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Project | Crystal Plaza II

Location | Arlington VA

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Thesis Proposal | Revised Thesis Proposal

Contents

Executive Summary

This document serves as a proposal for thesis research to be conducted during the spring. The requirements include the need for a minimal two topics of breadth study, a study of a critical industry issue, and connections to graduate level course work. The following topics have been identified as potential areas of research after review of constructability, value engineering, scheduling, and discussions with the construction team. While each analysis is different, there is an underlying theme throughout the proposal of value adding sustainability to Crystal Plaza II. The topics are listed below with descriptions of requirements met and a brief overview of the intended research.

Analysis 1: Building Integrated Solar Energy Systems & DC Distribution

(MAE-Alternate Power Sources, Sustainability; Breadth- Electrical)

The first analysis focuses on the rising cost of energy in the United States and a potential way for the owner to supplement these costs. The use of a building integrated solar energy system can provide energy for use within the building or to sell back to the local utility. Recent research has indicated that even non-optimal surfaces can still produce a substantial amount of energy to offset the cost of placing the PV material at a less the favorable location. Also of concern is the distribution and use of this energy. PV's produce their energy as direct current, DC, while nearly all building equipment utilizes AC, or alternating current. The need for an efficient DC distribution system will be evaluated as part of this analysis.

Analysis 2: Peak Demand Shift & Demand Response Programs

(Breadth- Mechanical/Electrical; Critical Industry Issue)

This analysis focuses again on the rising cost of energy, but as a critical industry issue in providing alternative uses for equipment to help lower energy costs. This analysis is not focused on energy savings, but on energy cost savings. The research and review of demand response programs, as well as the use of emergency energy generation equipment will be evaluated as ways to shift the building's energy demand spike and sell unused energy back to the utility. Additional research into combined heat and power will also be included, but not as the primary focus, as the emergency energy generation equipment has already been installed.

Analysis 3: Financing Projects through Energy Savings

(Critical Industry Issue)

The third analysis begins to look at the overall effect of the first two analyses and the results of saving energy. As the economy begins to face tough times, contractors will be forced to work more in a renovation type environment that deals with saving operating costs. This analysis will look into the current availability of energy programs, whether it be direct financial savings or through marketability of energy. Also, as part of this analysis an industry overview will be provided through the use of a survey of current industry members.

Analysis 4: Consolidation of Slab Penetrations

(MAE- Virtual Prototype/Modeling; Breadth- Mechanical, Structural)

The final analysis area will concentrate on the consolidation of mechanical and plumbing risers to lower the number of required slab penetrations. This has a direct effect on budget and schedule as costly structural reinforcement is required to meet the proper structural design loads. The process for structural reinforcement is costly, time consuming, and area intensive. By eliminating the need for some of the many penetrations and evaluating key areas, the structural reinforcement may not be necessary, in effect accelerating the schedule and saving the owner money.

Analysis 1: Building Integrated Solar Energy Systems & DC Distribution

(MAE-Alternate Power Sources, Sustainability; Breadth- Electrical)

Background

This analysis topic confronts the issue of rising energy costs in the United States. Onsite energy production has the ability to drastically lower or even "zero out" the building's energy cost. A developing area of onsite energy production is in the field of building integrated solar energy systems, also known as building integrated photovoltaics (BIPV). These systems integrate a PV material into a building component such as the façade or roofing material. The most common area of integration in commercial applications is within the curtain wall system that is a prominent part of new commercial design. As for residential applications the focus is more on roofing materials such as shingles and metal seam roofing. The use of a curtain wall integrated system at Crystal Plaza II provides the owner with an opportunity to market green energy onsite or sell the energy back to the utility for profit. This analysis provides research into graduate level material on sustainability and renewable energy, as well as a breadth in electrical in terms of the energy distribution.

Problem Statement

The current façade material at Crystal Plaza II is a non-typical residential façade material. The system is a unitized curtain wall system that contains operable windows. The ability to incorporate a BIPV system into the curtain wall would allow the building to create energy using the PV material. The use of a BIPV system would need to have little effect on the schedule as the curtain wall is currently a critical path item and has been in production since the beginning of the project, even through the suspension phase. While it is uneconomical to begin fabrication now or to replace the previously installed, custom panels, the ability to see the potential for similar buildings in the complex would greatly benefit the owner.

Potential area for BIPV System in curtain wall

The benefits of solar energy production are already well documented; however the distribution of the DC power on such a large scale provides a potential research area. The transmission and use of the DC power will need to be explained and designed. Without efficient transmission and use, the energy created by the BIPV system will be largely lost.

Goals

The goal of this analysis is to provide research into a BIPV system that is integrated into the curtain wall system. The research includes the distribution of the resulting energy produced via a DC system to components that use DC power or to efficient inverters to provide AC power. The cost implementations along with the potential production of such a system will be necessary to calculate the estimated payback period to install the system. Contacts with industry members will be key to understand lead time for such a system and the requirements of installation. The overall goal is to provide a "what if" scenario to the owner to market the use of BIPV and DC distribution in future projects at Crystal Plaza.

Research Procedure

1. Research BIPV systems
2. Evaluate BIPV systems based on desired use with advantages/disadvantages
3. Estimate various scenarios of BIPV implementation, access building façade/exposure
4. Research and develop equipment powered by DC or efficient AC inverters
5. Develop simplistic and basic DC distribution system for communal use of DC energy
6. Estimate total cost of BIPV and DC distribution system
7. Calculate energy savings
8. Determine payback period
9. Make suggestion of implementation of BIPV on current and future projects

Tools and Resources

1. Various manufacturer and supplier data
2. Photovoltaics in the Built Environment by Steven Strong
3. Whole Building Design Guide
4. National Renewable Energy Laboratory
5. Energy10 or similar energy modeling program
6. RS Means 2008

Expected Outcome

The expected outcome of this analysis is to provide a positive suggestion for the use of BIPV and a large scale DC distribution system for use on a limited scale at Crystal Plaza II, but can be incorporated into other projects by the owner at Crystal Plaza. It is expected that the BIPV system will create a larger upfront cost and a minimal time extension during the manufacturing phase, but installation will be at nearly the same time rate. Given the consistent ownership of Crystal Plaza II, the payback period may be longer than the industry average of 3-5 years, allowing for such a system to be profitable to the owner.

Analysis 2: Peak Demand Shift & Demand Response Programs

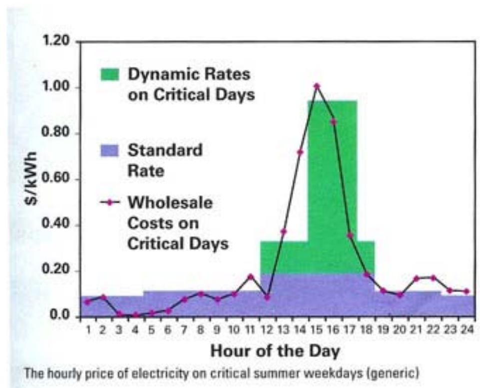
(Breadth- Mechanical/Electrical; Critical Industry Issue)

Background

The idea for this analysis comes from discussions in a graduate level class and a prior internship experience. Again, with energy costs on the rise in the United States, it is becoming typical for well educated owners to ask for out of the box solutions, especially when dealing with energy. The use of a peak demand shift or demand response program allows contractors and consultants to market a system that takes advantage of other facilities high peak demand by shifting their own to a time less costly. The ability to shift demand at a residential facility may prove difficult with the individual units, however, shifts in communal energy sources and HVAC systems, as well as the opportunity to utilize emergency power systems for energy generation may prove beneficial to the owner. The critical industry issue involves the non-typical use of a building system to create a project during a potential recession. The current market is fading away from new construction into renovation and this provides a possible project that benefits both the contractor and the owner.

Problem Statement

This analysis problem statement is twofold. After determination of demand response accessibility in the Washington D.C. area, it is necessary to develop a feasible system or process to shift the peak demand at Crystal Plaza II to another part of the day outside of the typical demand peak. This must still allow for the operation of critical systems and be able to continue occupant comfort. The second area is the use of the installed diesel generator to produce energy during the demand peak to lower or offset the buildings own demand or to sell to the utility at a commodity rate. Another option to consider is the replacement of the diesel generator with a combined heat and power source that is capable of handling emergency power generation, but can also provide energy to the grid.



Energy demand spike courtesy of http://www.energy.ca.gov

Goals

The goal of this research is to determine the feasibility of a demand response program at Crystal Plaza II and the use of the emergency power generation system to help offset demand or provide revenue. The analysis is not entirely an energy saving idea, but more of an energy cost savings for the owner. Interviews with specialty contractors that may have experience in this field will be crucial in determination of feasibility. The focus is to create a cost analysis and constructability review of the system. Additional research into combined heat and power and the use at Crystal Plaza II to produce energy and provide a potential pre-heat system for the boilers will also be considered.

Research Procedure

1. Research local demand response programs
2. Determine potential building energy use and energy use patterns
3. Conduct industry interviews about demand response and energy generation systems
4. Develop energy management program to shift demand for standard demand response program
5. Investigate use of generator to produce energy daily
6. Estimate life cycle costs of generator use
7. Develop cost/benefit analysis of energy production
8. Research CHP systems and potential uses
9. Estimate cost impact of using CHP over diesel generator
10. Provide conclusion on demand response and suggested course of action

Tools and Resources

1. Washington area Energy Utility Company
2. CLT Efficient Technologies Carnegie PA (Energy Service Company)
3. Energy10 or similar energy modeling software
4. Industry member interviews or surveys
5. Various manufacturer and supplier data

Expected Outcome

The expected outcome for this analysis is the ability for Crystal Plaza II to successfully be able to shift peak demand and produce energy that can be sold to the local utility during the demand peak time. The implementation of the demand response program should be feasible, as well as the use of the diesel generator. However, even a shift in the peak demand could provide potential savings for the owner and occupants. As for the CHP system, it is my opinion that the system would be beneficial but would have too large of a capital investment to be considered. The current system is already in place and may be operational. The removal and reinstallation of a new system powered by a different fuel makes the initial investment large. However, the benefits of the CHP system still deserve consideration as the ability to produce heat may supplement the boilers and create more savings through life cycle costs or equipment downsizing. The purpose of the CHP research will be to provide data concerning the heat production to a potential mechanical engineer that can resize or re-evaluate the boiler system. It is not intended to be a mechanical system redesign as the primary focus of the CHP will be the emergency energy production and the energy production for profit.

Analysis 3: Financing Projects through Energy Savings

(Critical Industry Issue)

Background

The idea for this analysis comes from topics discussed at the Pace Roundtable Conference held at Penn State University on October 16, 2008. As the economy seems to be slipping into a recession, financing for new projects is becoming harder to obtain. Allocating the necessary funding to produce a new building is hard in good economic times, let alone bad ones. As the economy is turning, the focus begins to shift from what can be done with a new facility to how expenses can be saved on an existing facility. Renovations seem to become the project type of choice during these times, most commonly those that save energy to lower the cost of operating and maintaining the facility. There is no exception at Crystal Plaza II. As my first two analyses show, the primary focus is on saving through energy. Whether it be through onsite production or by shifting the peak demand to take advantage of the rate structure of the utility, saving energy has the opportunity to save large portions of expenses for owners. This concept is radically different when used to fully finance a project, a renovation, of a change in the materials to create energy savings. Not only does it offer the opportunity for savings, but it is also sustainable in many ways. Research into the areas of smart grids, rebates and incentives, reverse metering, carbon credits, demand shift, and demand response programs offer alternative means to acquire the necessary funding for these projects and in the current economic situation, my prove the key difference in contractors landing their next project.

Problem Statement

This analysis will serve as research into a critical industry issue. That issue is the current availability of financing and funding for new or renovation projects (typical in times of economic stress) through the advantages of energy savings. The use of these advantages is often overlooked in good economic times, however energy savings is the first topic to be addressed when the economy takes a downward turn. Proper investigation into incentives, rebates, carbon credits, demand shift, and demand response programs are necessary as well as the current ideas and thoughts held by industry members about these topics to research their feasibility in the Washington D.C. area.

Goals

The goal for this analysis is to conduct an industry interview concerning the use of such programs described above in marketing potential projects to owners or to provide a competitive advantage in presenting an alternative way to finance a project or renovation that in turn can pay for itself. The goal is to provide the background necessary to support the first two analyses ability to benefit the owner. Also, information for the owner in how to market these potential energy savings and take advantage of federal and state programs is a goal

Research Procedure

1. Research programs available in the Washington D.C. area
2. Identify case studies of programs in the area
3. Create and conduct interview for industry members regarding energy savings projects
4. Prepare benefit report for current project if applicable and for analyses 1 and 2

Tools and Resources

1. Building energy information
2. Local utility structure/rates
3. Energy rebate/incentive/demand program websites
4. Industry members

Expected Outcome

This analysis will serve as the critical industry issue and is expected to show the current trend and thinking of industry members on the topic. With the current economic situation the outcome of the research should so a positive gain for both the owner and the contractors. The results provided will also help the current project, Crystal Plaza II, in applying for potential incentives and rebates. The results should also reinforce the use of analyses 1 and 2 as feasible alternatives or means of saving operating costs. It is expected that the benefit of using the federal rebates or demand response programs were applicable will be a substantial benefit to all parties.

Analysis 4: Consolidation of Slab Penetrations

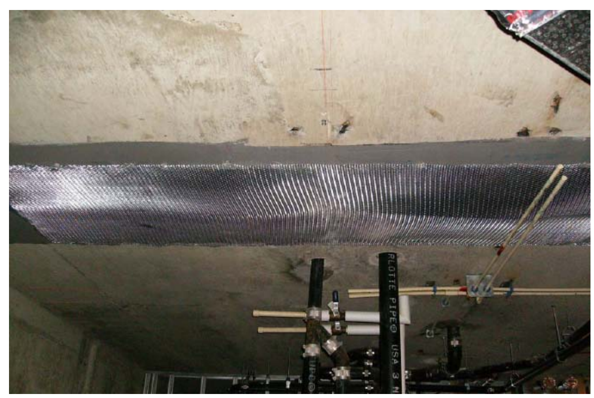
(MAE- Virtual Prototype/Modeling; Breadth Mechanical, Structural)

Background

The new use and construction type of Crystal Plaza II provides many unique challenges. One challenge focuses on the change from a commercial to residential use. The current building will be a residential complex with approximately 266 individual rental units. This analysis is designed to evaluate the issue with slab penetrations and structural integrity issues as a result of the amount of slab penetrations. Currently the design requires nearly 300 core drilled penetrations and approximately 25 slab cuts to provide areas for the necessary risers. This process requires the use of two core drill contractors, each responsible for a different trade, coordination with curtain wall installation to avoid damage, coordination with slab leveling to avoid penetration infill, and structural preservation. The substantial amount of penetrations has caused structural issues that require a change order to the project. The change order is to install CFRP on the underside of the slabs to reinforce the slab; also a two hour fire rating is required over the reinforcement not originally included in the change order. The structural preservation process is timely, costly, and requires a large lay down area that is affecting the production on each floor for only a small amount of required reinforcing.

Problem Statement

The issue is to determine if the original riser spaces are adequate for use as a centralized distribution system supplying the individual units rather than using consistent slab penetrations for risers. Risers that can be consolidated must be identified and basic information evaluated. Basic mechanical sizing of supply/return/waste lines will need performed to estimate size of consolidated risers and main distribution piping for a typical floor. The purpose of the mechanical resizing is to determine the feasibility of the existing riser areas to house the new risers. If the existing is not acceptable, consolidation to a lesser number of openings may provide the ability to avoid structural reinforcement. Also the location of the penetrations should be considered, and if the existing areas are not sufficient, strategic placing of new openings can prevent the use of structural reinforcement.



Fire proofed CRFP panel on underside of slab

Goals

The goal of this analysis is to eliminate the need for the large quantity of mechanical and plumbing risers through a typical slab. It is not intended to be a complete mechanical or plumbing redesign. The focus will be on the consolidation and distribution of risers to lower the number of slab penetrations. By consolidating the risers and eliminating penetrations, a formula already used in determination for structural reinforcement can be used to compare the new condition with the existing. The goal is to avoid structural reinforcement using the CFRP. The resulting scenario will then be used to conduct constructability and schedule analysis against the current system to determine the benefits from a construction manager's point of view. The resulting scenario will be modeled and combined with the schedule to produce a 4D model for comparison to the original in terms of time and work flow by expanding the typical floor to multiple floors.

Research Procedure

1. Conduct interview with Mechanical/Plumbing designer
2. Select risers to be consolidated for typical floor
3. Perform basic sizing calculations for risers for typical floor
4. Locate area to place new risers
5. Perform basic sizing calculations for main branches
6. Evaluate branches for clearance of ceiling
7. Determine new penetrations per typical floor
8. Conduct interview with Structural designer and obtain reinforcement calculation
9. Identify problematic areas that may require structural reinforcement
10. Evaluate need for structural reinforcement
11. Re-evaluate system if necessary to avoid structural reinforcement
12. Estimate cost and schedule impact of new layout
13. Compare new cost/schedule to existing to determine advantages/disadvantages
14. Produce 4D model of existing workflow and new workflow to compare efficiency and impacts to schedule

Tools and Resources

1. GHT Limited (MEP Designer)
2. Tadjer Cohen (Structural Engineer)
3. RS Means 2008
4. Mechanical & Electrical Equipment for Buildings by Stein and Reynolds
5. Revit MEP/Revit Architecture
6. Navisworks Jetstream
7. MS Project or Primavera Project Manager

Expected Outcome

The expected outcome of this analysis is that with the consolidation of applicable risers, the amount of slab penetrations can be reduced by a number that allows for no additional structural reinforcement. Given the limited number of areas requiring reinforcing, it is expected that by eliminating only a select few penetrations or moving select slab openings, the use of structural reinforcing can be avoided. The 4D model will also provide a valuable visual to the outcome, showing the benefits of avoiding the change order work in the form of schedule timing.

Weight Matrix

The following is a visual breakdown of how time will be divided among the four analyses areas and how time within each will correspond to one of four main topics.

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Building Integrated Solar Energy Systems & DC Distribution	10%	5%	5%	5%	25%
Centralization of Mechanical Risers		5%	15%	10%	30%
Peak Energy Demand & Demand Response Programs	10%	5%	10%		25%
Financing Projects through Energy Savings	15%	5%			20%
Total	35%	20%	30%	15%	100%

Appendix A: Breadth Studies

Analysis 1: Building Integrated Solar Energy Systems & DC Distribution

Breadth in Electrical and Alternative Energy Sources (MAE)

The breadth of this analysis will focus on the DC distribution system and the equipment that uses the DC power without the need of an inverter. This provides the opportunity to design a basic electrical system that can then be extrapolated to a larger scale for Crystal Plaza II. The analysis will include a basic electrical system for the DC power or the use of an inverter to provide AC power to communal areas. This is not the limit of this technology as it is only an exercise of what is possible. The use of energy in each individual unit is a definite possibility, however, the communal use of energy lends itself to a more owner controlled system that also does not require a compensation plan for those units that may not produce as much as others. The intentions for the DC system are to begin with a relatively simple system for a single unit and end with a basic schematic for a typical floor or the entire building for the BIPV scenarios described. The system will be focused on the communal areas such as hallways, janitorial facilities, mechanical/electrical closets, elevators, and stairwells. The research for the alternative, onsite energy is also outside of the typical construction management topics as it was covered in a graduate level course, but has been researched and presented in prior senior thesis. This topic offers the opportunity to go above the standard curriculum and use topics presented in graduate level classes.

Analysis 4: Consolidation of Slab Penetrations

Breadth in Mechanical and Structural, Opportunities for 4D CAD modeling (MAE)

This breadth analysis provides breath into the mechanical area as a basic redesign of the distribution system for a typical floor. Outside assistance from industry members will be key to producing a “rule of thumb” system to evaluate the feasibility of consolidating the mechanical and plumbing risers. The goal is to not design the entire distribution system, but rather to design a centralized riser and main branch system for select risers on a typical floor that allows for individual apartment hook ups, and thus limits the number of slab penetrations that are causing structural issues. This includes sizing of distribution piping and risers and layout of the distribution system to each apartment accounting for obstacles and ceiling heights. Only a single typical floor will be analyzed as many of the same areas and issues are prevalent on all existing floors. This topic also includes a structural breadth in the calculation of the structural reinforcement. A brief study of the current scenario will be analyzed to locate the problematic areas for the structure. This analysis will then lead to the isolation of those risers to be consolidated. The goal is to avoid the reinforcement required due to the penetrations, but a structural analysis will be performed to determine the acceptability of the structural integrity using the same system and calculations as the structural engineer.