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Project | Crystal Plaza II

Location | Arlington VA

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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: LEED- Value Engineering Sustainability

(MAE-Sustainability)

The third analysis is based on review of the value engineering performed at Crystal Plaza II. While hindsight always seems to be 20/20, this section will focus on the procedure to value engineer the project and the outcome of eliminating sustainable features. Of primary concern is how to re-evaluate the decisions to eliminate these features and possible ways to reinstate them back into the project by value engineering other areas.

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

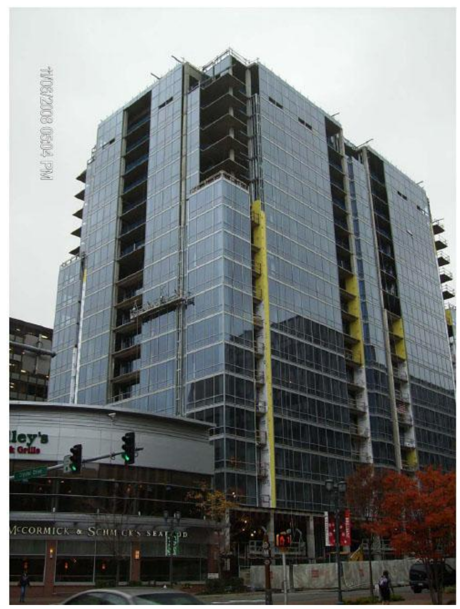
(MAE-Alternate Power Sources, Sustainability; Breadth- Electrical)

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
4. Research and develop equipment powered by DC or efficient AC inverters
5. Develop simplistic and basic DC distribution system
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

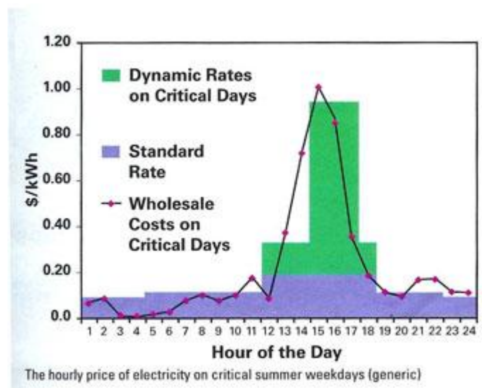
(Breadth- Mechanical/Electrical; Critical Industry Issue)

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: LEED- Value Engineering Sustainability

(MAE-Sustainability)

Background

The idea for this analysis comes from discussions with the project engineers and review of the value engineering report. Crystal Plaza II is pursuing a LEED silver rating and has been designed with the appropriate features to obtain that rating. However, the construction and design team are finding out firsthand the difficulties in keeping to plan with all of the sustainable features to finish a high performance building. Many of the sustainable features have be "value engineered" out of the project and/or been modified to help with budgeting and schedule problems. Certain items have been properly value engineered with the only outcome being cost benefit as both the original and new materials are nearly similar. However, the need to retain certain sustainable features should be considered.

Problem Statement

The necessity to investigate those sustainable features that have been value engineered out of the project and ways to retain those without valid reasoning for removal through a more thorough value engineering process. Research into alternative materials for non-sustainable products will need to be conducted that have the potential for cost savings to implement those sustainable features that have a higher initial cost. Cost/Benefit analysis of the sustainable versus non-sustainable features will provide a solid background for value engineering decisions.

Goals

The goal for this analysis is to use those features that have been eliminated and re-evaluate their potential for use. Cost/benefit analysis for each feature will be conducted with a comparison to the replacement or original material depending on the situation.

Research Procedure

1. Investigate value engineering materials/processes
2. Determine replacement materials
3. Research alternate materials for various sustainable (excluded from project) and non-sustainable (included in project)
4. Perform cost/benefit analysis
5. Complete value engineering of selected materials with suggestions

Tools and Resources

1. Project value engineering spreadsheet
2. Interviews with construction and design team
3. Various manufacturer and supplier data

Expected Outcome

This analysis is not as sizeable as the other analyses but does provide an important topic. Currently it seems that during the value engineering stage that the first materials to take the hit are those designed for sustainability. The goal here is to show that while not all designed features may be feasible or even usable for LEED credits, there are other ways to be sustainable. It is expected that alternatives to the most cost intensive products will be available and provide the same value to the owner, thus allowing the use of sustainable features elsewhere that have been excluded due to high initial cost. Additionally, it is expected that some of the excluded items may be re-instated into the project by finding alternative options or better information.

Analysis 4: Consolidation of Slab Penetrations

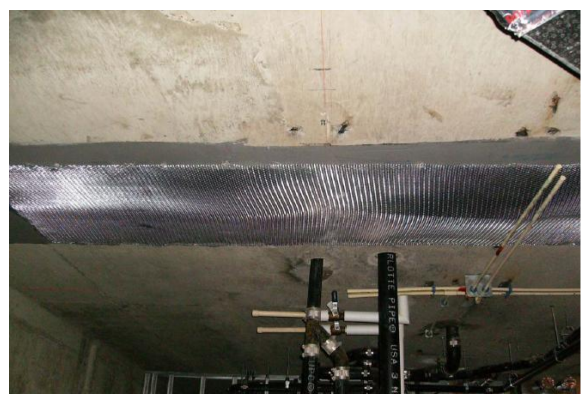
(MAE- Virtual Prototype/Modeling; Breadth Mechanical, Structural)

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%
LEED- Value Engineering Sustainability	10%	10%			20%
Total	30%	25%	30%	15%	100%

Appendix A: Breadth Studies

Analysis 1: Building Integrated Solar Energy Systems & DC Distribution

The breadth of this analysis will primarily 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 system that can then be extrapolated to a larger scale for Crystal Plaza II. The research for the alternative, onsite energy is also outside of the typical construction management topics, but has been researched and presented in prior senior thesis. 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 the building for the scenarios described.

Analysis 4: Consolidation of Slab Penetrations

This analysis provides breath into the mechanical option area as a basic redesign of the distribution system for a typical floor is observed. 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 branches for a typical floor that allows for individual apartment hook ups. This topic also includes a structural breadth in the calculation of the structural reinforcement. The goal is to avoid the reinforcement, but a structural analysis will be performed to determine the acceptability of the structural integrity.