UNDERSTANDING THE ISSUES OF PROJECT COST AND TIME IN SUSTAINABLE CONSTRUCTION FROM A GENERAL CONTRACTOR'S PERSPECTIVE: CASE STUDY

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Jason A. Weeks

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UNDERSTANDING THE ISSUES OF PROJECT COST AND TIME IN SUSTAINABLE CONSTRUCTION FROM A GENERAL CONTRACTOR'S PERSPECTIVE

Approved by:

Dr. Linda Thomas Mobley
College of Architecture
Georgia Institute of Technology

Professor Kathy Roper
College of Architecture
Georgia Institute of Technology

Dr. Daniel Castro
College of Architecture
Georgia Institute of Technology

Date Approved: March 12, 2010

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LIST OF ABBREVIATIONS

BIM	Building Information Modeling
BOMA	Building Owners And Managers Association
BREEAM	Building Research Establishment Environmental Assessment Method
CE	Civil Engineer
CS	Core and Shell
CSA	Canadian Standards Association
D-B	Design Build
EA	Energy and Atmosphere
EPA	Environmental Protection Agency
EQ	Indoor Environmental Quality
FSC	Forestry Stewardship Council
GBCI	Green Building Certification Institute
GBI	Green Building Initiative
GC	General Contractor
ID	Innovation and Design Process
LCC	Life Cycle Cost(s)
LEED	Leadership in Energy and Environmental Design
MEP	Mechanical, Electrical, and Plumbing
MR	Materials & Resources
NC	New Construction
ROI	Return on Investment

SCUD	Self-Contained Unitary Devices
SRI	Solar Reflectance Index
SS	Sustainable Sites
USGBC	United States Green Building Council
WE	Water Efficiency

SUMMARY

The green building market has seen tremendous growth in the past decade. Organizations such as the US Green Building Council have emerged to become a dominant leader in the building industry. Although the green building rating systems are cross-disciplinary, much of the focus has been directed towards design-related input.

General Contractors play an important role in delivering successful sustainable construction projects. If an integrated project delivery method is chosen, the General Contractor may offer insightful preconstruction assistance by providing ideas on green construction methods and materials. As sustainable building practices become more prominent in the construction industry, General Contractors must remain knowledgeable on current green building standards in order to stay competitive.

Two of the most important aspects of business for a General Contractor involve time and money. Through qualitative literature review and quantitative results from a case study, this research analyzes time and cost in sustainable construction projects from a General Contractor's perspective. The research also examines whether the management of a sustainable construction project is substantially different than a non-sustainable construction project for a General Contractor. Finally, because the green building process involves multiple parties, the collaboration effort from all parties involved in a green building project will be studied.

CHAPTER 1

INTRODUCTION

1.1 Overview of the Green Building Process

The presence of the green building market in the construction industry has grown exponentially in the past several years. In fact, the US Green Building Council (USGBC) now boasts over 20,000 corporate and individual members (USGBC 2009). The green building movement primarily stems from activity in the 1990's related to the formation of the Building Research Establishment Environmental Assessment Method (BREEAM), which was followed by the USGBC. Along with increased memberships of green building agencies comes increased volume of work. According to the Engineering News Record, over $38 billion of green building work was performed in 2008 by the top 100 green building contractors (Tulacz 2009).

The green building market has seen growth in almost every sector of construction. Experts estimate that the green building market could increase five times in size across all sectors by 2013 (Managed Care Business Week 2008). This includes municipalities and local governments, which have increasingly become advocates for incorporating green building practices into local standards. Municipalities such as the City of Atlanta now require that any new construction or renovation work of the city's facilities or city-funded projects obtain at least LEED Silver certification (Hunter 2009).

Green building standards, such as LEED, often promote collaboration through the design and construction processes. It is common for many parties of the project to be involved in the process of selecting applicable credits for the green building process. If selected early enough in the project, the General Contractor may be asked to provide input for construction-related credits. If this is the case, then the GC should be knowledgeable as to the requirements of a sustainable construction project.

Two very important factors of business for a General Contractor include time and money. Adding sustainable requirements to a development can completely change how the project is procured and delivered by the General Contractor. "Green project requirements can impact all aspects of the construction process as well as the contractor's cost, schedule, and productivity" (Glavinich 2008). Therefore, it is vital that the General Contractor quantitatively understand how the green building process will affect the aspects of time and cost.

1.2 Research Objectives

Although there is an abundant amount of current information available concerning green building, very little of is written for the General Contractor. As the green building market emerges and matures, more information will become available for General Contractors as to average costs of credits and what the "soft costs" of the credit may entail for the GC. The research in this document is a report of existing literature as well as a case study analysis concerning the General Contractor's involvement in the green building process. More specifically, the main goal of this research is to determine if the management of a green building project is substantially different than that of a non-sustainable construction project. The primary method of discovering the difference will include evaluating the General Contractor's time and cost on the Midtown Atlanta Office Building, which is seeking LEED Silver certification.

There are several other objectives of this research surrounding the green building process. Another objective is to evaluate the presence of collaboration in sustainable construction projects. This will be done by identifying the different parties' involvement concerning credits in the case study. Green building certification systems, such as LEED, highly encourage integrated design and the decision to implement the green process prior to construction. An additional research objective is to analyze the possibility of a project pursuing green certification after construction has commenced. Finally, through literature review, the stability of the green building market will be analyzed to determine if sustainable construction is a mere trend or a mainstay.

CHAPTER 2

RESEARCH METHODOLOGY

2.1 Research Overview

From the early stages of this thesis, it was clear that the study would entail both qualitative and quantitative research in order to properly report on the topic of a General Contactor's involvement in cost and coordination in sustainable construction. It was decided that triangulation would be an ideal research model to use for this topic. Triangulation can be defined as "the use of qualitative and quantitative techniques together to study the topic" which can in turn be "very powerful to gain insights and results, to assist in making inferences and in drawing conclusions" (Fellows and Liu 2008).

After deciding on using the triangulation method of research, the source of the data had to be determined. The case study of the Midtown Atlanta Office Building provided a plethora of data and results, so the case study proved to be a viable source of quantitative data, while the literature review sources provided insightful information regarding qualitative data. After determining the sources, the data was collected. At this point, the sample size of the results from the case study was determined. The results would report on the achievable LEED credits by illustrating the quantitative information regarding time and money spent by the General Contractor. Finally, the data was compiled into logical procedures and reported. Figure 2.1 below demonstrates the research overview of this thesis.

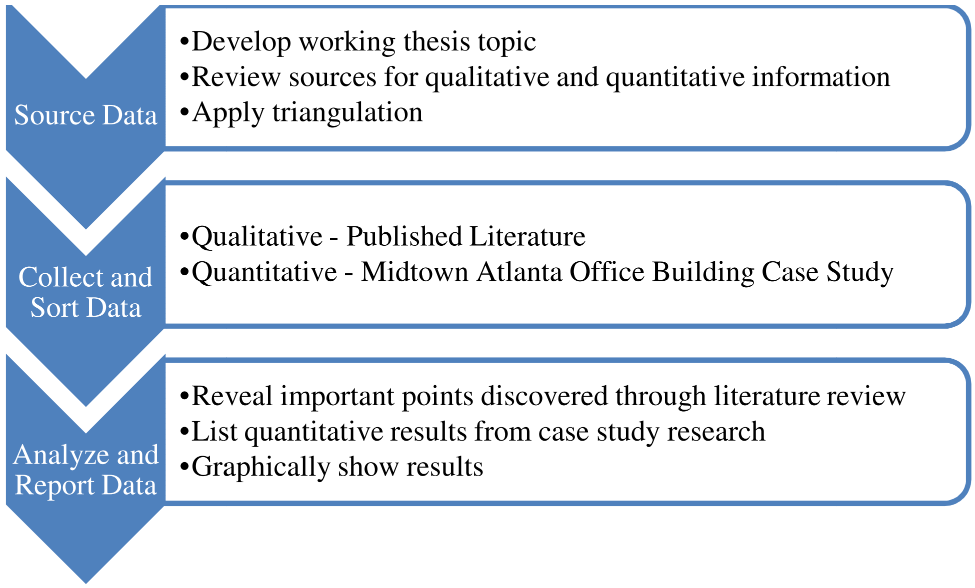

Figure 2.1 : Research Methodology Process Summary

2.2 Initial Research - Sourcing Data

After establishing a "working" thesis topic, the data needed to be sourced and found for the research. Green building is a relatively new and emerging field; it was important that the material was current and fresh. Only recently-published books, journals, and literature were used that were applicable to the topic. As mentioned, the literature provided solid qualitative information regarding the issues that surround General Contractors and green building. Although information regarding General Contractor's involvement with cost and coordination of green buildings was a specialized topic with little published information, consideration was given to avoid the saturation of general, non-specific green building information (much of which is opinionated and nonobjective).

The case study of the Midtown Atlanta Office Building contained recent, hard cost information regarding the General Contractor's involvement. Access to the project's files containing all of the pertinent information was granted. The GC's project manager from the Midtown Atlanta Office Building project was interviewed to extrapolate data concerning time and money spent on the green building process.

Time and cost were the two primary variables that were studied in the quantitative analysis. To initiate the study, information regarding cost spent on the LEED credits in the case study was extracted from the General Contractor's change order logs, estimates, and pricing sheets. The General Contractor tracked the related cost for each LEED credit separately, since the green building scope was considered change order work. This provided an objective method in which the cost of construction was realized for each credit in this research. The description of how the credit affected the General Contractor's cost was then provided by Mr. Kelley in an interview process.

The aspect of time spent on each pursued credit was analyzed after determining the cost for the credits. The process of calculating the General Contractor's time spent on each credit was slightly less objective than determining the cost spent on each credit. However, through several interviews and a study of meeting minutes, sufficient information was available to provide an accurate study on how much time the General Contractor spent on coordinating and implementing credits. After the data for time and cost spent on each credit was sourced and gathered, the information was compiled into organized charts (one per credit), as seen in Section 4.4.

It is possible to apply the logic and research methodology from this thesis towards other case studies. In order to do so, the researcher needs to have full disclosure of the project's files. Once permission has been granted to obtain cost and time information on the project, the researcher should breakdown the data relevant to each credit. This would allow the results to reflect which credits have the most impact on the General Contractor's time and cost efforts towards the green building process. Finally, if a holistic approach is desired, cost and time information could be extracted from the Designers and Owner to determine the full commitment put forth by the project team on a green building project.

2.3 Collecting and Sorting Data

Once the sources of information were determined, the data was sorted and collected. The information from relevant published literature was collected to objectively extract relevant information. When possible, relevant literature that was based on previous quantitative studies was used for the research. The process of collecting and sorting data from literature and the case study was actually a concurrent progression. The data from the case study became available through an interview process, as it was presented from Drew Kelley, the General Contractor's project manager. Mr. Kelley provided quantitative information regarding how much time was spent coordinating the credit, as well as the General Contractor's relative cost associated with the credit. Not all of the pursued credits involved time and cost from the General Contractor.

2.4 Analyzing and Reporting the Data

The selected literature provided an overwhelming amount of information and much of it was not applicable to the overall research. For example, it was found that a large amount of literature for green building focuses on presenting the material to designers and not builders. The literature was analyzed based on relevancy and then applied to the research. After receiving the information from the case study, it was determined that two variables, cost and time, were to be the focus of the study. The study was to analyze what effort the General Contractor gave the two variables in each one of the LEED credits. During the course of the study, it was discovered that an anomaly existed with EAc1 in the Midtown Atlanta Office Building Case Study. This was reported and made clear so that the overall findings could be better understood. Assumptions were also listed at the beginning of the study to clarify several unknown or undetermined factors.

CHAPTER 3

LITERATURE REVIEW

3.1 The History of the Green Building Market

Much of the early growth in environmental-conscious development occurred through national and international regulatory policy. After World War II, the GI Bill allowed veterans to purchase affordable mortgages with relatively low down payments. This sparked a demand for housing, which primarily occurred in suburban areas where land was purchased at a lesser premium than inside cities. After the suburban boom in the 1950's, the US government started focusing on environmental policy to help regulate growth. The National Environmental Policy Act of 1969 was one of the first regulatory polices implemented by the federal government that controlled development through environmental standards (Kone 2006).

The 1966 National Historic Preservation Act shifted attention to preserving existing structures rather than demolishing them to create new development. The first Earth Day was held in April 1970, which emphasized the growing concern of society's impact on the environment (Miles et al. 2007, 141). International attention was given to the environmental reform in the 1980's. The World Commission on Environment and Development met in 1987 and defined "sustainable development" as:

> Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activity (Glavinich 2008, 2).

The Montreal Protocol called for the limitation of chlorinated fluorocarbons, which had been found to be harmful to the ozone layer. The Committee on the Environment, a subcommittee of the American Institute of Architects, was also formed during this time to steer the organization towards more sustainable design practices (Yudelson 2008).

The 1990's brought forth many of the green organizations as they are known today. In 1990, the Building Research Establishment Environmental Assessment Method (BREEAM) was created in the UK to measure a building's sustainable performance. As defined by the organization's website, "BREEAM is the leading and most widely used environmental assessment method for buildings. It sets the standard for best practice in sustainable design and has become the de factor measure to describe a building's environmental performance." BREEAM primarily focuses on sustainable building in the UK (BREEAM 2009).

Shortly after BREEAM was founded, the United States Green Building Council (USGBC) was created in 1993 as consensus-based organization. From the beginning, the USGBC sought to involve participation from all pertinent industries, including architects, engineers, attorneys, developers, and contractors. In 1998, the USGBC conducted several pilot programs with the newly formed Leadership in Energy and Environmental Design (LEED) program. Subsequently, in 2000, the USGBC released the first publicized LEED certification program. Since the release of the first version of LEED in 2000, several versions of the rating system have been released, leading way to the most current version, LEED v3 (USGBC 2009).

The LEED rating organization has seen tremendous growth and increased participation since its conception. More owners and developers are understanding the benefits of life cycle costs and increased efficiency in green buildings. The outlook for the green building market seems promising, as more buildings are becoming certified through the LEED rating system every year. As seen below in Figure 3.1, the number of LEED certified projects has grown exponentially in the past five years.

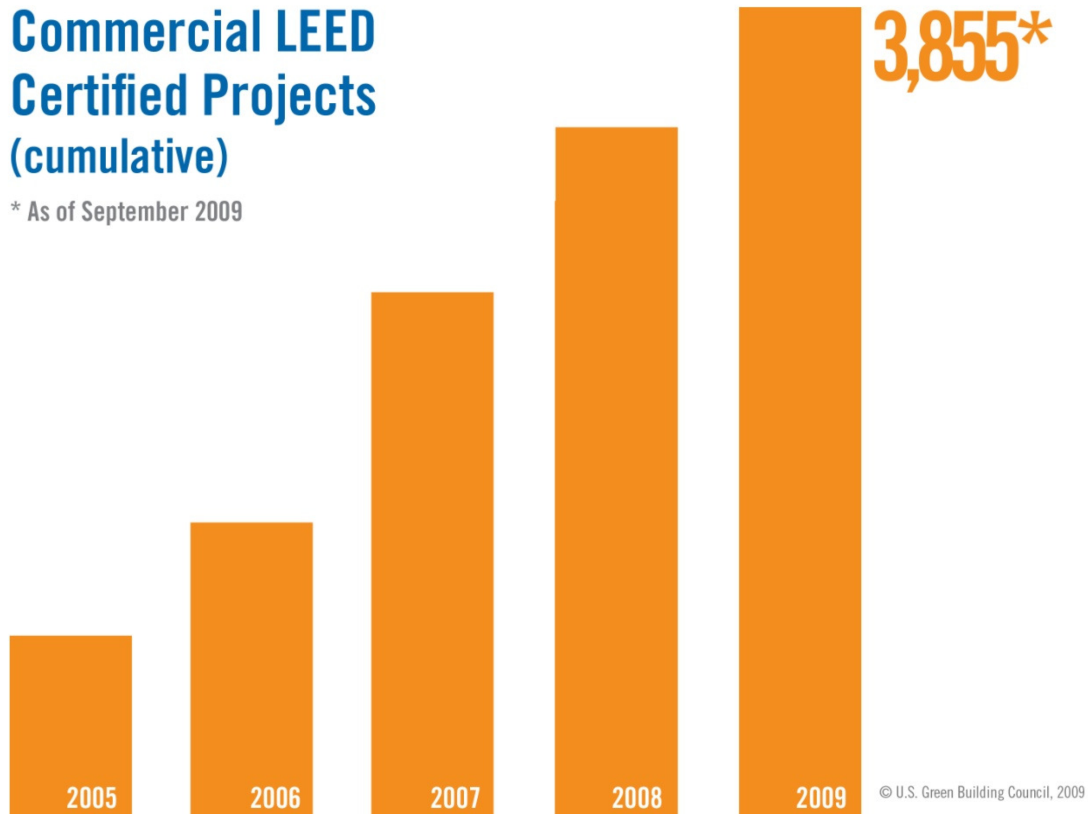

Figure 3.1 : Five Year Outlook of Commercial LEED Certified Projects (USGBC 2009)

3.2 Green Building Certification Agencies

Buildings currently consume more than 60% of the electricity in the United States (USGBC 2009). Statistics such as this one have sparked an interest to better understand the performance of buildings. LEED was created to provide an objective standard in which a building's environmental qualities and features could be rated (Glavinich 2008).

The LEED process involves credits in which a project team will seek to achieve in order to obtain a rating of Certification, Silver, Gold, or Platinum (respectively in order of accomplishment). A building is certified, not people or products. As of 2009, a LEED rating system is available for Homes, Commercial Interiors, Core & Shell, New Construction, Schools, Healthcare, Retail, and Existing Building – Operations and Maintenance. LEED for Neighborhood Development is currently under a pilot program and should be available within the next year (USGBC 2009).

Within the LEED rating, there are six major categories in which a project is judged on:

- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (EQ)
- Innovation and Design (ID)

Each category carries a group of credits and each credit is weighted a certain amount of points. A project team is successful in achieving a level of certification (i.e. Silver) by obtaining the specified amount of points necessary for that particular LEED rating system. Although the project team may choose which credits are pursued in order to achieve the necessary point total, there are several prerequisites that are required to seek any level of certification. For instance, a prerequisite in the Sustainable Sites category concerns preventing construction activity. This credit is required in the LEED rating system, regardless of what the project conditions may involve.

Not every LEED rating system has the same credits. For example, LEED Core and Shell encompasses SS credit 9, which is Tenant Design and Construction Guidelines. However, LEED for New Construction does not have this particular credit. Each type of LEED rating system may have different standards and associated credits. A reference manual exists for each type of LEED rating system and can be a valuable asset when planning, designing, and building a green project.

A project team may or may not know that the building will seek LEED certification during at the beginning of the project. There are many fundamental decisions that LEED may affect, including site selection, mechanical systems, and exterior cladding systems. Therefore, it is often considered advantageous for a project to consider LEED during the early phases of design (Glavinich 2008). However, as seen in the case study, not all projects lend themselves to start the LEED process from the very beginning.

During the design phase, the project team should meet to discuss potential LEED credits. If the delivery method has allowed a General Contractor to be hired on at this point, the GC should then assist the designers and Owner by advising the team of potential costs related to construction credits. Once it is determined (typically by the owner/developer) that a building will seek LEED certification, the project must be registered with the USGBC. A certification fee is required when submitting the project for registration. The fee breakdown is shown in Figure 3.2:

	Less than 50,000 Square Feet	50,000-500,000 Square Feet	More than 500,000 Square Feet	Appeals (if applicable)
LEED for: New Construction, Commercial Interiors, Schools, and Core & Shell full certification	Fixed Rate	Based on Square Footage	Fixed Rate	Per credit
Design Review				
Members	$1,250.00	$0.025 / sf	$12,500.00	$500.00
Non-Members	$1,500.00	$0.030 / sf	$15,000.00	$500.00
Expedited Fee*	$5,000.00 regardless of square footage			$500.00
Construction Review				
Members	$500.00	$0.010 / sf	$5,000.00	$500.00
Non-Members	$750.00	$0.015 / sf	$7,500.00	$500.00
Expedited Fee*	$5,000.00 regardless of square footage			$500.00
Combined Design & Construction Review				
Members	$1,750.00	$0.035 / sf	$17,500.00	$500.00
Non-Members	$2,250.00	$0.045 / sf	$22,500.00	$500.00
Expedited Fee*	$10,000.00 regardless of square footage			$500.00
LEED for Existing Buildings	Fixed Rate	Based on Square Footage	Fixed Rate	Per credit
Initial Certification Review				
Members	$1,250.00	$0.025 / sf	$12,500.00	$500.00
Non-Members	$1,500.00	$0.030 / sf	$15,000.00	$500.00
Expedited Fee*	$10,000.00 regardless of square footage			$500.00
Recertification Review**				
Members	$625.00	$0.0125 / sf	$6,250.00	$500.00
Non-Members	$750.00	$0.015 / sf	$7,500.00	$500.00
Expedited Fee*	$10,000.00 regardless of square footage			$500.00
LEED for Core & Shell: Precertification	Fixed rate for all projects			Per credit
Members	$2,500.00			$500.00
Non-Members	$3,500.00			$500.00
Expedited Fee*	$5,000.00			$500.00

Figure 3.2 : Fee Structure of LEED Projects (USGBC 2009)

After a project has been registered, the team should track their progress and document credit achievements. Certain LEED systems, such as Core & Shell, allow a project to be submitted for precertification, in which the design credits are submitted prior to the construction credits. A team may choose to keep track of the project's progress by using a scorecard that lists the credits and corresponding achievability. Adjustments, such as discontinuing or adding credits, to the scorecard may be necessary if obstacles are met during construction (Glavinich 2008).

Once the construction is complete on a project, the team may submit the final application for certification. According to the USGBC website, most project types will take up to 25 business days for review. As of 2009, the USGBC has introduced the Green Building Certification Institute to oversee the review process. After the project receives certification, the team will receive a certificate along with a LEED plaque. If there are any issues with certain credits or certification eligibility, the project team has 25 business days to file an appeal once the GBCI has reviewed and provided a ruling on the project. A project team may also want to review the GBCI's Credit Interpretation Rulings that are posted on the agency's website. These rulings show previous projects that encountered subjective issues with a certain credit and how the GBCI interpreted the situation (USGBC 2009).

Green Globes, which stemmed from BREEAM, is another green building certification agency. BREEAM was developed in the United Kingdom and helped spark the green building movement in Europe. In 1996, the Canadian Standards Association adopted BREEAM as BREEAM Canada for Existing Buildings. In 2000, the agency evolved into BREEAM Green Leaf for the Design of New Buildings. In 2004, an internet-based form of Green Leaf was developed and was called Green Globes. The Green Building Initiative (GBI) was then created to manage Green Globes. Finally, in

2005, the GBI licensed Green Globes to be adapted for the United States (Glavinich 2008).

The Green Globes rating system utilizes a self-assessment function to help identify the project's sustainable capabilities. The rating system is accessible to the team throughout the initial design process and can be updated until the issuance of construction documents, at which time a formal self-assessment must be completed. The Green Globes rating system is based on seven categories, totaling 1,000 points (Glavinich 2008):

- Project Management – 50 points
- Site – 115 points
- Energy – 360 points
- Water – 100 points
- Resources, Building Materials, and Solid Waste – 100 points
- Emissions and Other Impacts – 75 points
- Indoor Environment – 200 points

The Green Globes system awards certification based on percentage of points achieved from the applicable project points. This differentiates the Green Globes system from LEED, which takes into account all possible points on every project. The certification and verification process of Green Globes is a two-step process. The first step occurs when the construction documents are complete, at which the project team completes and online questionnaire. The second step occurs once the construction process of the building is complete. A GBI representative will come to the project and confirm that all credits are in conformance to what was submitted. If approved, the project will be awarded one to four globes, based on achieved applicable points. Table 3.1 below lists the certification level (Glavinich 2008):

Table 3.1 : Green Globes Certification Levels

CERTIFICATION LEVEL	PERCENTAGE OF POINTS REQUIRED
1 Globe	35-54
2 Globes	55-69
3 Globes	70-84
4 Globes	85-100

Although they both seek a similar goal of ultimately protecting the environment through more efficient buildings, LEED and Green Globes have several differences. The web-only interface with Green Globes is a distinct difference from LEED that a project team may experience. Another factor is that LEED and Green Globes sometimes reference different standards. For example, LEED only recognizes timber certified through the Forest Stewardship Council (FSC), whereas Green Globes recognizes FSC along with the American Tree Farm System, Canadian Standards Association, and Sustainable Forestry Initiative. This is an interesting difference considering that less than 1/6 of the North American certified forests are certified by FSC (Wood Promotion Network 2009). However, the greatest difference between the two agencies may be the market presence of LEED over Green Globes. As of 2008, the Green Globes certification process had less than two percent of the green building market. A report by the US

General Services Administration to Congress in 2006 also stated that LEED was the government's preferred green building certification system (Yudelson 2008).

There is an increasing trend in the government's involvement in sustainable construction. Although the government is not a green certification agency, there are still regulatory methods that may be put into place that lets the government promote green building. For example, the EPA and the US Department of Energy use the ENERGY STAR system. A new or renovated building may be awarded the ENERGY STAR label if it meets the specified criteria concerning energy (US EPA 2009). An example of government involvement on a municipal level is the growing number of cities that are adopting green standards. In 2003, an Atlanta city ordinance required all new construction and major renovations of city-funded projects to meet at LEED Silver rating or better. The US Council of Mayors developed the 2030 challenge in 2006, which seeks to have zero net carbon emissions from new buildings in 2030 (Hunter 2009).

One of the first steps for a General Contractor involved in a green building project is to understand what type of rating system will be used for the development. As seen above, the type of green building certification may dictate certain costs and coordination efforts that would otherwise not be present. The General Contractor should be educated on the project's green requirements even before the actual construction commences, so that a fair and comprehensive cost estimate is produced. If the GC takes the time to become knowledgeable and familiar with the specific green certification system on the project, then it is likely that the construction process will not have as many problems concerning green building methods.

3.3 Green Project Requirements Relative to the General Contractor

"Green project requirements can impact all aspects of the construction process as well as the contractor's costs, schedule, and productivity. There is often a misconception that green building construction impacts only the design and it is business as usual for the contractor. This is not the case" (Glavinich 2008). Whether through a competitive bid process or through negotiations, the General Contractor will price the work and provide the Owner with an estimate. After understanding which green certification system will be used, the General Contractor should analyze the bid documents and price the green requirements accordingly. If new and innovative products are to be used, the GC should educate themselves, along with any pertinent Subcontractor(s), about the cost, procurement time, and installation practices associated with the product.

Another component of the project that the General Contractor needs to understand before the project starts, and generally before the estimate starts, is the type of project delivery method. According the Association of General Contractors, there are three types of delivery methods: Design-Bid-Build, CM at-Risk, and Design-Build. The delivery method is partnered with a selection type for the Owner to award the contract to a General Contractor. Three selection types include Low Bid, Best Value, and Qualifications-Based Selection. Delivery methods will also lead to the type of contract arrangement for the GC, which is usually in either a lump-sum format or a cost-plus format. In a lump-sum contract, the total contract amount is fixed and the GC assumes the risk of increased cost. A cost-plus arrangement allows the General Contractor to be compensated for the cost of the work plus a fee from the Owner. Table 3.2 below shows selection types partnered with delivery methods (AGC 2004).

Table 3.2 : Construction Project Delivery Methods and Means of Contractor Selection (AGC 2004)

	Number of Contracts	
Selection Type	(2 separate contracts) Designer & Contractor	(1 combined contract) Designer-Builder
Low Bid	Design-Bid-Build	Design-Build (LB)
Best Value	CM at-Risk (BV)	Design-Build (BV)
Qualifications Based Selection	CM at-Risk (QBS)	Design-Build (QBS)

The type of delivery method will greatly affect the way the GC prices and manages the project in green construction. For example, if the project is to be design-build, then the GC may find itself in charge of the overall design process (through partnering with a design firm). As part of the Design-Build team, the GC would be exposed to the Owner's sustainable requirements much sooner than if the GC were on a Design-Bid-Build project. The reason that the project delivery system is so important is because it defines the GC's involvement and risk in a green construction project.

There are four types of risk management methods that concern the General Contractor in managing a construction project (including green buildings): risk retention, risk reduction, risk transfer, and risk avoidance. The GC should carefully identify the risks associated with each green building credit and manage the risk by associating it with one of the four risk management methods.

Risk retention may be a conscious or unconscious decision to retain the risk. For example, a General Contractor may retain the risk of providing regional materials to a sustainable building if the project team deems it necessary to achieve that particular credit. Risk reduction refers to a risk that is identified by the GC and then reduced, possibly through negotiations, to an acceptable level (Glavinich 2008). Using the previous example, the GC may negotiate to pursue the 10% regional materials credit in lieu of providing 20% regional materials by reducing the risk involved with obtaining the extra 10% of regional materials.

Risk transfer involves the contractual transfer of risk to another party, which is most often a Subcontractor. For example, if green specifications address a specialty product, such as an agrifiber wood product, then the GC may choose to contractually transfer along the risks of procuring and installing the agrifiber wood to a specialty millwork Subcontractor. An example of a green specification for the Midtown Atlanta Office Building is shown in Appendix A, in which the interior architectural millwork specification requires LEED considerations for EQ and MR credits. Finally, risk avoidance is a risk management method that suggests the General Contractor completely avoid the risk. For example, if a GC with only limited exposure to sustainable construction learns that project for bid is pursing LEED Platinum, the GC may choose to use risk avoidance and not bid on the project (Glavinich 2008).

Although a General Contractor may to choose to self-perform a portion of the work, it is vital that the GC clearly communicates the sustainable requirements to the necessary Subcontractors. Certain Subcontractors may not be able to fulfill the conditions of green construction, which means that sustainable construction requirements may have an influence as to which Subcontractors the GC will choose for the work. The General Contractor should objectively list the Subcontractor's sustainable responsibilities in the Subcontract Agreement, which is the contract between the General Contractor and Subcontractor. "On green building projects, the ability of the contractor to achieve the project's sustainable objectives depends on the subcontractor's performance and the contractor's ability to effectively manage subcontractors. The contractor must be able to communicate the green project objectives and requirements to the subcontractors as well as educate them about their role in achieving those objectives" (Glavinich 2008, 111).

3.4 The Necessity of Collaboration in Green Construction

The LEED process is a collaborative one that involves participation from many members of the project team. "If time is not taken to bring together all of the relevant parties and study alternatives before fixing on a final design, a project may miss opportunities to make single systems carry out multiple tasks" (Yudelson 2008, 50). As seen in the case study of the Midtown Atlanta Office Building, the LEED process employed the Owner, Architect, General Contractor, LEED Consultant, Civil Engineer, and MEP Engineer.

Sustainable construction rating systems intrinsically lend themselves to a collaborative environment. This is primarily because the credits are divided among multiple parties. Although the credits in LEED are labeled as "design" or "construction" credits, there are still components of the credits that crossover. For example, MRc7 states that a minimum of 50% of the wood products should be certified by the Forest Stewardship Council. In order for this credit to be effective, the Architect should specify a wood product or a wood veneer that would meet the FSC's requirements. The responsibility of the credit would then be passed along to the General Contractor, who should ensure that the product that is purchased from a vendor or Subcontractor is FSC certified (USGBC 2006).

If the General Contractor is awarded the contract on a green project prior to commencement of construction, then the GC can provide helpful preconstruction services in regards to green construction. The General Contractor may have historical data or experience from previous green building projects that could influence how the project team pursues certain credits. The project team members should facilitate a collaborative, idea-sharing environment early in the project in an effort to produce an successful green building process (Yudelson 2008).

3.5 Obstacles of the Green Building Industry

As with most innovations and changes, green building has encountered opposition since its formation. The complaints range from the overwhelming backlog of the green certification agencies to incorporating standards of a private organization (USGBC) into the public arena. Several problems of the green building industry will be discussed and related as to how they affect General Contractors.

It is no secret that the green building industry has seen a tremendous boom in the last decade. One of the biggest obstacles the USGBC has faced is itself. According to the International Council of Shopping Centers, the USGBC has had over 19,000 projects registered with only 2,500 that have received certification as of 2009 (ICSC 2009). In reference to the Washington DC area backlog of LEED projects, the Washington

Business Journal states, "Like many other developers, architects, tenants and property owners around the region, the company fell victim to one of the biggest stumbling blocks that the U.S. Green Building Council itself faces – a backlog of hundreds of LEED certification requests that has stretched processing periods from what should be five weeks to closer to five months" (Sinha 2009). The USGBC will need to combat this issue in order to remain effective. Meanwhile, Owners, General Contractors and other team members should enter into a LEED project with the understanding that the certification turnaround may not be an expeditious process.

Another concern, specifically addressed towards LEED, is the apparent monopoly that the this particular green building system has created. As mentioned in Section 2.2, LEED's competitor, Green Globes, only had a hold on less than two percent of the market as of 2008 (Yudelson 2008). The emergence of LEED as a dominant and green powerhouse in the industry has raised concern, due to the lack of valid competition. "But it is tough on green building aspirants given that LEED has a near monopoly in the region when it comes to increasingly fashionable eco-friendly design standards. So much so that most counties and cities in the region have adopted LEED as their green building standard of choice, relegating other guidelines such as Green Globes and EarthCraft to stepsister status" (Sinha 2009). A General Contractor educated in green building methods and systems can help counter the monopoly of LEED. If the GC is hired by the Owner early enough in the project, the General Contractor can let the Owner know that there are other options besides LEED available for green building certification.

Because green building is a relatively new facet of the construction industry, there is a lack of historical data for General Contractors. One challenge for GCs coming into the green building industry is understanding the sometimes overwhelming amount of information regarding certification systems, products, methods, and costs associated with sustainable construction. More quantitative information will come forth as green building stabilizes and becomes a mainstay in the construction industry. As a General Contractor completes green building projects, the GC should establish a database of historical information relative to the sustainable elements of the projects. This, in turn, will help provide more accurate pricing to Owners for future projects (Glavanich 2008).

Many municipalities, including the City of Atlanta, have adopted LEED standards for their new developments. In fact, the City of Atlanta has required that any new construction project for the city must achieve at least LEED Silver certification (Hunter 2009). The USGBC, which resides over the LEED system, is a private non-profit organization made up of members from many different industries. However, since many municipalities have adopted the LEED standards, the local code changes every time the privately-operated USGBC makes a change. This could potentially create problems when if building codes start conflicting with ever-changing LEED standards (ICSC 2009).

Along with the benefits of green construction come the unfortunate situations as well, thereby exposing the industry to lawsuits. There have been claims that pro-environmental LEED credits, such as a vegetative roof, have led to mold problems in buildings. In another case, added solar panels on top of a college building led to the outbreak of a fungal disease due to a large concentration of pigeons congregating underneath the solar panels. Due to the collaborative process of LEED, the litigation then begins with finger-pointing and all parties claiming to not be responsible for the problem. Since lawsuits due to green construction may be emerging with the rise of the industry, General Contractors and project teams should take special precaution in understanding the process prior to becoming involved with a green building project (Davis 2009).

3.6 Financial Incentives of Sustainable Construction

The selling point for Owners to offset the upfront costs of sustainable construction is the savings offered by improved life cycle costs (LCC). Life cycle costs can be defined as an accounting method that is used to analyze the economic performance of a product over its useful lifespan. LCC should consider operating and maintenance costs in the calculations as well (USGBC 2009). Other advantages, such as tax incentives and a healthier building, are also encouraging reasons for Owners to build green. Some sources even say that Owners have financial pressures from lenders to build green. “Even banks are talking about no longer financing developments that don’t follow guidelines of LEED” (Sams 2009). A statement such as this would certainly cause Owners to consider incorporating sustainable construction prior to asking for money from lenders.

Many newly constructed green buildings are designed to use up to forty percent less energy than what is required by code. This translates to approximately an operational savings of $2.25 per square foot per year for electricity. For some Owners, the payback period is three years or less, which is a huge increase in LCC for the mechanical and electrical systems that provide this service. However, these figures are dependent upon several factors, such as the type of systems installed, regional location, and climate. The entire up-front premium of LEED, from the use of more expensive energy efficient glass to waterless urinals, is meant to be offset by Life Cycle Costs. As more projects become certified and operational for several years, more quantitative data regarding LCC will emerge (Yudelson 2008).

Energy efficient and green buildings also boast healthier work environments, which generally lead to a more productive workforce. A study conducted by Carnegie Mellon University found a 3.2 increase in productivity occurred by using high-performance lighting throughout eleven different studies (Yudelson 2008, 35). According to the USGBC, some buildings in operation claim an increase of production up to 16%. The USGBC also claims that students in day-lit schools consistently have higher test scores than those using conventional lighting (USGBC 2009).

General Contractors should understand the concept of providing Owners with sustainable projects in order to offer the best product available. As the green building market continues to grow, an increasing amount of materials, products, and options will be available for the General Contractor's use. The GC should keep in mind that it is not always the least expensive product that is the best option, but instead the product that provides the most value to the Owner (whether through Life Cycle Costs or another means of sustainability).

3.7 What General Contractors Should Know About the Future of Green Building – Is It More Than a Trend?

The US Green Building market is expanding at quite a remarkable rate. According to McGraw-Hill Construction, the value of the green building market in 2008 had increased five times the size of the market in 2005, growing from $10 billion in 2005 up to $49 billion in 2008. Even through an otherwise slow economy, recent estimates predict that the green building market could reach over $100 billion by 2013. The USGBC is reporting that green buildings are less affected by the down market than non-sustainably-marketed buildings. This is most likely due to the perceived economic benefits, including higher market value of green buildings and lower life cycle and operating costs (Managed Care Business Week 2008). Figure 3.3 below shows the staggering increase of USGBC memberships, which is currently over 20,000.

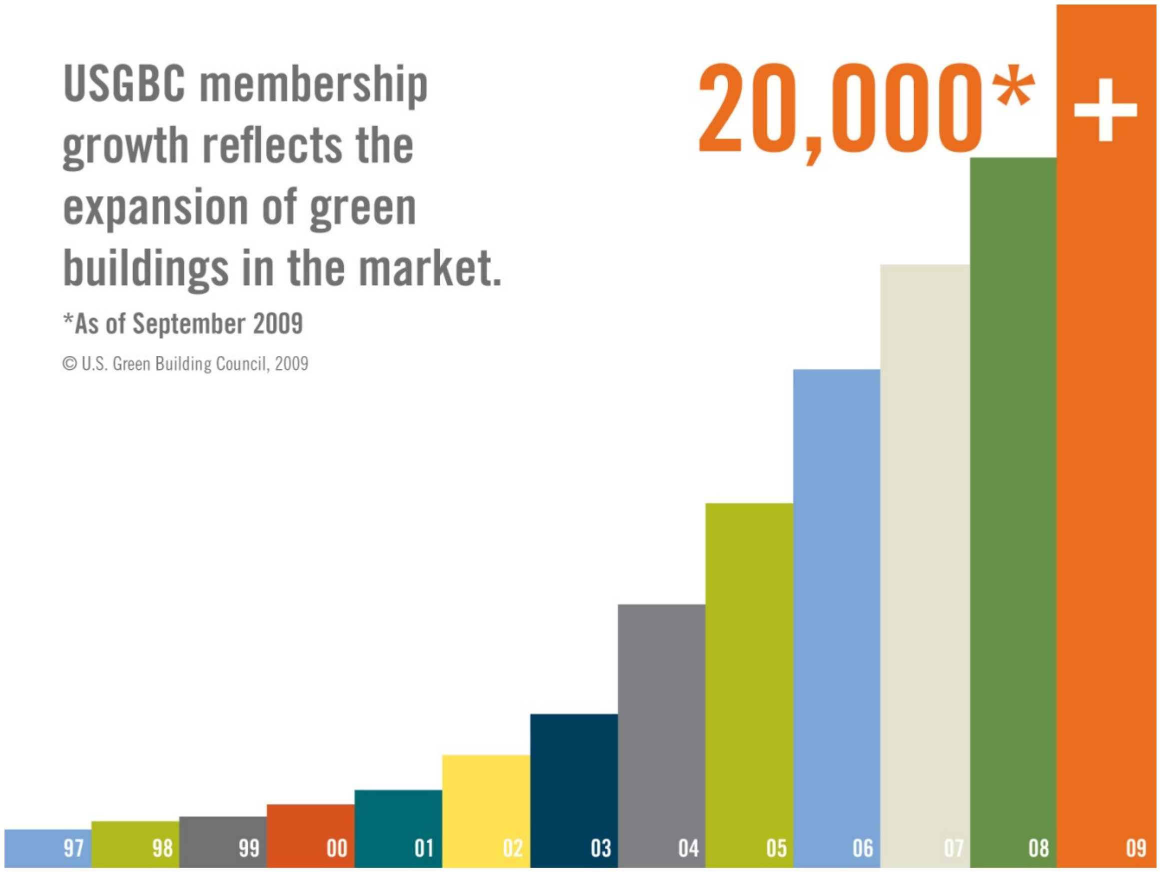

Figure 3.3 : USGBC Membership Growth (USGBC 2009)

As the industry looks towards the future of the green building, it is prudent to analyze what is driving the market. Below are twelve factors that are driving the green building market: (Yudelson 2008, 56)

- Increased evidence and support for the business case of green buildings
- Increased amount of commercial and institutional green projects
- Energy Policy Act of 2005
- State tax incentives for green construction

- Higher oil and natural gas prices
- Urban infill (movement back into the cities)
- Changes in cultural preferences that favor eco-friendly lifestyles
- Increased green residential construction demand by homeowners
- Recession in residential market causes homebuilders to build green for competitive reasons
- Local municipalities mandating green construction (i.e. City of Atlanta)
- Increased awareness of carbon dioxide emissions
- Growing pressure on companies to provide sustainable a environment for employees

As the green building industry progresses, the demand for higher-performing buildings will increase. This can already been seen in attention given to higher-performing systems in LEED version 3 as compared with the previous LEED Version 2.2. Along with higher-performing buildings comes a demand for a higher grade of technology to support these buildings. New technology in green building's systems should address concerns with energy, water, materials, occupant health, and interface with natural systems (Kibert 2005). In order to meet these improvements, a General Contractor must continue to stay educated on the latest construction materials and methods regarding sustainable construction.

What was once a green building market primarily focused on commercial office buildings is now a diverse, multi-faceted platform that focuses on sustainability in many different sectors. Many General Contractors now consider green construction projects as a core activity across different markets, instead of what used to be considered a “fringe” activity. The healthcare, laboratory, and hospitality markets are seeing increased growth in the past several years, in part because these markets are large energy users and the USGBC has now addressed these markets in LEED version 3 (Tulacz 2009). Figure 3.4 below shows how the revenue produced by the top 100 green General Contractors in 2008 was divided amongst the markets.

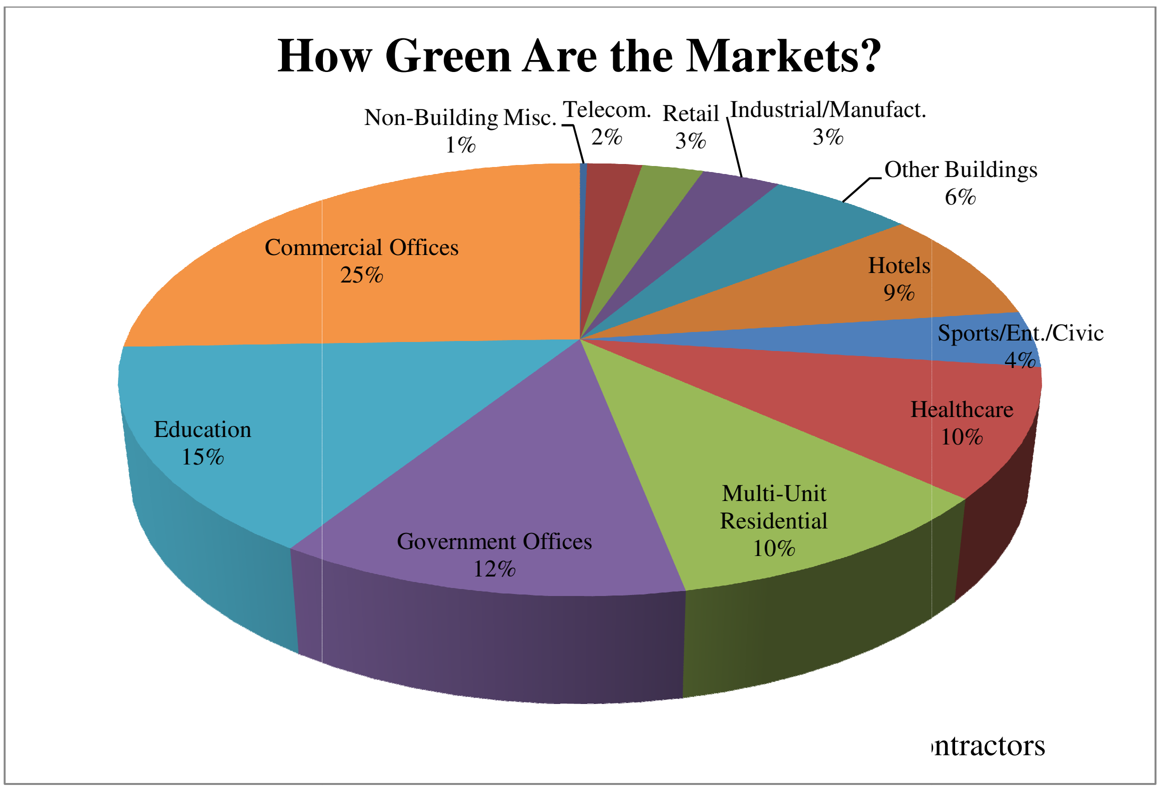

Figure 3.4 : Distribution of Green Building Projects Throughout the Markets (Tulacz 2009)

Considering the vast increase and sustained growth patterns, it appears as if green building is here to stay. With a current market value of at least $50 billion, there is little doubt that the sustainable construction industry is a mere trend. Although most General Contractors have taken a hit on overall revenue during the current downturn, many GCs still report that revenue produced by green projects is growing compared with previous years (Tulacz 2009). In order to be competitive, General Contractors must understand that the green building market is growing at a rapid pace and will remain a large presence in the construction industry.

CHAPTER 4

CASE STUDY

4.1 Introduction of Case Study

The case study used in this research is from the Midtown Atlanta Office Building, which the specific name of the project has remained anonymous in respect of the Developer's rights. Further information regarding the specifics of the project may be available upon request through the author of this thesis. The data and information has been gathered from Drew Kelley, the project manager of the General Contractor that was involved in the project.

The office building is core and shell construction, which consists of a similar core space on each floor, comprised of elevator lobbies and restrooms, with the shell representing the exterior skin envelope. This type of construction is ideal in the commercial office building market since it does not limit itself in how the tenant space is built-out in the future. The office building is composed of twenty-five office floors with ten floors of parking deck beneath the building, yet in the same envelope. The project is a mixed-use development with components of retail, condominiums, and a hotel in the same lot. However, due to various cost allocation constraints, market conditions, and contractual issues, the office tower was the only component to pursue LEED certification.

Schematic Drawings were released in 2006 for the General Contractor to price. The General Contractor provided the Owner with a competitive number based on the information represented on the drawings that were available. In 2007, the Design Development drawings were given to the Contractor to confirm the price. After a long and extensive estimate, General Contractor signed a contract of approximately $255 million with the Owner through a negotiated process. The Office Building scope, which is the component of the project discussed in this research, was determined to be approximately $85 million. The design phases of the Midtown Atlanta Office Building project are represented in Figure 4.1.

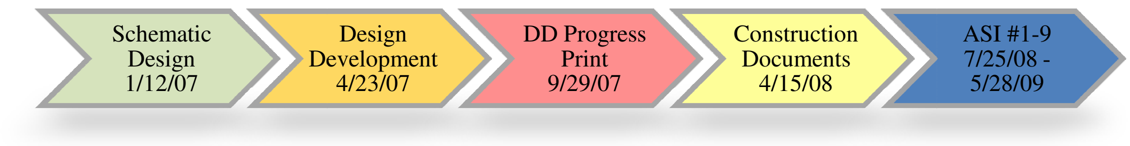

Figure 4.1 : Midtown Atlanta Office Building Design Phase Milestones

Immediately after the execution of the Prime Contract, or the contract that exists between an Owner and the General Contractor/Construction Manager, the General Contractor subcontracted the work that was not to be self-performed. Key Subcontractors, such as the Electrical Contractor and Mechanical Contractor, were among the first Subcontractors to be released on the project. Interestingly enough, these two trades were Design-Build scopes of work for the project. The D-B scopes allowed greater flexibility to coordinate sustainable design ideas into practical construction methods for the mechanical and electrical scopes of work. As shown later, this became instrumental in collaboration between the construction parties when reviewing which LEED construction credits would be obtainable.

Projects can be chosen to be sustainable at several phases of the project, but it is generally considered advantageous to implement green procedures in the very beginning stages of planning. As with most construction projects, there is generally less impact on cost when planning and design decisions are made at the beginning of a project. "If you were to ask experienced architects and engineers, developers, and builders how to reduce the costs of green buildings, I think the first thing they would all say is that an integrated design process…is essential" (Yudelson 2008, 51).

It was between the Design Development Documents and the Construction Documents that the Owner decided to pursue LEED certification. There were several reasons why the decision to build a green project was not chosen in the earliest phases of the project. One of the primary reasons that the decision to implement LEED was delayed until the Design Development phase was due to the fast-tracked nature of the project. Fast-track is defined as "any project or process in which there is overlap between two or more project phases" (AGC 2004). For the Midtown Atlanta Office Building project, this meant the design of the building was not complete when General Contractor had started work on the structural foundations. The Midtown Atlanta Office Building was also this particular Owner's first LEED project; as suspected, an Owner's first LEED project may be met with slight hesitation and questions (Kelley 2009).

During the early phases of the project, the Owner was also finalizing feasibility analyses (due to varying terminology used in today's convoluted contractual responsibilities, it should be clarified that the term "Owner" in this report refers to the company that was the developer as well as the property owner/manager). The Owner knew that there was a demand for approximately 700,000 sf of Class A office space, but there were certain aspects of the project that were still unknown to both the Architect and Owner. The unknowns consisted of questions such as:

- What should the exterior curtainwall and rooftop element look like?

- Where should the Central Energy Plant be located?
- What could aesthetically set this building apart from the competition?
- Should the building be LEED certified?

These questions were being answered while the Owner finalized the feasibility analyses and pro form calculations (Kelley 2009). A Pro forma test is a financial statement that analyzes components of gross income, operating costs, and net operating income to a projected future period. Clarifications and assumptions are made in order to try and project future results (Miles et al. 2007). Appendix B shows an example of a pro forma for an office building complex.

As previously mentioned, the Owner played the active role of the Developer throughout the project. This meant that there was an incentive for a high-quality project with efficient systems. The Owner understood that paying any upfront premiums for a high-performing product meant that their facility management operations could be easier. The MEP systems were to function at a higher efficiency rate (as compared with a non-green building MEP system), which meant long term energy savings for the Owner. The Owner's intent of paying more upfront may differ if the Owner is developing a project to "flip" or sell immediately after construction. Since members of the project team were familiar with the LEED process, the concept of life cycle costs was understood and was met with little to no hesitation (Kelley 2009).

The decision was made by the Owner to move forward with pursuing LEED certification at the end of 2007. The original mindset was to achieve LEED certification for the least amount of cost possible. It was then realized that LEED Silver could be achieved without extraordinary costs, as long as the decisions were made quickly. The project team started a series of meetings in which a green building consultant was introduced to the project to help facilitate the achievement of LEED certification. Although the project was in the early phases of construction, it was not too late to introduce sustainable practices in order to achieve the desired LEED certification (Kelley 2009).

4.2 Initial Implementation of LEED in Case Study

Once it was decided that the Midtown Atlanta Office Building would seek LEED certification, one of the first objectives was to decide which classification system to apply to the project. As previously mentioned, the office building is a CS (Core and Shell) project. LEED version 3 outlines when to use CS by stating, "LEED for Core & Shell was developed to serve the speculative development market, in which project teams do not control all scopes of a whole building's design and construction. Depending on how the project is structured, this scope can vary significantly from project to project. The LEED for Core & Shell Rating System addresses a variety of project types and a broad project range." (USGBC 2009, xv). When it was decided that the Midtown Atlanta Office Building was to be LEED certified, the most applicable LEED standard was LEED CS version 2.0, which differs slightly from LEED NC (New Construction) version 2.2. For example, LEED CS v2.0 version requires that 23 points are obtained for minimum certification, whereas LEED NC v2.2 requires 26 minimum points are achieved for certification. Hence why it is important to properly classify the project with the appropriate rating system.

After properly establishing which classification system to use, another early objective was to determine which points were achievable. As mentioned, a green building consultant was introduced to the project team by the Owner when the team was analyzing the feasibility of achieving LEED. Some Owners may choose to delegate many of the day-to-day project decisions to the Architect. This would also include diverting the responsibility of overseeing the LEED consultant to the Architect. Although the Owner of the Midtown Atlanta Office Building project was very active in making decisions throughout the project, the choice was still made to have the Architect manage the green building consultant (primarily because of design reasons). The contractual project relationship, including the LEED consultant, is shown below in Figure 4.2. The dashed line between the D-B Subcontractors and Design Consultants represents a non-contractual yet collaborative relationship.

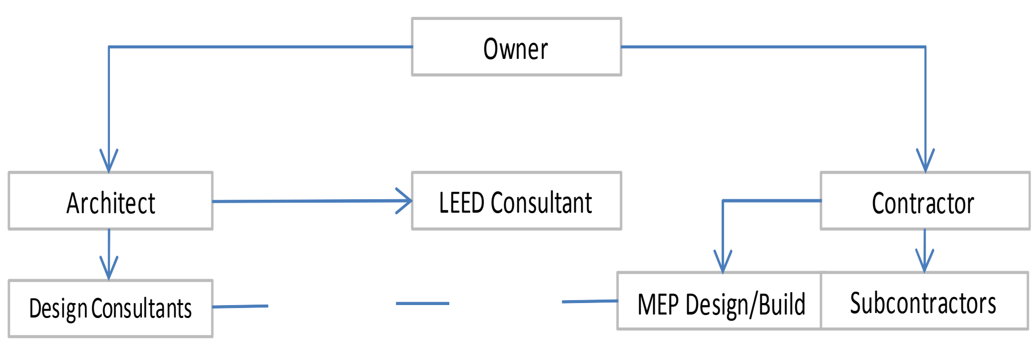

Figure 4.2 : Contractual Relationships of the Midtown Atlanta Office Building Project (Kelley 2009)

Since most of the team members were new to the green building process, the consultant brought experience and invaluable knowledge of the LEED system to the team. The LEED consultant on the Midtown Atlanta Office Building project provided energy modeling services. According to the "Integrated Green" website, "An energy model is a simulation based on building design, envelope, orientation, weather, schedules, controls, and energy-using systems to project comparative energy consumption and costs." (Integrated Green 2009). Various software programs allow a user to input the project's data into equations that calculate the building's energy efficiency. Recent technology has even allowed energy models to become integrated with BIM (Building Information Modeling) software programs. Below in Figure 4.3 is an actual BIM model that was used to help coordinate the mechanical and electrical trades with the rooftop structural steel by the GC on the Midtown Atlanta Office Building.

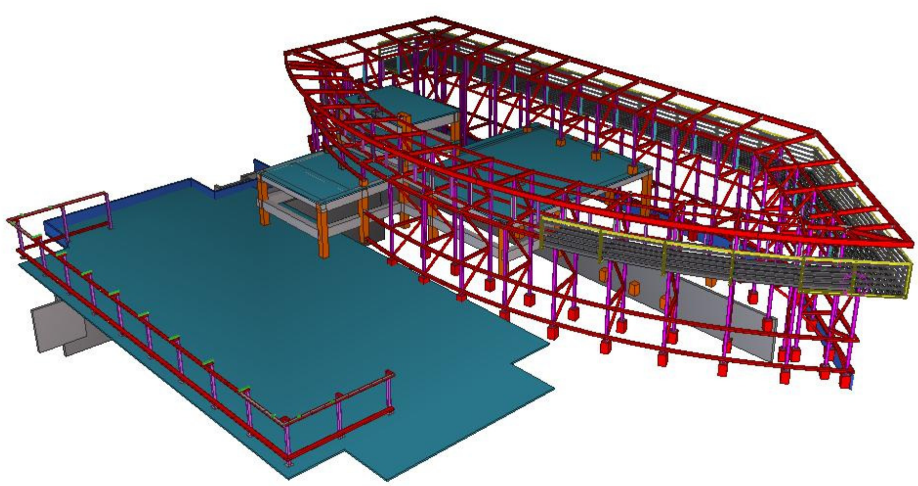

Figure 4.3 : BIM Model of Midtown Atlanta Office Building (Kelley 2009)

The energy analysis and other calculations for the Midtown Atlanta Office Building were being processed at the end of 2007. As previously mentioned, much design had occurred prior to the implementation of LEED on the project. This includes the building's mechanical system, which was based on self-contained unitary devices on each level, also referred to as SCUDs. The SCUDs would basically act as individual air handlers for each floor. During the energy analysis, the LEED consultant discovered that the project's mechanical system encompassed the SCUDs. This was unfortunate, considering that the originally designed SCUD system would not meet LEED Energy and Atmosphere credit 1, which became a required 2 point credit as of June 26, 2007 per the USGBC (USGBC 2009). LEED EA credit 1 necessitates a minimum of 14% cost savings in the proposed building performance rating compared to the baseline building performance be met. This was to be carried out per ASHRAE/IESNA Standard 90.1-2004 by a whole building project simulation using the LEED Building Performance Rating Method of the Standard (USGBC 2006).

At this point, the project had not been officially registered yet with the USGBC. The mechanical SCUD systems had not been procured yet either, allowing the project team to quickly reconsider the mechanical design. It was determined, through the assistance of the project's mechanical engineer and the LEED consultant, that a chilled water system would be the most viable option to achieve the required 14% cost savings (Kelley 2009). A chilled water mechanical system consists of:

"…one or several chillers that produce chilled water. This chilled water is pumped to one or more air handlers, where it cools the indoor air. The cool air is then distributed within the building through a network of ducts. The ducts run to terminal units that control the flow of air to diffusers. The chilled water plant also requires several additional devices, known as auxiliaries, to move chilled water between the chilled water plant and the air handlers. In addition, the waste heat from the chilled water plant must be rejected to the outside air using pumps and a cooling tower" (Dagostino and Wujek 2005, 292).

Figure 4.4 below shows a diagram of a chilled water system, similar to the revised mechanical system that was implemented at the Midtown Atlanta Office Building.

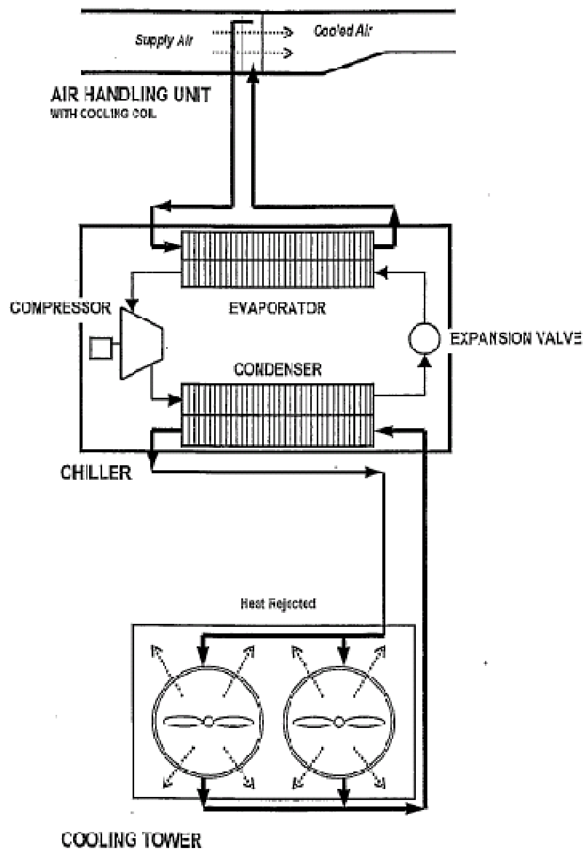

Figure 4.4 : Components and process of a central chilled water system (Dagostino and Wujeck 2005).

The aforementioned description of a chilled water system hints to the complexity that went into changing a SCUD mechanical system to a chiller-based program. The switch to the chilled water system not only added two chillers to the project, but an energy recovery unit as well to ensure maximum efficiency of the chillers. Energy recovery units are often paired with chillers to help reuse heating or cooling energy that might otherwise be lost if not captured by this piece of equipment. Fortunately, no mechanical equipment had been installed at the time the decision was made to switch mechanical systems, thereby disallowing any cost premium to remove existing equipment. Instead, extra cost for the upgrade to a chiller system was limited to new equipment and labor to install additional piping (Kelley 2009).

The new chillers were to be located on the roof. A major consideration in adding two chillers and an energy recovery unit, especially on the roof of a building, is the structural capacity to carry these new loads. These pieces of equipment were enormous in size and carried considerable live and dead loads that required extensive review by the structural engineer. Since the project was in the sitework phase at this point, it allowed the structural engineer to analyze the new loads and include additional concrete beams, reinforcing steel, and post-tensioning materials to provide structural support. Other aspects of adding this mechanical equipment to the roof that needed to be studied included noise and vibration transfer to the office tenant floor below. A third-party acoustical consultant studied the situation and concluded using isolators on the mechanical equipment should be sufficient in eliminating most sound and vibration transfer. Although these were indirect costs for green building on the Midtown Atlanta Office Building project, they were still items that had to be considered. These costs are reflected in the Quantitative Analysis portion of the case study.

Another analysis that had to occur before fully pursuing LEED on the Midtown Atlanta Office Building was a study of the energy model concerning the glazing factor. The glazing factor can be defined as, "The ratio of interior illuminanace at a given point on a given plane (usually the work plane) to the exterior illuminance under known overcast sky conditions. The variables used to determine the daylight factor include the floor area, window area, window geometry, visible transmittance and window height" (USGBC 2006, 410). The glazing factor affected several Indoor Environmental Quality credits and needed to be evaluated before fully pursing LEED since the curtainwall glazing system and floor layouts were already designed. The analysis showed that the current system would suffice and no major changes were required of the curtainwall system.

Throughout these initial analyses, the General Contractor was updating pricing and assisting the LEED consultant and Architect in providing any information regarding construction materials or practices. Although the LEED process was new to the General Contractor's project management team on the Midtown Atlanta Office Building project, the project managers were able to use historical data from other LEED projects as a point of reference. After several months of feasibility studies and analyses, the results concluded that the Midtown Atlanta Office Building could achieve LEED certification status, pending the implementation of the previously stated design changes. The next step was to create a task list and allocate the credits to the appropriate party, followed by developing a formal proposal and submitting the proposal to the USGBC for approval of the credits.

4.3 Coordination of Credits

The LEED process, as implemented in the Midtown Atlanta Office Building project, can be broken down into nine different phases. This analysis assumes that an Owner/Developer has already conceptualized the idea of creating a sustainable building. The nine phases of LEED that were carried-out at Midtown Atlanta Office Building are shown below in Figure 4.5.

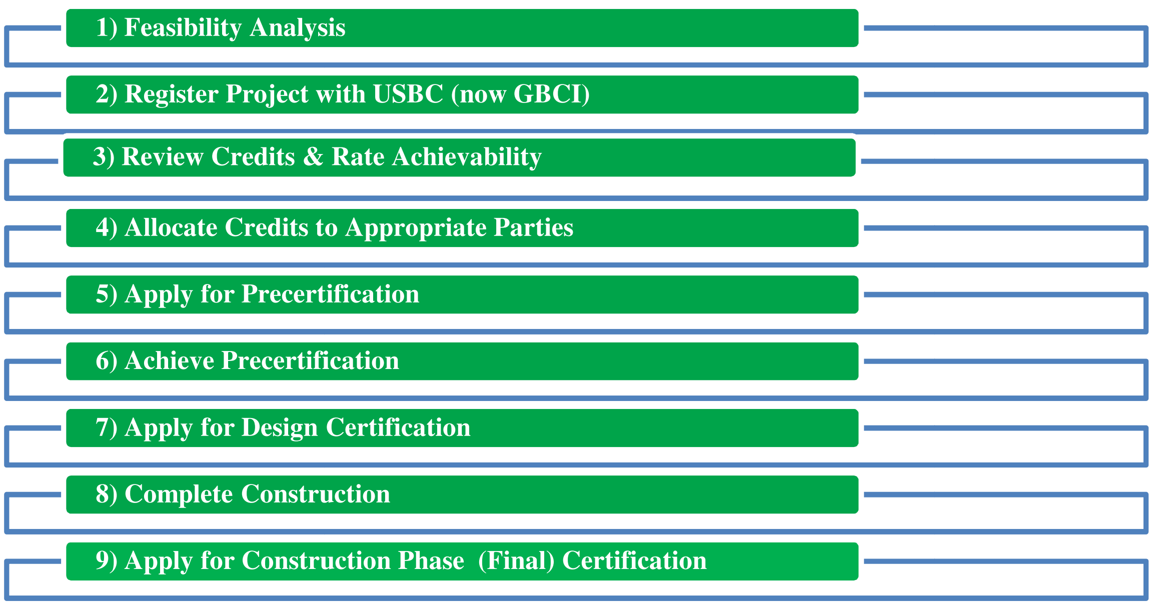

Figure 4.5 : LEED Process of the Midtown Atlanta Office Building (Kelley 2009)

Most developers will conduct feasibility studies to better understand market conditions and profitability surrounding a potential project. Typically this means conducting market studies, analyzing pro forma reports, identifying project constraints, studying life cycle costs, and a multitude of other development factors. A feasibility study can be defined as, "A combination of a market study and an economic study that provides the investor with knowledge of both the environment where the project exists and the expected returns from investment in it" (Miles et al. 2007, 628). Even though this process is frequently used on a macro level for developments, it can also be used to initially study the viability of a sustainable project.

Most of the early analyses of green building on the Midtown Atlanta Office Building project were conducted by the LEED Consultant, with assistance given by the Owner. As mentioned, the project was not originally planned as a green project. Therefore, a unique situation occurred in which a feasibility analysis was performed within the restrictions of an existing project. During the analysis, the LEED Consultant studied the existing project and recognized potential credits. The General Contractor, Architect, and other team members participated by providing estimates for the potential credits. Enough credits were recognized that allowed the feasibility study to determine that it was achievable to pursue at least the LEED "Certified" level.

Many projects that have a schedule over 12 months may consider submitting the credits in two phases (design and construction). This allows project teams, such as the Midtown Atlanta Office Building team, to expedite and have the anticipated design credits approved prior to completion of construction. However, before submitting a proposal to the USGBC to receive acceptance on the design credits, it is essential to review the credits with the project team for two reasons: to understand which credits are obtainable and to identify which party is responsible for carrying-out and achieving each obtainable credit. Answering these two questions will help the project team assemble a working plan and proposal, which can then be submitted to the USGBC for design credit review.

The Midtown Atlanta Office Building Team developed a checklist of all the credits that could be achieved and listed the responsible party beside the credit. The results of the checklist, based upon LEED CS v2.0, are listed below in Table 4.1.

Table 4.1 : Midtown Atlanta Office Building Credit Analysis (Kelley 2009)

Credit	**Description**	**Credit Leader**	**Achievability**
SS prereq. 1	Construction Activity Pollution Prevention	CE	Required
SS credit 1	Site Selection	Owner	Yes
SS credit 2	Development Density & Community Connectivity	LEED consultant, Owner	Yes
SS credit 3	Brownfield Redevelopment	Owner	Yes
SS credit 4.1	Alternative Transportation – Public Transportation Access	LEED consultant, Owner	Yes
SS credit 4.2	Alternative Transportation – Bicycle Storage, Changing Rooms	N/A	No
SS credit 4.3	Alternative Transportation – Low-Emitting and Fuel Efficient Vehicles	Owner, Architect	Maybe
SS credit 4.4	Alternative Transportation – Parking Capacity	N/A	No
SS credit 5.1	Site Development – Protect or Restore Habitat	N/A	No
SS credit 5.2	Site Development – Open Space	N/A	No
SS credit 6.1	Stormwater Design – Quantity Control	N/A	No
SS credit 6.2	Stormwater Design – Quality Control	N/A	No
SS credit 7.1	Heat Island Effect – Non-Roof	Architect	Yes
SS credit 7.2	Heat Island Effect – Roof	Architect	Yes
SS credit 8	Light Pollution Reduction	N/A	No
SS credit 9	Tenant Design & Construction Guidelines	LEED consultant	Yes
WE credit 1.1	Water Efficient Landscaping – Reduce by 50%	CE	Yes
WE credit 1.2	Water Efficient Landscaping – No Potable Use or No Irrigation	CE	Yes

Table 4.1 continued

WE credit 2	Innovative Wastewater Technologies	n/a	No
WE credit 3.1	Water Use Reduction – 20% Reduction	LEED consultant	Yes
WE credit 3.2	Water Use Reduction – 30% Reduction	LEED consultant	Yes
EA prereq. 1	Fundamental Commissioning of Building Energy Systems	CxA	Required
EA prereq. 2	Minimum Energy Performance	LEED Consultant	Required
EA prereq. 3	Fundamental Refrigerant Management	MEP Engineer	Required
EA credit 1	Optimize Energy Performance	LEED Consultant	Yes
EA credit 2	On-Site Renewable Energy	N/A	No
EA credit 3	Enhanced Commissioning	N/A	No
EA credit 4	Enhanced Refrigerant Management	MEP Engineer	Yes
EA credit 5.1	Measurement & Verification – Base Building	LEED Consultant	Maybe
EA credit 5.2	Measurement & Verification – Tenant Sub-Metering	LEED Consultant	Maybe
EA credit 6	Green Power	GC	Yes
MR prereq. 1	Storage & Collection of Recyclables	Architect	Required
MR credit 1.1	Building Reuse – Maintain 25% of Existing Walls, Floors, & Roof	N/A	No
MR credit 1.2	Building Reuse – Maintain 50% of Existing Walls, Floors, & Roof	N/A	No
MR credit 1.3	Building Reuse – Maintain 75% of Interior Non-Structural Elements	N/A	No
MR credit 2.1	Construction Waste Management – Diver 50% from Disposal	N/A	No
MR credit 2.2	Construction Waste Management – Divert 75% from Disposal	N/A	No
MR credit 3	Materials Reuse – 1%	N/A	No
MR credit 4.1	Recycled Content - 10%	GC	Yes
MR credit 4.2	Recycled Content – 20%	GC	Maybe
MR credit 5.1	Regional Materials – 10%	GC	Yes
MR credit 5.2	Regional Materials – 20%	GC	Maybe
MR credit 6	Certified Wood	GC	Yes

Table 4.1 continued

EQ prereq. 1	Minimum IAQ Performance	MEP Engineer	Required
EQ prereq. 2	Environmental Tobacco Smoke (ETS) Control	Owner	Required
EQ credit 1	Outdoor Air Delivery Monitoring	MEP Engineer	Yes
EQ credit 2	Increased Ventilation	N/A	No
EQ credit 3	Construction IAQ Mgmt Plan	N/A	No
EQ credit 4.1	Low-Emitting Materials – Adhesives and Sealants	GC	Yes
EQ credit 4.2	Low-Emitting Materials – Paints & Coatings	GC	Yes
EQ credit 4.3	Low-Emitting Materials – Carpet Systems	GC	Yes
EQ credit 4.4	Low-Emitting Materials – Composite Wood & Agrifiber	N/A	No
EQ credit 5	Indoor Chemical & Pollutant Source Control	N/A	No
EQ credit 6	Controllability of Systems – Thermal Comfort	N/A	No
EQ credit 7	Thermal Comfort – Design	MEP Engineer	Yes
EQ credit 8.1	Daylight & Views – Daylight 75% of Spaces	N/A	No
EQ credit 8.2	Daylight & Views – Views for 90% of Spaces	LEED Consultant, Architect	Yes
ID credit 1.1	Innovation in Design – Green Housekeeping	Owner	Yes
ID credit 1.2	Innovation in Design – Exemplary Performance of SSc7.1	Architect, LEED Consultant	Yes
ID credit 1.3	Innovation in Design – Green Education Program	Owner, LEED Consultant	Yes
ID credit 1.4	Innovation in Design – Exemplary Performance MRc6	N/A	No
ID credit 2	LEED AP	LEED Consultant	Yes

The above Table 4.1 was developed over the course of several coordination meetings in 2007 and 2008. As discussed in the Literature Section, collaboration of all parties in the LEED process can greatly help achieve desired results. The party assigned to each credit can vary from project to project. For example, if a LEED consultant is not hired on, then their associated credits must be divided between the Owner, Design Team, and General Contractor. Other credits, such as ID credit 2 (providing a LEED AP on the project), may be applicable to any of the parties involved that has LEED AP involved in the project. Although a credit leader exists for each credit pursued, the Midtown Atlanta Office Building project demonstrated that most credits involve multiple parties. Therefore, this process naturally lends itself to a collaborative environment.

Once the task list was created, it let the team identify which credits seemed achievable. When reviewing the credits for the first time, it's important to note that not all credits may have an objective "yes" or "no" achievability status to them. As discovered in the Midtown Atlanta Office Building project, there may be several variables to a credit. For example, the General Contractor realized that MR credit 4.1 (Recycled Content – 10%) was achievable; however, a further analysis needed to be conducted before MR credit 4.2 (Recycled Content – 20%) was objectively declared as an achievable credit. The team therefore gave it a "maybe" status, dependent upon the results of the analysis (Kelley 2009).

Prior to labeling a credit as a definitive "no", the team should have a clear understanding of what is restricting the credit. Many of the credits may share similar attributes; therefore the reasons for not being able to achieve the credit should be listed to help identify the affect on other credits. The prerequisite credits obviously must be met. If the prerequisite credits are not able to be met, then the project either needs to be fundamentally changed to allow the achievement of the prerequisites or to disregard the project's ability to achieve LEED certification.

The Midtown Atlanta Office Building may have had more objective "yes" and "no" credits than most projects undergoing LEED certification, due to the project's design already being close to completion. For example, any credits involving site selection were already decided upon (given that the site had been selected several years prior and the construction process was underway). Credits such as SSc5.2, Maximize Open Space, would have required a major change in layout of the project or the design of the roof to hold vegetation in order to meet the credit requirements. The team did not pursue the on-site renewable energy credit; provisions for on-site renewable energy would need to be considered early in the process to be effective. It is possible that alternative energy systems such as photovoltaic panels could be added after the project has started, but it would be much more cost effective if this was considered prior to designing and installing the electrical system.

After evaluating the credits and their associated achievability status, the team was able to estimate what level of certification might be obtained. There are four levels of certification in the LEED CS version 2.0 system. The four levels of certification, along with the required points include (USGBC 2006):

- Certified: 23-27 points
- Silver: 28-33 points
- Gold: 34-44 points
- Platinum: 45-61 points

Based upon the achievability of the points, the team concluded that there were 28 points that were classified as "yes", while 5 points were a "maybe" and 28 points were listed as "no." Therefore, using the certification levels as indicated above, the project team decided to submit an application for precertification for LEED Silver in the CS category.

The precertification status is unique to the Core & Shell category. This is primarily so that the developer can use the achievement of precertification as a marketing tool to attract tenants. It is not a requirement for CS projects, but it certainly may prove to be beneficial to the Owner. The application is sent in as soon as requirements for sustainable design and construction are determined. The achievability of design credits should be known at this point. "Precertification generally occurs early in the design process and is based on declared goals and the intent to use green strategies, systems, and/or features, not actual achievement of these features" (USGBC 2009, xviii).

At the point of submitting the application for precertification, the Midtown Atlanta Office Building team knew which design credits could were obtainable. The USGBC states in the reference manuals whether each credit should be submitted as a design or construction credit. The team concluded that the project would be able to capitalize on the following "yes" design credits and thus submitted these in the precertification application, not including prerequisites (Kelley 2009):

- SSc1 – Site Selection
- SSc2 – Development Density & Community Connectivity
- SSc3 – Brownfield Redevelopment
- SSc4.1 – Alternative Transportation – Public Transportation Access
- SSc7.2 – Heat Island Effect – Roof
- SSc9 – Tenant Design & Construction Guidelines
- WEc1.1 – Water Efficient Landscaping – Reduce by 50%

- WEc1.2 – Water Efficient Landscaping – No potable use or no irrigation
- WEc3.1 – Water Use Reduction – 20% Reduction
- WEc3.2 – Water Use Reduction – 30% Reduction
- EAc1 – Optimize Energy Performance (partial)
- EAc4 – Enhanced Refrigerant Management
- EAc5.1 – Measurement & Verification – Base Building
- EAc5.2 – Measurement & Verification – Tenant Sub-Metering
- EQc1 – Outdoor Air Delivery Monitoring
- EQc7 – Thermal Comfort – Design
- EQc8.2 – Daylight & Views – Views for 90% of Spaces
- IDc1.1 – Innovation in Design – Green Housekeeping
- IDc1.2 – Innovation in Design – Exemplary Performance of SSc7.1
- IDc1.3 – Innovation in Design – Green Education Program
- IDc2 – LEED Accredited Professional

As the GC on the Midtown Atlanta Office Building project, Drew Kelley and his team found that they were principally involved in the credits concerning construction materials. This meant identifying the sustainable and green products in the contract documents and pricing accordingly. It is often agreed upon that there are two types of specifications produced by the design team: prescriptive and performance. Most of the specifications for the sustainable products were prescriptive and described the product (and possibly the manufacturer). However, there are credits, such as EAc1 – Optimize Energy Performance, that are performance-based specifications. Although EAc1 is a design-related credit, the GC must fully understand the credit so that the

Mechanical/HVAC Subcontractor comprehends what is expected from the performance specification. Therefore, it may be auspicious for the General Contractor to sort through the specifications and separate the prescriptive requirements from the performance requirements (AGC 2004).

It should be noted that there are relatively few "pure" design or construction credits. This was realized by the General Contractor's project managers through the collaborative process of assigning credit responsibilities. For example, SSc7.2 (Heat Island Effect – Roof) requires that a certain SRI (Solar Reflectance Index) is met and/or a vegetated roof is installed. The General Contractor may be able to provide helpful information to the Architect concerning a new roofing product that meets the SRI requirement. Another point to consider– MRc5.1 (Regional Materials – 10%) is listed as a construction credit and therefore falls under the scope of the General Contractor (per the arrangement and organizational structure of the Midtown Atlanta Office Building; other project structures may differ). How might the GC pursue and achieve this credit if the Architect has specified materials that cannot be found locally? Instead of abandoning the credit completely, the GC may know of a local vendor or supplier that would have a very similar product. The GC could then discuss with the Architect the possibility of rewriting the specification to include the local product. Therefore, dependent upon each credit's achievability according to the specific project, it is important to note that collaboration between the design and construction teams can bring successful results when coordinating the credits.

4.4 Quantitative Results of Sustainable Construction – Issues of Cost and Time for a General Contractor

A current focus in the green building industry is documenting and measuring sustainable performance. In fact, in the September 2009 LEED USGBC Update has this to say about the upcoming LEED summits: "…the summits are only the first part of the Building Performance Initiative. This will begin an essential national discussion about buildings and will guide the continued evolution of a program that is committed to real performance in all building through rigorous data collection and analysis, feedback loops and continuous searching for better ways to design, build, manage and occupy buildings" (USGBC 2009). In order to make improvements to a system such as LEED, quantitative data and results need to be gathered and measured.

Time and money are two very important aspects of the construction process. Most contractors value time and money as two of the most important assets of their operation. That is why the information extracted from the Midtown Atlanta Office Building contains quantitative results concerning these two subjects. The study evaluates how much of the General Contractor's time was spent on each credit. This may include time spent coordinating the work due to an attempt to achieve a credits or even checking a submittal for a sustainable product. The study also evaluates the cost percentage premium relative to the total contract value.

The credits that are analyzed below are only the credits which were pursued by the project team. This includes credits that were classified in the matrix with an achievability level of "Yes" or "Maybe." A small amount of time may have been spent evaluating a "maybe" credit that was later classified as "No." However, according to the

General Contractor, most of the credits that were not pursued did not entail extensive time consumption or research by any of the involved parties. Other assumptions that were made to complete the study include:

- Unless noted otherwise, the "Approximate time spent General Contractor spent on credit" refers to the time a project manager spent in coordination and project planning. Many contractor-related credits, such as those for recycled content or regional materials, require up front coordination by the project management team and may not affect field labor. However, in the event of a construction credit that involved field labor, the field-personnel costs were considered as well.
- The cost assigned to a Project Manager's billable rate is 60 $/hr.
- Coordination of a credit generally includes reviewing material/product selection, confirming that the material is in accordance with the contract documents (i.e. by reviewing and checking shop drawings), ensuring that the material delivers in a timely manner, and that the material is installed correctly.
- The costs associated with these credits solely involve construction-related costs. For an understanding of the holistic costs associated with LEED credits, design fees should be calculated as well.

The study below represents the credits that were pursued (either by choice of the project team or by prerequisite requirements) in order to achieve the LEED CS Silver level.

SSprereq.1	Construction Activity Pollution Prevention
Credit Type	Construction
Credit Leader	Civil Engineer
Achievability	Required
GC Involvement	Potential maintenance and labor involved in upkeep of silt fence and erosion control. This would have occurred regardless of this particular LEED credit.
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.6 : Case Study Credit SSprereq.1 (Kelley 2009)

SSc1	Site Selection
Credit Type	Design
Credit Leader	Owner
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.7 : Case Study Credit SSc1 (Kelley 2009)

SSc2	**Development Density & Community Connectivity**
Credit Type	Design
Credit Leader	LEED Consultant/Owner
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.8 : Case Study Credit SSc1 (Kelley 2009)

SSc3	**Brownfield Redevelopment**
Credit Type	Design
Credit Leader	Owner
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.9 : Case Study Credit SSc3 (Kelley 2009)

SSc4.1	**Alt. Transportation - Public Transportation Access**
Credit Type	Design
Credit Leader	LEED Consultant/Owner
Achievability	Yes
GC Involvement	Priced and provided bike racks for project
Approx. Time General Contractor Spent on Credit	3 hours
Approx. Construction Cost Premium of Credit	$2,180

Figure 4.10 : Case Study Credit SSc4.1 (Kelley 2009)

SSc4.3	**Alt. Transportation - Low Emitting/Fuel Efficient Vehicles**
Credit Type	Design
Credit Leader	Owner/Architect
Achievability	Maybe
GC Involvement	Coordination of signage and potential electrical provisions
Approx. Time General Contractor Spent on Credit	4 hours
Approx. Construction Cost Premium of Credit	$240

Figure 4.11 : Case Study Credit SSc4.3 (Kelley 2009)

SSc7.1	Heat Island Effect - Non-Roof
Credit Type	Construction
Credit Leader	Architect
Achievability	Yes
GC Involvement	Provided Landscape and hardscape pricing and Coordination
Approx. Time General Contractor Spent on Credit	7 hours
Approx. Construction Cost Premium of Credit	$420

Figure 4.12 : Case Study Credit SSc7.1 (Kelley 2009)

SSc7.2	Heat Island Effect – Roof
Credit Type	Design
Credit Leader	Architect
Achievability	Yes
GC Involvement	Coordinated purchasing and installation of modified bitumen roofing system with high SRI value cap sheet ($10k premium for cap sheet)
Approx. Time General Contractor Spent on Credit	8 hours
Approx. Construction Cost Premium of Credit	$10,480

Figure 4.13 : Case Study Credit SSc7.2 (Kelley 2009)

SSc9	Tenant Design & Construction Guidelines
Credit Type	Design
Credit Leader	LEED Consultant
Achievability	Yes
GC Involvement	Assisted Owner with reviewing and writing construction Guidelines
Approx. Time General Contractor Spent on Credit	2 hours
Approx. Construction Cost Premium of Credit	$120

Figure 4.14 : Case Study Credit SSc9 (Kelley 2009)

WEc1.1	Water Efficient Landscaping - Reduce by 50%
Credit Type	Design
Credit Leader	Civil Engineer
Achievability	Yes
GC Involvement	In conjunction with WEc1.2 (see below)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.15 : Case Study Credit WEc1.1 (Kelley 2009)

WEc1.2	Water Efficient Landscaping - No Potable Use/No Irrigation
Credit Type	Design
Credit Leader	Civil Engineer
Achievability	Yes
GC Involvement	Coordinated plant types with landscaping Subcontractor
Approx. Time General Contractor Spent on Credit	2 hours
Approx. Construction Cost Premium of Credit	$120

Figure 4.16 : Case Study Credit WEc1.2 (Kelley 2009)

WEc3.1	Water Use Reduction - 20%
Credit Type	Design
Credit Leader	MEP Engineer, LEED Consultant
Achievability	Yes
GC Involvement	In conjunction with WEc3.2 (see below)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.17 : Case Study Credit WEc3.1 (Kelley 2009)

WEc3.2	**Water Use Reduction - 30%**
Credit Type	Design
Credit Leader	MEP Engineer, LEED Consultant
Achievability	Yes
GC Involvement	Priced and reviewed low-flow fixtures, checked submittals, and managed field coordination of low-flow urinals and lavatory faucets, and dual-flush toilets
Approx. Time General Contractor Spent on Credit	8 hours
Approx. Construction Cost Premium of Credit	$480

Figure 4.18 : Case Study Credit WEc3.2 (Kelley 2009)

EAprereq.1	**Fundamental Commissioning of the Building Energy Systems**
Credit Type	Construction
Credit Leader	Commissioning Authority
Achievability	Required
GC Involvement	Attended meetings concerning the commissioning process and helped plan dates of when commissioning should start
Approx. Time General Contractor Spent on Credit	5 hours
Approx. Construction Cost Premium of Credit	$300

Figure 4.19 : Case Study Credit EAprereq.1 (Kelley 2009)

EAprereq.2	Minimum Energy Performance
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Required
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.20 : Case Study Credit EAprereq.2 (Kelley 2009)

EAprereq.3	Fundamental Refrigerant Management
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Required
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.21 : Case Study Credit EAprereq.3 (Kelley 2009)

EAc1	Optimize Energy Performance
Credit Type	Design
Credit Leader	LEED Consultant
Achievability	Yes (Partial)
GC Involvement	Added a chiller system in lieu of a SCUD system. This change, which occurred after construction started, also affected stuctural, electrical, and architectural elements of the project.
Approx. Time General Contractor Spent on Credit	75 hours
Approx. Construction Cost Premium of Credit	$2,108,676

Figure 4.22 : Case Study Credit EAc1 (Kelley 2009)

EAc4	Enhanced Refrigerant Management
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.23 : Case Study Credit EAc4 (Kelley 2009)

EAc5.1	Measurement & Verification - Base Building
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Maybe
GC Involvement	A small amount of coordination was involved with the Mechanical Subcontractor as to scheduling the Tests.
Approx. Time General Contractor Spent on Credit	2 hours
Approx. Construction Cost Premium of Credit	$120

Figure 4.24 : Case Study Credit EAc5.1 (Kelley 2009)

EAc6	Green Power
Credit Type	Construction
Credit Leader	Owner/GC
Achievability	Yes
GC Involvement	Priced out different companies, reviewed submittal packages, and released green power vendor.
Approx. Time General Contractor Spent on Credit	4 Hours
Approx. Construction Cost Premium of Credit	$4,603

Figure 4.25 : Case Study Credit EAc6 (Kelley 2009)

MRprereq.1	Storage & Collection of Recyclables
Credit Type	Design
Credit Leader	Architect
Achievability	Required
GC Involvement	N/A (provided by Owner)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.26 : Case Study Credit MRprereq.1 (Kelley 2009)

MRc4.1	Recycled Content - 10% (post-consumer + 1/2 pre-consumer)
Credit Type	Construction
Credit Leader	GC
Achievability	Yes
GC Involvement	In conjunction with MRc4.2 (see below)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.27 : Case Study Credit MRc4.1 (Kelley 2009)

MRc4.2	Recycled Content - 20% (post-consumer +1/2 pre-consumer)
Credit Type	Construction
Credit Leader	GC
Achievability	Maybe
GC Involvement	Most Subcontractors were already under contract, so the process involved researching materials that were already selected for the project. The GC also completed the LEED forms online for this credit
Approx. Time General Contractor Spent on Credit	8 Hours
Approx. Construction Cost Premium of Credit	$480

Figure 4.28 : Case Study Credit MRc4.2 (Kelley 2009)

MRc5.1	Regional Materials-10% Extracted, Processed & Manufactured
Credit Type	Construction
Credit Leader	GC
Achievability	Yes
GC Involvement	In conjunction with MRc5.2 (see below)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.29 : Case Study Credit MRc5.1 (Kelley 2009)

MRc5.2	Regional Materials-20% Extracted, Processed & Manufactured
Credit Type	Construction
Credit Leader	GC
Achievability	Maybe
GC Involvement	Most Subcontractors were already under contract, so the process involved researching materials that were already selected for the project. The GC also completed the LEED forms online for this credit
Approx. Time General Contractor Spent on Credit	11 Hours
Approx. Construction Cost Premium of Credit	$660

Figure 4.30 : Case Study Credit MRc5.2 (Kelley 2009)

MRc6	Certified Wood
Credit Type	Construction
Credit Leader	GC
Achievability	Yes
GC Involvement	GC had to ensure 50% of all wood products were FSC certified, including millwork panels, doors, blocking, and wood trim. A small premium was paid for FSC wood material
Approx. Time General Contractor Spent on Credit	7 Hours
Approx. Construction Cost Premium of Credit	$18,270

Figure 4.31 : Case Study Credit MRc6 (Kelley 2009)

EQprereq.1	Minimum IAQ Performance
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Required
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.32 : Case Study Credit EQprereq.1 (Kelley 2009)

EQprereq.2	Environmental Tobacco Smoke (ETS) Control
Credit Type	Design
Credit Leader	Owner
Achievability	Required
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.33 : Case Study Credit EQprereq.2 (Kelley 2009)

EQc1	Outdoor Air Delivery Monitoring
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.34 : Case Study Credit EQc1 (Kelley 2009)

EQc4.1	Low-Emitting Materials - Adhesives & Sealants
Credit Type	Construction
Credit Leader	GC, Architect
Achievability	Yes
GC Involvement	Reviewed submittals to confirm they were in compliance with green specifications
Approx. Time General Contractor Spent on Credit	4 Hours
Approx. Construction Cost Premium of Credit	$240

Figure 4.35 : Case Study Credit EQc4.1 (Kelley 2009)

EQc4.2	Low-Emitting Materials - Paints & Coatings
Credit Type	Construction
Credit Leader	GC, Architect
Achievability	Yes
GC Involvement	Reviewed submittals to confirm they were in compliance with green specifications
Approx. Time General Contractor Spent on Credit	4 Hours
Approx. Construction Cost Premium of Credit	$240

Figure 4.36 : Case Study Credit EQc4.2 (Kelley 2009)

EQc4.3	Low-Emitting Materials - Carpet Systems
Credit Type	Construction
Credit Leader	GC, Architect
Achievability	Yes
GC Involvement	Reviewed submittals to confirm they were in compliance with green specifications
Approx. Time General Contractor Spent on Credit	2 Hours
Approx. Construction Cost Premium of Credit	$120

Figure 4.37 : Case Study Credit EQc4. (Kelley 2009)

EQc7	**Thermal Comfort – Design**
Credit Type	Design
Credit Leader	MEP Engineer
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.38 : Case Study Credit EQc7 (Kelley 2009)

EQc8.2	**Daylight & Views - View for 90% of Spaces**
Credit Type	Design
Credit Leader	Architect, LEED Consultant
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.39 : Case Study Credit EQc8.2 (Kelley 2009)

IDc1.1	Innovation in Design - Green Housekeeping
Credit Type	Design
Credit Leader	Owner
Achievability	Yes
GC Involvement	Coordinated with Owner in providing information regarding installed products and how they may be Maintained
Approx. Time General Contractor Spent on Credit	3 Hours
Approx. Construction Cost Premium of Credit	$180

Figure 4.40 : Case Study Credit IDc1.1 (Kelley 2009)

IDc1.2	Innovation in Design - Exemplary Performance - SSc7.1
Credit Type	Design
Credit Leader	Architect, LEED Consultant
Achievability	Required
GC Involvement	N/A (All parking was covered, so GC had no involvement in this credit)
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.41 : Case Study Credit IDc1.2 (Kelley 2009)

IDc1.3	Innovation in Design - Green Education Program
Credit Type	Design
Credit Leader	Owner, LEED Consultant
Achievability	Yes
GC Involvement	Provided Owner with submittal information and assisted in producing brochure for tenants
Approx. Time General Contractor Spent on Credit	2 Hours
Approx. Construction Cost Premium of Credit	$120

Figure 4.42 : Case Study Credit IDc1.3 (Kelley 2009)

IDc2	LEED Accredited Professional
Credit Type	Construction
Credit Leader	LEED Consultant
Achievability	Yes
GC Involvement	N/A
Approx. Time General Contractor Spent on Credit	0
Approx. Construction Cost Premium of Credit	$0

Figure 4.43 : Case Study Credit IDc2 (Kelley 2009)

By extracting the data from the information given above, several conclusions can be reached concerning the General Contractor's time and financial involvement. The first aspect to be analyzed is the General Contractor's overall involvement in the LEED process. More specifically, the GC's contribution as a credit leader is where most of the coordination occurred for the General Contractor. As seen below in Figure 4.44, the GC was a credit leader for 19% of the achievable credits. This involvement is broken down a step further in Figure 4.45, which shows that the General Contractor was most involved as a credit leader in the Material & Resources category, followed by Indoor Environment Quality and Energy & Atmosphere.

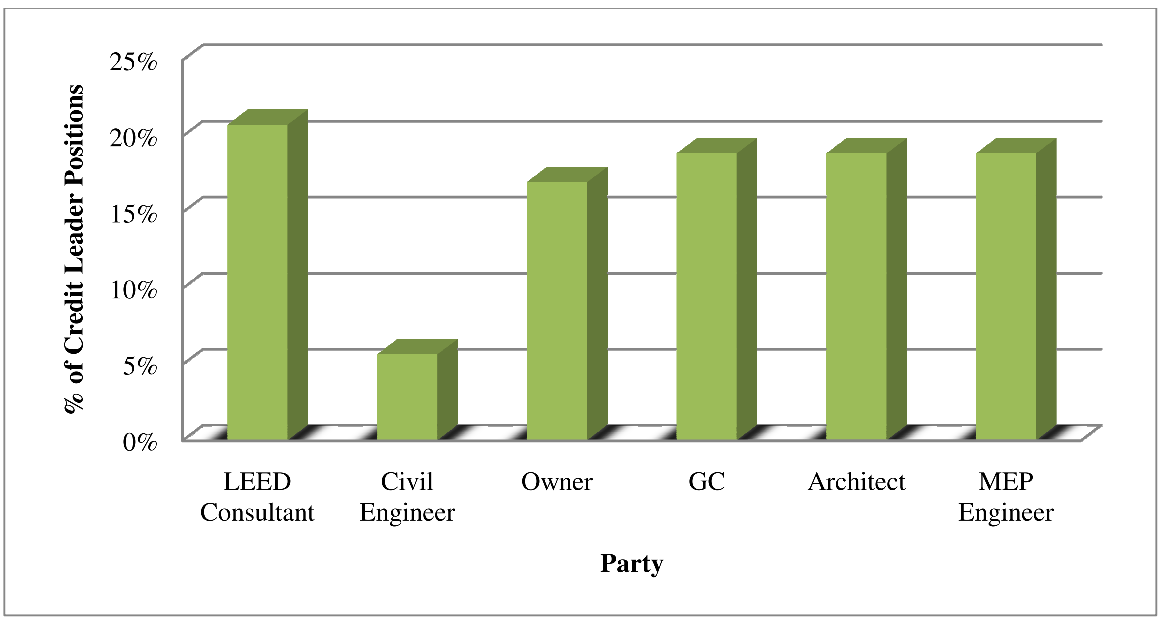

Figure 4.44 : Party Involvement as a LEED Credit Leader in the Midtown Atlanta Office Building

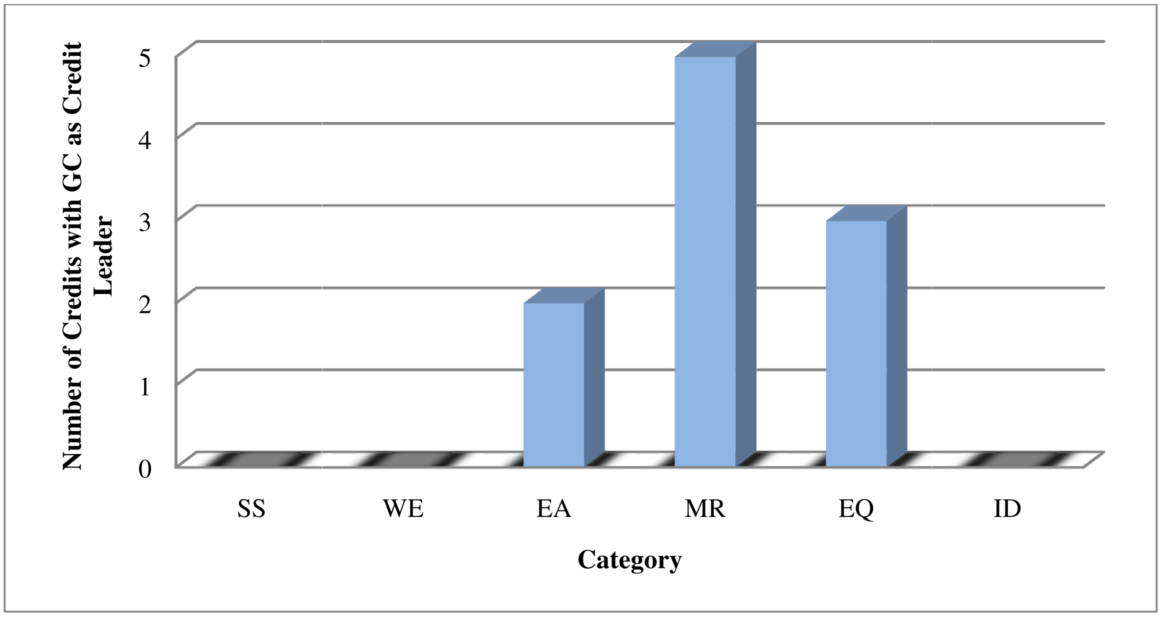

Figure 4.45 : Breakdown of General Contractor Involvement as a Credit Leader in the Midtown Atlanta Office Building

Figure 4.45 above illustrates that the General Contractor was the credit leader on five credits concerned with the Material & Resources category. Much of the GC's coordination efforts in the Material & Resources category focused on identifying if the products that were already specified for the project would meet the MR requirement. For example, the General Contractor was able to receive a letter from the reinforcing steel supplier for the project that states how the product is in compliance with the post-consumer and pre-consumer requirements of LEED (Kelley 2009).

The study shows that several credits were achievable simply because a higher performance was available. The General Contractor knew that over 20% of the construction materials were located regionally, meaning that no additional time had to be spent on MRc5.1. These credits may be considered more productive since the team could spend time achieving one credit while receiving points for two credits. Therefore, the study allocates all time spent on the conjoined credits to the greater of the two credits.

One very important point to consider in this case study is that EAc.1 is an anomaly. As previously mentioned, almost all of the costs related to the General Contractor could have been avoided in this credit had the chiller-based mechanical system been specified in the original design. The breakdown of the EAc.1 cost is as follows:

$1,502,141 for new chiller, mechanical equipment, and connections
$200,080 for cast-in-place concrete and reinforcing to create a new penthouse space
$126,761 for a new stop on the elevator to serve the penthouse space
$279,694 for new electrical loads associated with the chiller
$2,108,676 for EAc1 (Kelley 2009)

Below are two figures – Figure 4.46 shows the summation of the cost and time that the General Contractor spent achieving LEED C&S Silver on the Midtown Atlanta Office Building. Figure 4.47 is a hypothetical analysis of what time and money the GC would have spent on construction-related green building credits had the chiller system been incorporated in the original design:

	SS	WE	EA	MR	EQ	ID
Time	24 hrs	10 Hrs	86 hrs	26 hrs	10 hrs	5 hrs
Cost	$13,440	$600	$2,113,699	$19,410	$600	$300

TOTALS	
161	hours
$2,148,049	Construction cost premium
2.53%	Premium over original contract for construction costs of LEED C&S Silver

Figure 4.46 : General Contractor Time and Cost Spent on LEED Credits in the Midtown Atlanta Office Building Project

Midtown Atlanta Office Building

Item Description	Time	Cost
-Original project time and cost spent on LEED credits	161 hrs	$2,148,049
-Deduct premium of changing building for chillers	(75) hrs	($2,108,676)
Potential Total	86 hrs	$39,373
Premium over contract for construction costs		< .5%

Figure 4.47 : Hypothetical General Contractor Time and Cost Spent on LEED Credits if LEED Had Been Considered Before the Design Process

Interestingly enough, Figure 4.46 (General Contractor Time and Cost Spent on LEED Credits in the Midtown Atlanta Office Building Project) does not concur with

Figure 4.45 (Breakdown of General Contractor Involvement as a Credit Leader in the Midtown Atlanta Office Building). Once again, this is disproportionate due to change in mechanical systems after commencement of construction. Although the $39,373 for potential costs in Figure 4.47 is speculative, it is still important to understand that the potential reduction could have been exponential by implementing LEED early in project conception. By extrapolating the data from Figure 4.46, the quantity of time and money spent on each category is graphically shown below in Figure 4.48.

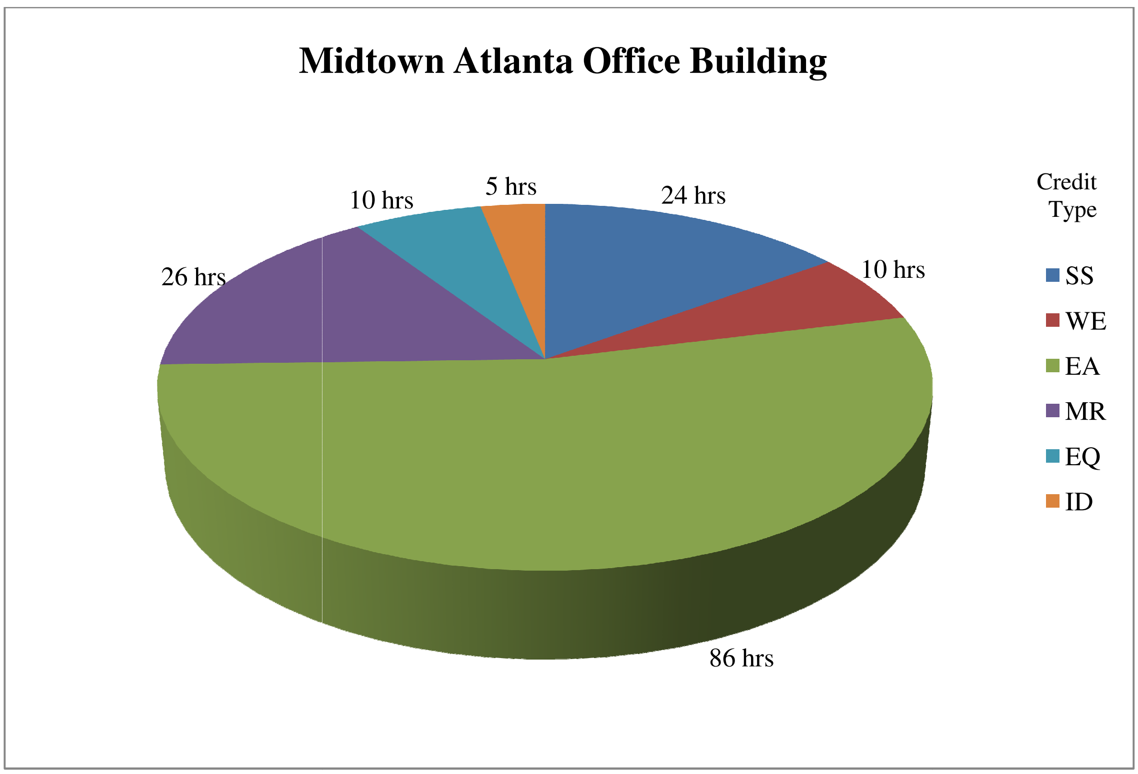

Figure 4.48 : Hours Spent by General Contractor on LEED Credits, Grouped by Category

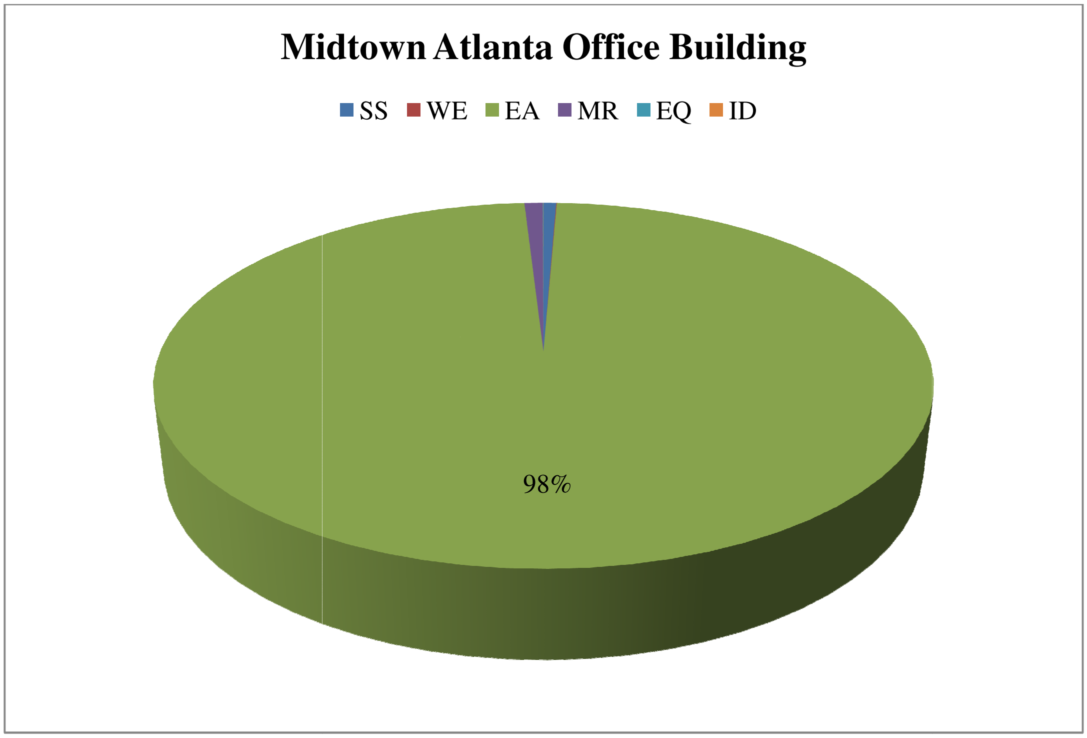

Figure 4.49 : Percentage of LEED Construction Costs, Grouped by Category

Although certain portions of this case study (i.e. cost for EAc1) may need to be reevaluated prior to applying to another project, there are certainly aspects that are universal and could apply to other sustainable projects.

In order to improve in the growing field of sustainable construction, General Contractors should continue to track and manage cost and time considerations in order to be more effective. "Clearly there can be no single, across-the-board answer to the question 'What does green cost?' On the other hand, it is possible, and quite easy, to answer the question 'What will green cost me on my project?' It is also possible, and quite easy, to manage those costs so that sustainable features can be delivered in a cost-effective and efficient manner" (Morris and Langdon 2007).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

As green building becomes increasingly prevalent, General Contractors need to have a better understanding of what the green building process entails, both in cost and time. Through literature review and a relevant case study, the research presented in this thesis has identified several conclusions concerning a General Contractor's involvement in sustainable construction.

The goal of the case study was to quantitatively analyze the General Contractor's involvement in a green building project. The case study confirms that the General Contractor's involvement in the LEED process of the Midtown Atlanta Office Building was substantially different than if the project team would have not pursued LEED Silver certification. The case study reveals that a total of 161 hours were spent managing and coordinating constructability issues concerning the LEED process on the project. Furthermore, LEED CS Silver on the Midtown Atlanta Office Building project equated to a 2.53% construction cost increase. As discussed in the research, it is vital to understand that an anomaly existed in which the mechanical system was redesigned in order to meet the required minimum points of EAc1. If this would have not occurred, then it is likely that the General Contractor would not have experienced substantially different time and cost considerations in the LEED process. In fact, it may have been possible for the General Contractor to have only spent 86 hours and less than 0.5% of construction-related costs had the LEED-compliant mechanical system been designed from the beginning.

Collaboration between all parties is extremely important in conducting a successful green building process. The literature review determined that the green building process intrinsically promotes a collaborative environment. As seen in the case study, there are very few credits in which only one party is involved. Instead, each credit encourages interaction and involvement from several parties. The General Contractor should be receptive to the collaboration and when possible, provide insight such as historical cost data for sustainable construction.

A common misconception is that a building has to be designed as a green building early in the design, prior to commencement of construction. Through literature review and the case study, the research has revealed that it is possible for a building to comply with sustainable standards even after construction has started. However, schedule impacts and cost premiums are also associated with the late decisions of turning a building under construction into a green building. Integrated green design and early General Contractor involvement in the green building process should be encouraged to avoid excess premiums.

Finally, it can be objectively stated that the green building market is more than a current fad or trend. The literature review discovered that the sustainable construction industry is a very stable market and is currently valued around $50 billion. Predictions state that the industry may easily become worth over $100 billion by 2013 (Tulacz 2009). Membership of organizations such as the USGBC has grown exponentially in the past five years and many local municipalities are adopting green standards. General

Contractors should stay educated on new sustainable materials and methods in order to stay competitive in the rapidly-growing industry of green construction.

5.2 Recommendation for Further Research

As much as the market of green building is expanding and growing, there seems to be only limited quantitative information available for General Contractors. Further research in the form of case studies should take place in order to develop a better understanding of a General Contractor's time and money spent on sustainable construction. Organizations such as the USGBC should track and publish costs related to sustainable construction so that General Contractors new to green building have a better understanding of what the process entails. Meanwhile, it is recommended for the individual General Contractors to quantitatively record the time and cost spent on building a sustainable project. This will greatly improve companies' ability to provide accurate construction services for green buildings in the future.

APPENDIX A : EXAMPLE OF MILLWORK GREEN SPECIFICATION

1. **Molding, Trim, Window Sash and Sill, Door Frame, Jambs and Stops: 12 inch long sample of each.**
2. Plastic Laminate: Manufacturer's standard color and pattern selections for selection by Architect.
3. Finish Samples: Submit one sample of each type of selected finish on samples of species and grade veneer specified. Apply veneer to backing; approximately 12 inches x 12 inches. Stained solid stock members shall be approximately 12 inches long. **Samples shall include:**

   a. **Each different wood to receive veneer finish.**
   b. **Each different wood to receive paint finish.**
   c. **Each different wood to receive transparent finish.**
   d. **Each different wood to receive lacquered finish.**
   e. **Stain finished wood veneer applied to each different backing.**

4. Exposed cabinet hardware and accessories, one unit for each type and finish, only if requested by Architect. Samples will be returned to supplier.

E. LEED Submittals:

1. Credit EQ 4.1: Manufacturers' product data for installation adhesives, including printed statement of VOC content.
2. Credit EQ 4.4:

   a. Composite wood manufacturer's product data for each composite wood product used indicating that the bonding agent contains no urea formaldehyde.
   b. Adhesive manufacturer's product data for each adhesive used indicating that the adhesive contains no urea formaldehyde.

3. Credit(s) MR 4.1 and MR 4.2: Product Data indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content.

   a. Include statement indicating costs for each product having recycled content.

4. Credit MR 7.0: Certificates of chain-of-custody signed by manufacturers certifying that products specified to be made from certified wood were made from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC 1.2, "Principles and Criteria." Include evidence that mill is certified for chain-of-custody by an FSC-accredited certification body.

F. Fire-Retardent Treatment Certification (FIO - For Information Only): Submit certification by treating plant that fire-retardent treatment materials comply with governing ordinances and that treatment will not bleed through finished surfaces, for Architects information only.

1.5 QUALITY ASSURANCE

A. Applicable Standards: Comply with the following standards as referenced herein:

1. American National standards Institute (ANSI).
2. APA The Engineered Wood Association (APA).

APPENDIX B : EXAMPLE OF PRO FORMA ANALYSIS

Office Building Pro Forma	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Revenue					
Base Rental	$139,800	$145,890	$158,900	$130,500	$145,870
Absorption and Vacancy	($20,100)			($15,400)	
Total Gross Revenue	$119,700	$145,890	$158,900	$115,100	$145,870
Operating Expenses					
Utilities	($32,800)	($31,890)	($33,090)	($29,860)	($30,120)
Insurance	($5,150)	($5,170)	($5,125)	($5,020)	($5,070)
Real Estate Taxes	($8,190)	($8,210)	($8,220)	($8,050)	($8,200)
Management Fee	($1,030)	($1,030)	($1,030)	($1,030)	($1,030)
Total Operating Expenses	($47,170)	($46,300)	($47,465)	($43,960)	($44,420)
Leasing and Capital Costs					
Tenant Improvements	($22,350)	($22,350)	($22,350)	($20,300)	($22,350)
Leasing Commissions	$3,020	$4,390	$5,170	$800	$6,780
Structural Reserve	($2,200)	($2,200)	($2,200)	($2,200)	($2,200)
Total Leasing and Capital Costs	($21,530)	($20,160)	($19,380)	($21,700)	($17,770)
TOTAL CASH FLOW	**$51,000**	**$79,430**	**$92,055**	**$49,440**	**$83,680**

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