a 2” air space. On the roof is an EPDM built up coal tar roofing system, while the floors are basic 2-way 4”-6” slabs with spread footers extending down from below the 12” CMU wall systems.

1.4: Air Side Systems

Any system drawing outside air has been fitted with a dry-bulb temperature based economizer. Several exhaust hoods have been required for applications throughout the building, including use in the kitchen, dish-wash, and training areas. Make up ventilators have been placed in combination with the designed exhaust hoods. The spaces have been separated into predominantly single zone systems with a total of 10 air handling units serving the building.

1.5: Mechanical System Operating History

While the mechanical system has been operating smoothly in general, several problems have been reported throughout its short operating history. For instance, the placement of room thermostats near open doorways to the outdoors has led to overcooling in the arena. This problem has been easily fixed, as have been most of the small problems encountered through the system's history. However, there has been a recurring problem with the space humidity levels that has yet to be resolved. The moisture problem is so prevalent that the hardwood gym floor has been replaced, and the theater has observed mold growth upon its seats. This problem has been under consideration since building completion, and a number of outside consultants have been employed to no avail. Therefore, this will be among the first of the problems addressed in the proposed building renovation.

Another consideration in the operating history of the system is the fact that the building is about 75% underutilized. The spaces are never occupied at design capacity, and some spaces are used only several times per year. Because the building has been designed to a much higher and more frequent occupancy rate, the systems are oversized through most of the year, and are not operating at their peak efficiencies. This problem, while not as blatant as the moisture problem, is insidious in its invisibility. Energy costs are elevated, the first cost has been inflated, and the system lifecycle could be shortened because the equipment is performing well below its best efficiency point. Any renovation of the mechanical systems in this building must include consideration of the actual occupancy rate and hopefully a down size in equipment.

2. Problem Statement

As discussed in the mechanical system operating history, the most visible problem to be addressed is a recurring moisture problem within the building. The second problem, affecting all of the building systems, is the extreme under-utilization of the building. On a typical day, the building receives about 25% of its original estimated design occupants, and several large spaces designed to hold large crowds are rarely used. This under-utilization must also be considered in the building renovation, as the building systems are operating inefficiently and are oversized. A final problem to consider that is related to the building underutilization is the energy waste of the system. The building systems have been designed to a standard of economy to minimize the first cost, and have no green or sustainable energy saving options beyond the economizers implemented within the air handling units. Therefore, the systems are not energy conscious, and energy is being wasted within many of the building systems.

To optimize the building life cycle cost, these three identified problems must be solved. Through the course of this renovation proposal, several alternatives will be presented. These will vary in complexity from the solution of the most urgent problems to the creation of a fully green and sustainable building. The choice of which final alternatives to be used lies with the owner. Breaking the renovation proposal into several alternatives provides the owner with options and control over the final construction of the project. The owner may pick the alternatives that suit the project budget and the goals for the renovated building.

3. Eliminated Solutions

As mentioned in the problem statement, several alternatives will be presented for the final proposal. However, a wide variety of solutions have been considered in the rendering of this final solution. Some of these solutions appear ideal, and will be presented within Section 4: Proposed Solutions. The solutions that have been eliminated from consideration are represented here.

In direct response to the building moisture problem, a wide variety of solutions have been reviewed. Included in the eliminated moisture solutions are the following: dehumidification within the cooling coil, more exact controls strategies, over-ventilation of the spaces to provide mass quantities of dry air, the use of portable dehumidification systems for when the spaces are not occupied, and placement of desiccants in key places throughout the space inaccessible to the general public. Many of these methods are too complicated or inefficient and have been removed from consideration.

Solutions have also been proposed to solve the building under-utilization problem. However, none of these ideas have been discounted as of yet, as they are plausible ideas that may be considered by the building owners in a proposed alternative.

Finally, a wide variety of schemes have been considered to counter the building energy waste. Eliminated schemes are as follows: fuel cell technology, solid waste processing, waterless urinals, grey water heat recovery, green roofs, and rain water catchment. These have been discounted due to excessive cost and scarcity of materials, ease of use, lack of sufficient steady hot grey water, excess weight, and required modifications to the roof and structural systems.

While the above eliminated solutions are not feasible for the current project, they are still viable solutions for a variety of other applications. These methods are practical and have only been discarded because they either require more cost and energy than they will recover, or a more efficient alternative is available for this system. To view the final design and renovation selections, see Section 4: Proposed Solutions.

4. Proposed Solutions

The proposed solutions have been separated into alternatives based upon their complexity and the urgency of the problems solved within each solution. The least cost-prohibitive and most necessary solutions will be proposed in Alternative 1, and increase in complexity until the final Alternative is proposed. With this wide selection of alternatives, the owner will have a variety of separate packages that may be chosen depending upon the cost and other concerns that may affect the decision of which solutions to implement in the renovation.

4.1: Alternative 1: Pressing Problems

4.1.1: Proposed Redesign

In this alternative, the most basic and pressing problems have been addressed: the moisture in the spaces, the mold growth within the theater, and the underutilization of the building as an administrative problem. Research shall be performed to determine the actual cause of the excess moisture. If the problem is simply a lack of epoxy sealant around the joint between the edge of the slab and the wall, then the sealant will be applied after thoroughly drying the afflicted building materials and hopefully the problem will be mitigated. However, if the problem is caused by the incorrect placement of a vapor barrier or from low space usage, further measures must be attempted. Desiccant wheels are the most efficient way of moisture removal in the industry, and these will be applied within the air handling units with an appropriate control schedule to counteract the moisture collection within the spaces.

Also, the mold growth found within the theater must be addressed. Studies shall be conducted in mold remediation, in modeling the probability of mold within the walls and building materials, and the best means of removing the mold to provide adequate indoor air quality within the theater. Possibly, there will be use of ultraviolet lights within the space for a certain amount of time to kill any existing mold particles and discourage future mold growth.

Finally, to counter some of the building underutilization, studies into possible university programming, advertising of rentable spaces to area organizations, cost discounts for community members, and other methods shall be suggested to increase the building occupants. This shall include a study of the site layout to see if any possible alterations to the site layout will encourage more use of the structure.

4.1.2: Justification of work

The work proposed in this section counteracts moisture and mold problems as well as a lack of building occupants. While the addition of desiccant wheels and the possible use of ultraviolet lights will slightly increase energy consumption, the moisture and mold problems are causing property damage and countless costs in consultant fees. There will be a definitive increase in both occupant comfort as well as the indoor air quality as well. The studies to improve building occupancy have no direct impact upon building function and operations. If successfully implemented, increased occupancy will increase the building loads. However, the equipment will then have to operate closer to its design condition, and therefore operate more efficiently. Additionally, increased occupancy rates will increase the revenues from the building as most visitors have to pay for the use of the facilities.

4.1.3: Methodology

The possible sources of the moisture problem will be explored through either on-site investigation, contact with the construction manager, or a comprehensive overview of the as-built documents. The moisture concentrations within the building materials will be modeled using the WUFI 4 program. This program will provide a time varying estimate of the amount of moisture present within the wall system at all times, as well as an estimate of the concentration of contaminants that will be growing at certain times of the year. Using this tool, the best time to dry out the wall system can be identified, and pertinent information about the mold growth can perhaps be identified. The visible mold has been removed from the theater at this time. However, trace amounts of its spores may remain, and great amounts of it may remain within the walls, out of sight. An indoor air quality analysis shall be conducted, either within CONTAM or through an EES model to study the varying concentrations of mold within the space and model the efficiency of the decided mold remediation method. Marketing and site planning ideas as well as organization scheduling ideas will be identified and perhaps a marketing consultant will be approached.

4.1.4: Integration and Coordination

The addition of desiccant wheels will affect the current mechanical system. If this is the only alternative undertaken by the owner, this must be taken into consideration. However, if both Alternative 1 and Alternative 2 are chosen by the owner, then the mechanical systems may be redesigned to include the necessary desiccant wheels, and the coordination issue will be cleared. Other areas of coordination include the building electrical system and structural system, because the desiccant wheels will use extra fan energy, add extra weight to the air handling units, and the mold remediation will also use extra energy.

4.2: Alternative 2: Mechanical Systems Redesign

4.2.1: Proposed Redesign

The current mechanical system is grossly oversized for the demands that are uniformly placed upon the building system. Therefore, the system shall be redesigned to incorporate energy efficiency as well as reducing the size of the system to meet the required load. Currently, the spaces are served by separate air handling units with radiant heating along the perimeters of the space. The zoning is logical, and mezzanine mechanical rooms are already constructed, so the current zoning and placement layout of the mechanical system will remain the same. With widely varying loads within the spaces, as well as a prevalence of single zone systems, the building lends itself to a demand control ventilation application of a dedicated outdoor air system. Ventilation air will be provided through the air handling units, at a low temperature and low flow condition. The radiant panels and radiation heat will remain to counter heat loads. Studies will be performed to see if the radiant panels currently used can be switched to also use chilled water and provide further cooling. If the use of the current radiant systems for both heating and cooling applications is not feasible, then radiant ceilings will be introduced as necessary.

The arena will provide the greatest challenge for this redesign, because it is often only marginally loaded, while several times per year must also accommodate up to 2000 people for sporting events and commencement ceremonies. Currently, the arena is divided between four equal air handling units designed to handle the entire load. The redesign will incorporate one smaller dedicated outdoor air system or regular air handling unit that will handle loads of up to 40 people – an overestimate of the arena's most common use of sports practices and basketball games. Backup air handling units sized to accommodate the occasional larger load will be provided and only switch on during times of peak load. The units in the arena may be dedicated outdoor air systems and may be simple recirculation systems that use air to serve the load depending upon how well the load is handled by radiant applications existing in the walls. The distribution system may have an option to switch between the single unit and multiple units to save ductwork costs, depending upon layout and space within the ceiling. The theater may also be designed in a similar fashion, with backup units for its occasional full load use.

The chiller will be resized to only supply the average load for everyday partial use. Thermal storage will be employed to store excess chilled water for applications when full load is encountered. The chiller will be staged so that it remains available for cooling during the daylight hours, and reverts to charging the storage at night. Any loads that exceed the capacity of the chiller will be handled by the thermal storage, including loads from a fully occupied arena, fully occupied theater, and the rare occasion that the wood fired pizza oven is used.

Combining with the redesign of the chiller system, the air cooled condenser will be removed from the roof of the mechanical room and be replaced with a cooling tower. The tower will employ water side free cooling to further reduce the building energy usage. Further study will go into the possibility of using the prominent water feature at the front of the building as a heat rejection loop.

4.2.2: Justification of work

The scope of the mechanical redesign is justifiable and even necessary considering the over-sizing and under-utilization of the current equipment. The energy savings will hopefully justify the cost, though a life cycle cost analysis will be run for every alternative to determine the costs vs. the savings of each option.

4.2.3: Methodology

CFD models will be employed to determine if the wall radiant panels will be as efficient with cooling as with heating. Possible spaces to be considered for a CFD model will be the arena, the theater, and the fitness area. The best application of time and effort with a CFD model will be determined as the design commences. A model of the chiller/cooling tower/thermal storage combination will be developed either in EES or in Excel depending upon the complexity and the time constraints of the required calculations. Extra attention will be paid to the possibility of free cooling and whether or not the free cooling and thermal storage options are cost effective. The water feature will be modeled in either EES or Excel, and a final decision will be made depending upon the efficiency and cost of the study results.

4.2.4: Integration and Coordination

This option will affect the electrical system (increases or decreases in power), the structural system (moving and adding equipment), and possibly the architecture (additional equipment required upon the roof).

4.3: Alternative 3: Plumbing System Energy Efficiency Measures

4.3.1: Proposed Redesign

Water use reduction is another green and sustainable method of saving both energy and water utility cost. To improve the building water use, several methods will be employed. First, low water use fixtures will be specified. An up-flush / down-flush valve with very low flow on the up-flush for liquid waste and a standard 1.6 gpm down-flush for solid waste can be added to existing toilet fixtures for marginal time and cost, while saving gallons of water per day. Flow attenuators will be added to sinks and showers and the kitchen equipment will be scheduled to either minimize use or redesigned for a lower water use. Grey water will be stored and reused in the toilet fixtures, and the storage tank will be sized such that the stored grey water will be enough to handle a large arena crowd for at least 4 hours.

4.3.2: Justification of work

Improvement of the building water use can save energy and operating costs, though the amount saved is impossible to know without an analysis of the water utility bills. Also, a reduction in water use will earn potential LEED credits if the owner chooses to follow that path.

4.3.3: Methodology

A thorough review of the available products on the market will provide the best choices in plumbing fixture selection. The grey water reuse and storage systems will be sized based upon average building occupancy schedules, and the total building water reduction will be calculated in Excel after the redesign is complete.

4.3.4: Integration and Coordination

These systems must be integrated with the mechanical system redesign, as the new tanks must fit in with the existing system. Also, coordination must be implemented with the electrical system as the grey water storage will add additional pumps, controls, and pumping energy.

4.4: Alternative 4: Renewable Energy Sources

4.4.1: Proposed Redesign

There are several renewable energy resources available in Pennsylvania today. The system that will be utilized with the Eberly Campus Community Center will be combination of wind power and solar power. There are a wide variety of wind turbines available on the market today, and of particular interest to this project are small series wind turbines that mount on the roof of low, horizontal buildings as well as helical wind turbines that require low wind velocity and only forty feet of clear height.

Solar panels will be either placed upon the flat roof or located on the convenient south facing slope just below the building. Evacuated tubes will be placed either on the south wall of the façade or along the south facing hill as well. Through the solar panels and the wind turbines, variable amounts of DC power may be produced, while the evacuated tubes can generate hot water to add to the building heating system. Because the solar panels and the wind turbines both require an inverter, a single inverter may be used for both applications to save time and cost.

4.4.2: Justification of work

Renewable energy is highly beneficial from both an energy use standpoint and an operating costs standpoint. The only drawback is the extreme cost associated with an installation of the systems. The addition of these systems will also count toward LEED points as well as provide a showcase for solar and green design in the southwest corner of Pennsylvania.

4.4.3: Methodology

The relative power production of the different components as well as the requisite number of panels and turbines shall be calculated and input into an EES model, and the solution will be maximized according to power with panel area and number of turbines as the changing variables. Also, the area of evacuated tubes required to produce enough heat to counter building loads will be calculated. If this area is too large to be feasible, then further optimization studies shall be created to make an informed decision about the number of evacuated tubes to buy, or whether to eliminate the evacuated tubes altogether.

4.4.4: Integration and Coordination

This technology needs to integrate with the electrical system, the mechanical system, and the plumbing system, as all three systems will be supplied with the byproducts. Also, space must be provided for storage tanks, inverter(s), and battery banks. Therefore, architecture and site design will also require coordination.

4.5: Alternative 5: LEED EB Certification

4.5.1: Proposed Redesign

If the owner has employed all of the previous alternatives, the building can consider applying for a LEED EB rating. The building will be checked for credit compliance, and suggestions for cheap or easy credits will be given. The goal will be to attain a LEED Certified rating. However, if higher ratings are attainable with a few extra design considerations, the rating goal will be raised.

4.5.2: Justification of work

As the movement towards green and sustainable design gains momentum, a LEED certification is becoming more desirable. The attainment of a certification will bring the school prestige and notice throughout the industry.

4.5.3: Methodology

A copy of the LEED EB checklist shall be obtained, and the User's Manual will be sought. Compliance checks will be calculated are required for credits. Any credits that will be easily obtainable will be added to the building systems redesign.

4.5.4: Integration and Coordination

The LEED rating system requires compliance and green design from the entire building project. Therefore all systems shall be affected, and may be redesigned in an attempt to attain the desired rating.

4.6: Alternative 6: Carbon Neutral Building

4.6.1: Proposed Redesign

While the achievement of a 100% carbon neutral building is very difficult, it is possible to reduce carbon use and emissions. The stated goal of this alternative is to redesign the building so that it is at least 50% carbon neutral from an energy and operations standpoint. If the building does not meet the 50% carbon neutral goal, then the set of alternatives will be checked once for possible new ways of energy conservation. If additional energy reduction is not possible, the goal shall be abandoned.

4.6.2: Justification of work

The building industry is currently trying to move toward carbon neutral homes and buildings by the year 2030. Therefore, any experience with regard to the calculations and systems available to create a carbon neutral building will be invaluable.

4.6.3: Methodology

The building energy use shall be computed either by hand, through a spreadsheet, or using an energy model (either Trane Trace or Energy Plus, depending upon complexity, time available, and the steepness of the learning curve). Emissions shall also be under scrutiny to determine the total building carbon use.

4.6.4: Integration and Coordination

This option does not need to be coordinated unless the calculations unearth an error in the previous alternatives, or if a few small design changes will produce definitive positive results for a more carbon neutral project.

4.7: Alternative 7: Breadth Topics: Acoustics and Lighting Redesign

4.7.1: Proposed Redesign

There are several large spaces within the building that may need acoustical attention. The theater in particular requires a delicate balance of absorptance and reverberation time to produce the desired sound effects. These spaces shall be studied and redesigned if the current acoustical conditions are found to be unacceptable.

With the addition of the previous alternatives, the electrical system is often mentioned as under direct impact. However, the electrical design of the building may itself provide many opportunities for energy savings. Therefore, the lighting system shall be redesigned to produce the required lighting levels while consuming less electricity. If there is sufficient time, the electrical system itself shall be reduced and redesigned to accommodate the changing loads and energy requirements.

4.7.2: Justification of work

The acoustics within a lecture hall, theater, or other gathering space have a significant impact upon the audience interest and retention. Meanwhile, there are large energy savings possible through the use of lower wattage lighting fixtures with high efficiency ballasts. Both acoustics and the lighting design will be evaluated and changed if they are unacceptable.

4.7.3: Methodology

The acoustics of the spaces shall be modeled and calculated within the ESP-r program, a free program available through the U.S. Department of Energy. The lighting design will commence simply through a comparison of different properties of the fixtures used, while outside lighting professionals will be consulted about the lighting redesign as well as the use of applicable software packages.

4.7.4: Integration and Coordination

The redesign of the building acoustics as well as the lighting system provides many opportunities for coordination of the project. The acoustics needs to integrate with the existing structural and sound systems, while the lighting system must again integrate with the electrical system.

5. Preliminary Research

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6. Spring 2007 Schedule: Draft

Please see the following Excel Spreadsheet for the preliminary draft of the proposed schedule.

January						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	15	16	17	18	19	20
	Spring Semester Classes Begin	Start Alternative 1			Alternative 1 Done	
21	22	23	24	25	26	27
	Start Alternative 2					
28	29	30	31			

February						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
					Alternative 2 Done	
4	5	6	7	8	9	10
	Start Alternative 3				Alternative 3 Done	
11	12	13	14	15	16	17
	Start Alternative 4					
18	19	20	21	22	23	24
					Alternative 4 Done	
25	26	27	28			

March						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
	Start Alternative 5				Alternative 5 Done	
4	5	6	7	8	9	10
	Start Alternative 6				Alternative 6 Done	
11	12	13	14	15	16	17
	Start Alternative 7					
18	19	20	21	22	23	24
					Alternative 7 Done	
25	26	27	28	29	30	31
					Start Writing Paper	

April						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
					Start Writing Presentation	
8	9	10	11	12	13	14
	Presentation Practice	Presentation Practice	Presentation Practice	Presentation Practice	Presentation Practice	
15	16	17	18	19	20	21
	Thesis Present. Begin					
22	23	24	25	26	27	28
29	30					