



Influence of Project Delivery Methods on Achieving Sustainable High Performance Buildings

Report on Case Studies

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EXECUTIVE SUMMARY

The demand for sustainable buildings in the United States (US) has risen due to accelerated depletion of natural resources, rising energy costs and green house gas emissions, and increased awareness of indoor environmental quality. Recently this demand expanded from including only low energy strategies and products in buildings to prioritizing maximum energy conservation and occupant well being. All of these characteristics represent aspects of *sustainable, high performance buildings*. In the United States several green building assessment systems such as Leadership in Energy, Environmental Design (LEED®), and Green Globes®, which quantify levels of sustainability recognize such buildings.

The LEED® and Green Globes assessments are primarily product-based in their ratings. They do not consider or provide guidelines for project delivery methods. Project delivery methods affect the level of team integration, which has been reported by the industry to result in optimal project outcomes and better value to the owner. Literature suggests that project delivery methods influence the timing of project team members' involvement, and this timing potentially affects the level of integration. The literature also suggests that integration affects participants' relationships and that these relationships impact project outcomes. Although, the industry members involved in sustainable construction and literature point towards a significant volume of literature, considering guidelines to govern and achieve these goals, is lacking. This report is part of a comprehensive study that is seeking to determine how project delivery methods influence an owner's ability to achieve its sustainability goals in delivering building projects. This report's particular aim is to:

“determine the extent of the effect of project delivery methods and practices on the level of integration achieved in projects and further their effects on project outcomes with a focus on sustainability goals.”

The specific objectives of the study are to:

1. Determine the relationship between the level of integration achieved in the delivery process and sustainability goals;
2. Determine the relationship between various project delivery methods and the levels of integration achieved in the design process; and
3. Identify the main project delivery attributes that have relationships to project outcomes in a green building and examine the identified patterns according to various project delivery methods.

To achieve the study's goals and objectives, the study conducted 12 in-depth case studies of the project delivery phase and compared them with building performance at project completion. Case study selection is the result of carefully designed criteria, including distribution across various project delivery methods including Design-Bid-Build (DBB), Design-Build (DB), and Construction Management at Risk (CMR). To provide equal comparison among the cases, the study focuses only on office buildings in the US that received awarded at various levels of LEED® certification according to new construction or core and shell categories. Data collection arose from case study interviews of multiple, primary respondents (i.e., owner, designer, and constructor) representing each project. The data, in the format of both open and closed ended survey responses, were analyzed through qualitative methods of pattern matching, cross case synthesis, and explanation building. Pattern matching assisted the proposition testing procedure,

while the cross case synthesis helped to compare the project delivery attributes of buildings with outcomes at both ends of the scale in overall performance (i.e., level of sustainability, high performance, cost, schedule, quality, and post occupancy). Lastly, explanation building helped to understand outliers in the dataset.

The primary findings of the study show that the level of integration in the delivery process affects final project outcomes, particularly sustainability goals. Also, the study determines that project delivery attributes, such as owner commitment and timing of participant involvement, affect the level of integration more than the characteristics of the project delivery method selected.

The findings also suggest that strong owner commitment towards sustainability, early involvement of the constructor, and early inclusion of green strategies are crucial attributes for a delivery process that can potentially affect project outcomes, especially sustainability goals. Although this research employs case study methods with a small sample size, the majority of results are verified through external validation of previous research findings. The verified results include:

- Green projects delivered by CMR and DB outperform DBB projects;
- Early inclusion of the green concept in the project is necessary, as early as the pre-design phase;
- The reason to pursue green strategies should be an owner driven factor;
- The project's LEED[®] AP should hold a direct contract with the owner in CMR and DBB projects;
- LEED[®] certification level should be a contractual mandate for all team members, especially for designers and constructors ;
- The constructor is a key factor in the success of a project and should be involved in the early design phases to increase the probability of meeting green goals, and
- Design charrettes and collaboration sessions assist the project team's focus on specific goals.

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INTRODUCTION

The demand for sustainable buildings in the United States (US) has risen due to accelerated depletion of natural resources, rising energy costs and green house gas emissions, and improved awareness of indoor environmental quality. Different from traditional construction approaches that emphasize only cost, schedule, and quality performance of projects, sustainable construction expands performance goals to attributes such as low energy consumption, reduced air emissions, and minimal waste generation (Vanegas et al. 1995). Although, the market for sustainable buildings continues to expand, in recent years the scope of the required performance from such buildings has increased and now includes user satisfaction and occupant well being. Such buildings, along with sustainability issues, which address concerns of indoor environmental quality and user satisfaction, health, and productivity, are known as sustainable, high performance buildings (DOE 2009).

The achievement of sustainable building goals increases the level of project complexity in comparison to with traditional project delivery. Increasing interdisciplinary interaction is becoming an imperative for optimal solutions. This interdisciplinary interaction, also known as the integrative design process, suggests that attributes such as early involvement of participants, levels and methods of communication, and compatibility within project teams result in better outcomes (Lapinski et al. 2006, Enache-Pommer and Horman 2009, Korkmaz et al. 2007, 7 Group and Reed 2009). The literature indicates that the project delivery methods might affect the above-mentioned attributes. The three primary project delivery methods include design-build (DB), design-bid-build (DBB), and construction management at risk (CMR). These methods define the contractual relations, timing of involvement of project participants, and contract conditions such as penalties, incentives, risks, and liabilities among participants.

“Early involvement of participants, level and methods of communication, and compatibility within project teams, overall known as the characteristics of integrative design, would result in better outcomes.”

Although the green building industry and the literature point toward the need for higher integration in green building project delivery, literature addressing guidelines toward “how” to achieve the sustainable goals is lacking. Green building assessment systems such as Green Globes (2009) and LEED[®] (USGBC 2009) are heavily product-based and are missing the process component, which directs project teams on “how to achieve product-based strategies.” Other forms of guidelines for integrative design in green project delivery (e.g., Integrated Project Delivery [IPD 2009], Whole Building Design Guide [WBDG 2009]) are recent and yet to be verified through rigorous research. As a response to this need, a comprehensive study is essential for determining how project delivery methods influence achievement of sustainability goals in delivering building projects. As a part of such a study, this report attempts to answer the following essential research question:

What is the extent of the effect of project delivery methods and practices on the level of integration achieved in projects, and further, does it have an effect on project outcomes with a focus on sustainability goals?

Recent research piloted evaluation metrics for high performance green building project delivery and verified data collection tool and analysis methods to improve the understanding of high performance green buildings (Korkmaz 2007). The current effort employs and expands

upon Korkmaz's (2007) data collection tools and analysis methods through a well-conceived case study protocol to respond to the research question.

RESEARCH GOALS AND OBJECTIVES

The main goal of this portion of the research is to “determine the extent of the effect of project delivery methods and practices on the level of integration achieved in projects and further their effects on project outcomes with a focus on sustainability goals.” The specific objectives of this study are:

1. Determine the relationship between the level of project team integration in the delivery process and the achievement of sustainability goals;
2. Determine the relationship between various project delivery methods (PDMs) and the levels of integration achieved in the design process, and
3. Identify the main project delivery attributes that have relationships with green building project outcomes and examine the identified patterns according to various PDMs.

SUSTAINABLE, HIGH PERFORMANCE BUILDING PROJECT DELIVERY METRICS

This section presents the evaluation metrics, based on previous research, for sustainable, high performance building delivery being used in this study (Korkmaz et al. 2010, El Wardani et al. 2006, Gransberg and Buitrago 2002, Konchar and Sanvido 1998). A building's project timeline consists of: (1) project delivery; (2) project performance upon the completion of construction; and (3) building's actual performance in the post-occupancy stage. This study primarily focuses on the first two stages by investigating the effects of project delivery attributes (independent variables) on project performance at construction completion (dependent variables).

Project Delivery Attributes

This section summarizes the variables for analysis in this study. These variables, adopted from Korkmaz (2007), allow for comparison of the results with previous studies. The variables include:

- Owner commitment;
- Project delivery methods;
- Project team procurement;
- Contractual provisions;
- Level of integration in the design process; and
- Project team characteristics.

Owner Commitment

This study defines owner commitment as the level of an owner's dedication to sustainable, high-performance features and predetermined goals in a building project. This is inclusive of criteria such as introducing “green” features to the project, reasoning for pursuing “green” objectives, timing for introducing the “green” concept in the process, supporting the importance of the “green” goals for the project, and the representative to be assigned to a project and their demonstration of commitment through all phases.

The owners or the clients are the most important and powerful players in the construction industry. According to Carr (2000), owners accrue such status as they create construction jobs, by engaging in construction projects (Gugel and Russell 1994, Carr 2000). Being the primary

consumers of construction services and dispenser of project finances, they are often in pivotal positions in the project (Huang 2003). Traditionally, they control design, construction, contract documents, and selection of the project team. However, this control has shifted due to different project delivery systems adopted by the industry. Although, for obvious reasons, the owner maintains control of the design's intent and to a large extent the design itself, owners can now choose levels of risk and control to exercise control over the project (Col Debella 2004). Modification of contractual arrangements can facilitate shifting of risks and management control to other participants, such as construction manager, constructor, and/or design-build entity.

Project delivery attributes in this study include: owner commitment; project delivery method; procurement; contractual provisions; integration in the design process; and project team characteristics.

Typically an owner's responsibilities include determining the project's objective, focus, budget, schedule, and operating requirements. They communicate these items to team members through procurement and contractual documents. The choice of contractual arrangements determines the lines of communication between the team members (Huang 2003, Bubshait and Al-Musaid 1992). The owners' choice of contractual arrangements significantly influences the end product. According to Enache-Pommer and Horman (2009), increased owner commitment leads to better project planning, and consequently leads to improved cost and schedule performance.

Project Delivery Method

Project delivery systems define major project participants' official involvement in the project, the level of integration, and contractual relationships between project parties (Oyetunji et al. 2001, Al Khalil 2002, Ibbs et al. 2003, AIA-AGC 2004). Three types of project delivery systems have wide use in the US: DBB; DB; and CMR.

DBB is a traditional process in the US construction industry, where the owner contracts separately with a designer and a constructor. The owner normally contracts with a design company to complete design documents. He/she then solicits fixed price bids from constructors to perform the work. One constructor is usually selected and enters into an agreement with the owner to construct a facility in accordance with the plans and specifications.

DB, on the other hand, is a single agreement between an owner and a single entity to perform both design and construction under a single design build contract. Portions or all of the design and construction may be performed by the entity or subcontracted to other companies.

Lastly, under CMR, the owner contracts with a design company to provide a facility design. The owner separately selects a constructor to perform construction management services and construction work in accordance with the plans and specifications for a fee. The contractor usually has significant input in the design process and generally guarantees the maximum construction price.

Enache-Pommer and Horman (2009) suggested that integrating the sustainable project's objectives with other delivery aspects during programming of design and construction eventually results in reducing delays, costs, and rework on the project.

Project Team Procurement

The procurement method can strongly affect the relationship between different project participants and the chemistry that they share with each other. Procurement systems range from

sole source selection to price only competition, and various types of best-value procurement systems in between. Each method stresses different qualities; therefore, the owner must select a particular system according to the project goals and requirements (Gransberg and Senadheera 1999, Molenaar and Gransberg 2001, Molenaar et al. 1999, El Wardani et al. 2006).

Contractual Provisions

This variable includes evaluation of contractual terms of the project: the importance of “green” in the contract; contractual relations between important team member; incentive/penalty clauses within the contract; established criteria for communication; such as timing; milestones; level of completed work; and established criteria for the shift of liability for safety; productivity; risk; and quality (Korkmaz 2007, Ibbs et al. 2003, Gransberg and Molenaar 2004).

Building performance metrics in this study include: schedule; cost; levels of sustainability and high performance; quality; and owner’s post occupancy evaluation.

Level of Integration in the Design Process

Integration in the design process suggests attributes such as early collaboration of the project’s participants, methods and timing of communication, and chemistry among participants, for optimized results (USGBC 2009). Integration at this point does not necessarily mean that all the participants should enter into the project at the same time. Rather integration proposes that all the participants become involved in the project at the “correct” time (Bubshait and Al-Musaid 1992, Drexler and Larson 2000). Chemistry among participants has potential to affect integration through working comfort/discomfort arising from participants’ past experiences of working with each other and on the type of facility in question (OGC 2005, Pocock et al. 1997).

As another indicator, Enache-Pommer and Horman (2009) suggested that energy modeling helps to optimize the building’s design and allows the design team to prioritize investments in strategies that will have the greatest effect on the building’s energy use. Achieving energy modeling not only requires technical effort but also input from various team members, thereby reflecting multidisciplinary integration during the design phase.

The evaluation of this metric also includes the timing and method of communication, facilitation of design charrette, the level of owner involvement in the project, chemistry among participants, ease of communication among participants, and techniques for energy modeling.

Project Team Characteristics

Project teams consist of individuals having very unique and diverse characteristics. The purpose of this metric is to evaluate the level of compatibility among project team members by measuring communication and chemistry among project team members (Korkmaz 2007, Chan et al. 2002). This metric also includes team members’ experiences with similar projects and the owner’s capabilities for understanding the project team’s competencies.

Project Performance at Construction Completion

A variety of available metrics can measure project performance at construction completion. The metrics chosen for the current study include: schedule, cost, quality, construction safety, levels of high-performance and sustainability (including achievement of goals as they relate to the level of

LEED® certification), and owner’s perception of the building’s actual performance. The measurement approaches and techniques for each described metric appear in Table 1.

Table 1: Study’s Metrics

INDEPENDENT VARIABLES	DESCRIPTION	CONTROL VARIABLES
OWNER COMMITMENT	<ul style="list-style-type: none"> • Party to introduce “green” features to the project; • Reason to pursue “green” objectives; • Timing of introducing the “green” concept; • Importance of the “green” goals for the project; • Mandating green metric (contractually or verbally); 	<ul style="list-style-type: none"> • Building Size • Location • Project Complexity • Regulatory or Legal Constraints
DEPENDENT VARIABLES		
PROJECT DELIVERY METHOD	<ul style="list-style-type: none"> • Design-Bid-Build (DBB); • Design-Build (DB); • Construction Management at Risk (CMR). 	<ul style="list-style-type: none"> • Schedule <ul style="list-style-type: none"> - Schedule Growth • Cost <ul style="list-style-type: none"> - Cost Growth
PROJECT TEAM PROCUREMENT	<ul style="list-style-type: none"> • Negotiated v/s competitive selection process; • Ability to pre-qualify participants; • Sole source selection, qualification based selection, best value source selection, fixed budget/ best design, low bid. 	<ul style="list-style-type: none"> • Quality <ul style="list-style-type: none"> - Facility start up - Call backs • Construction Safety <ul style="list-style-type: none"> - OSHA- RIR - DART Rate - LTC - LWD
CONTRACTUAL PROVISIONS	<ul style="list-style-type: none"> • The party to hold contract for project’s green features; • Contractual relations between important team members; • Incentive/ penalty clauses within the contract; • Onerous contract clauses. 	<ul style="list-style-type: none"> • Building Actual Performance (Owner Perception): <ul style="list-style-type: none"> - Water Consumption - Energy Consumption - Occupant Turnover Rate - Absenteeism - General Satisfaction - Acoustic Quality - Ventilation - Controllability - Lighting - Thermal Comfort
INTEGRATION IN THE DESIGN PROCESS	<ul style="list-style-type: none"> • Timing of contracting; • Methods and timing of communication; • Presence of a LEED® AP and contractual position; • Design charrettes; • Project team characteristics such as level of communication and compatibility among team members. 	<ul style="list-style-type: none"> - Absenteeism - General Satisfaction - Acoustic Quality - Ventilation - Controllability - Lighting - Thermal Comfort
PROJECT TEAM CHARACTERISTICS	<ul style="list-style-type: none"> • Teams prior experience as a unit; • Team members’ experience in similar projects; • Owner’s representatives’ capabilities; • Owner’s ability to define scope; • Owner’s ability to make decisions; • Evaluation of the level of compatibility by measuring communication and chemistry among project team members; • Site teams’ level of knowledge in LEED®. 	<ul style="list-style-type: none"> • Levels of Sustainable High Performance <ul style="list-style-type: none"> - Levels of Green - Levels of High Performance - Intended vs. Achieved Certification

Schedule

The potential measure to evaluate schedule performance for this study is schedule growth (Konchar and Sanvido 1998). The measure has either positive or negative expression in which positive represents a condition “bad” for the project and negative expression represents a “good” condition. Although schedule growth is useful in showing a snapshot of the project, its ambiguous nature induces a lack of clarity since it does not explain the reasons behind the change in project schedules; neither does it assign responsibility for the change (Gransberg and Buitrago 2002). Therefore, a numerical schedule growth measure that only accounts for “planned and as built schedules” is not a very reliable metric. As a remedy to this ambiguity in the schedule growth metric, construction and design time growth need to be separated, so that the responsibility for delays can be understood exactly. Also, different project delivery methods (e.g., DBB, DB) allow either sequential or overlapping conduct of design and construction phases. Therefore, comparative analysis of schedule growth values in a pool of projects with various project delivery methods becomes even more challenging. For a comprehensive evaluation of the schedule growth metric, this study not only recorded the planned and actual project schedules but also examined all project parties’ views (especially the owner’s) of the schedule growth in terms of meeting the expected milestones and the reasons behind positive or negative growth if there is any (e.g., weather related problems, permit issues, project team errors, and scope changes directed by the owner).

Cost

Cost defines the magnitude of the investment made by a facility’s owner or developer. These costs entail design and construction of a building and exclude property costs, owner costs of installed process or manufacturing equipment, furnishings, fittings and equipment, or items not included in the cost of the building (Konchar and Sanvido 1998). Similar to schedule growth, cost growth also presents ambiguous results and for more lucid results construction and design cost growth need to be disassociated. However, depending upon different project delivery methods, the segregation of construction and design costs might not be possible. Therefore, in addition to collecting budgeted and actual cost information, this study also adopts a technique to take project participants’ evaluations (especially the owner’s) into account for a cost growth metric.

Quality

Quality perception, being a relative metric, significantly differs for each team member. Being on the receiving end of the project, quality assumes relevance from the owner’s perspective. The quality metric for the pre-occupancy stage includes: 1) turnover quality combining the difficulty of facility start up, number and magnitude of call backs during the turnover process, the difficulty of the submittal review process (Konchar and Sanvido 1998), and the difficulty of LEED® documents’ submission process; and 2) value of the cost and schedule growth for the project owner. Cost and schedule growth, if positive, can have a negative impact on the owner’s perception of quality. However, if the growth is due to owner-related scope changes, owners may remain satisfied with the results (Naoum 1994, Korkmaz 2007). Therefore, owners’ satisfaction with the cost and schedule growth is also an important evaluation to determine for the owner’s perception of the project’s quality.

Construction Safety

During design and construction at the site, management determines the level of safety a policy. Project delivery methods shift the safety liability to different players. This shifting of liability has

major effects on the safety. For example, according to Toole (2002), under the traditional DBB arrangement, subcontractors have a high level of ability to influence root causes of accidents; general contractors have a moderate ability, A/Es have a mixed ability, and owners have a low ability to influence safety. Due to added complexities involved in sustainable building construction such as waste management and sorting of materials for recycling purposes, safety conditions might be adversely affected. Safety metrics and open-ended questions were added to the survey to understand if such effects exist.

Levels of High-performance and Sustainability

Green building assessment systems address critical guidelines to enable high-performance buildings. Among these assessment systems, LEED[®] (USGBC 2010) has received the most recognition in the US green building community. Therefore, this research utilizes the LEED[®] energy and indoor environmental quality (IEQ) and overall sustainability criteria to assess high-performance and sustainability levels of projects. More specifically, the variables used for this metric are: energy performance, indoor environment quality performance, level of sustainability, and achieved certification versus intended certification.

Owner's Perception of Resource Consumption and Level of User Satisfaction in the Post-Occupancy Phase:

Since collecting first-hand data was beyond the scope of this study, owner/facility managers responded to a request to rate the level of their satisfaction on a Likert scale for these metrics:

- a. *Energy:* Energy consumption and reduction is the most important building utility affecting building performance. It is typically responsible for the highest building operating costs and has an environmental impact, influenced by the energy sources used (Fowler et al. 2005). Energy consumption involves heating, cooling, lighting, ventilation, and equipment (e.g., elevators, security systems, etc.).
- b. *Water:* Potable water consumption is the second most important building utility representing cost and resource use (Fowler et al. 2005). The evaluation of this metrics is similar to that for energy consumption.
- c. *User satisfaction with the facility:* Post-occupancy evaluation and user satisfaction with buildings during their use are metrics that have recently gained attention in the literature. This study evaluates, with a Likert scale, the owner's early perception of the building according to the post-occupancy metrics. The variables used in the data collection tool for this metric appear in Table 1.

RESEARCH APPROACH

This research uses a case study protocol to achieve the study's goals. This section summarizes the data collection procedure including the adopted performance evaluation metrics, methods to test and verify the data collection tool, case study selection criteria, and the data collection process.

Case Study Selection Criteria

The study focuses on sustainable building case study projects with outlined selection criteria:

1. *US Green Building Council's (USGBC) LEED[®] Rating:* USGBC's LEED[®] is the one most popular green building assessment systems in the country. Currently 35,000 projects are participating in this system, comprising over 4.5 billion square feet of construction space in

all 50 states and 91 countries (USGBC 2010); therefore, the system reflects an apt database for project selection.

Project selection for this study spanned all the ratings of USGBC’s LEED® certification (i.e., platinum, gold, silver, and certified). Kats (2003) reported the costs and financial benefits of green buildings and reported distinct differences among benefits of the four-certification levels. According to Kats (2003) although certified and silver buildings provide cost benefits in terms of energy and water consumption, gold and platinum buildings’ benefits are greater because they represent benefits for productivity and occupants’ health, which are far more significant than the costs of buildings and energy. Similar results appeared in another report: “Building Better Buildings,” prepared by the Sustainable Building Task Force and the State and Consumer Services Agency (SBTF 2003). The report suggested higher benefits from gold and platinum rated buildings than those gaining certification or a silver rating. Hence, a reasonable conclusion is that certified and silver projects can be achieved by standard practices; however gold and platinum projects require more optimization. Therefore, the study prioritized selection of case studies from both ends of the LEED® rating scale.

2. *Project delivery methods:* The case study must be delivered according to one of the three PDM’s: DBB, DB, or CMR. Efforts attempted to include an equal number of PDMs within the study’s sample to eliminate bias towards any one method. Final distribution of the cases, complying with these two primary case study selection criteria, appears in Table 2.

Table 2: Distribution of study cases according to LEED® rating and delivery method

	Platinum	Gold	Silver	Certified
DB	2	2	1	0
DBB	1	0	1	1
CMR	1	0	1	2

3. *LEED® Certification System/Construction Type:* This study focuses on projects certified under LEED® New Construction and Core and Shell certification systems for the selection of mainly new construction projects.
4. *Location:* Certain regions, cities, and states in the US are recognized as supporting the sustainability movement with enabling legislation. Location can affect project outcomes by the available pool of contractors/designers in an area. Therefore, variation in location in the sample was a preference to eliminate any city, region, or state biases in the results.
5. *Function:* Only office spaces were selected for analysis to eliminate functional and major construction systems/materials differences. Minimizing combinations with other functions was a selection criterion.

Data Collection, Coding, and Analysis

This study adopts the performance metrics defined and data collection tool developed by Korkmaz (2007). The survey has its basis in one developed in the previous research of Konchar and Sanvido (1998) and El Wardani et al. (2006). Industry professionals twice verified the survey instrument. It was then tested against 40 green building projects. The study followed the General Accounting Office (GAO 1991) methodology for structured interviews. The data collection tool was pilot tested prior to case study data collection.

Data collection occurred via telephone and e-mail. Three primary respondents (i.e., owner, designer, and constructor) provided input for each case study. Data collection questions' segregation depended upon the particular respondent. On average, each interview spanned approximately 40-50 minutes. Data was collected through voice recordings and completed survey questionnaires. To facilitate analysis, this data was processed through:

1. Inputting survey data in Excel® spreadsheets;
2. Transcribing open ended responses using Transana 2.12®;
3. Categorizing open-ended responses using ATLAS.ti®; and
4. Eliminating discrepancies within responses for the same projects.

Table 3 shows the final coding parameters for all variables used in this study. The safety metric was eliminated at the coding phase due to low response rate. Coding the categorized data followed the logic sequence.

Owner's Commitment: The patterns arising within the data and from the literature review provided the framework for coding this metric. Of all the parameters used to evaluate owner commitment, the primary issues for project success were: 1) the reason to pursue green, and 2) the timing of incorporating green.

Level of design integration achieved by projects: Responses to most parameters under this metric were common among the project participants. For example, timing of communication was consistently a weekly occurrence; every project except one had a designated green design coordinator, conducted collaboration sessions, and educated subcontractors for the LEED® submittal process. However, discrepancies arose mainly within three parameters: timing of contractor involvement, communication methods, and quantitative performance metrics used to measure the sustainable performance of the building. Timing of constructor's involvement, which showed the highest variation among responses, became the primary metric to identify the level of integration achieved by projects in the design process.

Levels of Sustainable High Performance: Evaluation of this metric used three parameters: level of green, level of high performance, and intended vs. achieved certification. Coding of intended vs. achieved, projects reaching achievement above the intended target, were on target, or were below target received codes of +1, 0, and, -1, respectively. Level of high performance evaluation is the result of combining achieved IEQ and energy scores in the LEED® checklist since by definition high performance buildings are energy efficient and facilitate healthy indoor environments (DOE 2009). According to Korkmaz (2007), energy and IEQ sections reflected that some of the criteria in these sections might conflict with each other. However, the results of a regression analysis conducted in the same study demonstrated a positive relationship between these two sections with a 13.4% variance.

To render energy and indoor environmental quality scores comparable for different versions of LEED®, this study converted the scores to achieved/available percentages. Once listed, the detected median in the data received a code of zero; points above and below the median range received a code of +1 or -1, respectively. The median was determined to have a range of 10 based on the difference between the project scores. 10 was determined to be an optimum range as the study had a small pool of projects to have a range of five or over 10. It was observed that if a range of 5 was taken then most projects became outliers, which was not true

Table 3: Data Coding for all Variables

METRIC	CODING PARAMETER	CODING
INDEPENDENT VARIABLES		
Owner's Commitment	Vision statement	High Commitment
	Certification and/or Grants and Schematic/Conceptual	Medium Commitment
	Certification & grants and design development	Low Commitment
Project Delivery Method	Design-Bid-Build	Design-Bid-Build
	Design-Build	Design-Build
	Construction management at risk	Construction management at risk
Project Team Procurement	Sole source selection, best value source selection, competition, negotiation, low bid, fixed budget/best design, qualification based selection.	Sole source selection, best value source selection, competition, negotiation, low bid, fixed budget/best design, qualification based selection.
Contract Conditions	Contractual relations between important team members	Contractual relations between important team members
Integration in the Design Process	Timing of constructor entry: Pre-design, Conceptual	High integration
	Schematic or design development	Medium integration
	Construction documents and bidding	Low integration
DEPENDENT VARIABLES		
Intended vs. Achieved Certification	Below target	-1
	On target	0
	Above target	+1
Level of High Performance	Less than 55	-1
	55-65	0
	More than 65	+1
Level of Green	Less than 50	-1
	50-70	0
	More than 70	+1
Post Occupancy	Below 39	-1
	39	0
	Above 39	+1
Quality	Below 26	-1
	26	0
	Above 26	+1
Cost Growth	High growth	-1
	On target	0
	Under budget	+1
Schedule Growth	High growth	-1
	On target	0
	Under schedule	+1

when the entire project population was considered. Also a range of over 10 included most projects within the medium range, which was also not entirely representative for the population either. A similar process provided codes for the level of green except this parameter's calculation considers a sum of the project's total points in LEED®.

Building Actual Performance and Quality: To evaluate this metric, owners, responded to Likert-type scale questions. A listed entry reflects the sum of the resultant scores for each metric. Similar to the previous metric, a detected median received a coded 0; values above and below the median received a +1 or -1 code, respectively.

Cost and Schedule Performance: As many respondents were uncomfortable sharing, or did not have access to exact cost figures and schedules from their projects, the coding for these metrics reflected the perceptions of the respondents. If the respondents, especially the owner, suggested that the project had a significant cost or schedule expansion, the project received a code of -1. If perception was of an on-target project, the code was 0. A value of +1 was used if the project finished under the target cost or faster than that planned schedule.

Next, data analysis methods are explained.

Proposition Development: Proposition testing was followed for data analysis, due to the qualitative nature of the collected data. Study propositions represented *expected patterns*, based on the literature. This research followed a spiral analysis format, i.e., a proposition was developed/observed, next analysis was conducted focusing on the concerned variables, further if the analysis supported the proposition then it was converted to a result; otherwise it was discarded and another proposition was tested. Three adopted methods tested the propositions: Pattern matching, cross case synthesis, and explanation building (Yin 2003). The details of these are:

Pattern Matching: This refers to emergence of patterns within similar attributes in different projects. It demonstrates the existence of a pattern in projects of similar types and assists in explaining a recurring phenomenon.

Cross Case Synthesis: In this approach, projects showing great final outcomes (e.g., platinum LEED® certification, low or no cost growth, on schedule, high quality) were compared to projects that displayed the lowest performance across the outcome metrics. This method assisted in distinctly illustrating the differences in a project's delivery attributes, which may have led to those different outcomes.

Explanation Building: Within the pattern matching results, a number of outlier projects were apparent. Outliers were projects that displayed different results than expected. An individual analysis of the outlying projects' specific characteristics attempted to explain the reasons for a lack of conformity.

CASE STUDY PROJECTS

The study's dataset included a representative mix of project delivery methods. The majority of projects was private enterprises and ranged between 7,000 and 186,000 square feet in size. At least two respondents from each project participated in the data collection process. Table 4 illustrates the characteristics of the case studies for this research.

Table 4: Study Population Characteristics

Project Codes	State	Type	PDM	Certification	Size (Sqft)	Responses	Respondents
A1	New York	Confidential	DBB	Certified	25,000	3	O, D, and C
A2	Texas	Private	CMR	Certified	7000	2	O/D and C
A3	Colorado	Private	CMR	Certified	89,200	3	O, D, and C
B1	Colorado	Private	DBB	Silver	60,000	3	O, D, and C
B2	Colorado	Private	CMR	Silver	7,700	3	O, D, and C
B3	Alabama	Private	DB	Silver	12,900	2	O/C and D
C1	Ohio	Private	DB	Gold	14,077	2	O/C and D
C2	Pennsylvania	Developer	DB	Gold	35,000	3	O, D, and C
D1	Colorado	Private	DB	Platinum	186,000	1	O/D/C
D2	Arkansas	Private	CMR	Platinum	94,000	3	O, D, and C
D3	California	Private	DB	Platinum	66,000	2	O and D
D4	Missouri	Public	DBB	Platinum	120,000	3	O, D, and C

* O= Owner, D= Designer, C= Constructor

Note: '/' sign between respondent abbreviations indicates that the two entities are same.

FINDINGS OF THE CASE STUDY PROTOCOL

Overview

The main goals of this study are to: Determine the extent to which project delivery methods and practices affect levels of integration in projects and whether or not this integration has an effect on project outcomes, especially for achieving sustainability goals. To achieve these goals, this study developed four main propositions:

1. Higher levels of integration in the design process will lead to higher levels of sustainability;
2. CMR and DB will provide higher levels of integration in the design process compared to DBB;
3. Project delivery attributes affect final project outcomes; and
4. PDMs affect project outcomes through the level of integration in the project delivery process.

Testing these propositions occurred using pattern matching. Additional insight into project delivery of sustainable, high performance buildings arose from analysis of outlier projects during proposition testing and comparison of good and exceptional projects through cross-case synthesis. This section discusses the findings of the case study protocol based on: (1) the given propositions, (2) study of outlier projects through explanation building, (3) comparative analysis of good and exceptional projects, and (4) additional lessons learned. Notably important is that Project B3, due to lack of survey response, was eliminated from all the tables, except Table 5 for which data was available.

Design Process Integration and Sustainability

Proposition 1 - Higher levels of integration in the design process will lead to higher levels of sustainability: To test this proposition, assessment of the patterns within the case studies followed the protocol in Table 5. The table lists the projects' sustainability outcomes according to the level of integration achieved in their design processes. The specific patterns seen within the table are:

- Projects achieving a high level of integration also scored high on the sustainability outcomes;
- A higher level of integration appeared within projects that achieved gold and platinum certifications under the USGBC's LEED® assessment system;
- The probability of exceeding the intended certification target was higher in projects with higher levels of integration.

Overall, Table 5 shows that projects with a high level of integration have a greater chance of success in the sustainability metric, while projects achieving medium or low integration may or may not be successful. This indicates that integration in the design process is a very important attribute that can potentially influence the level of sustainability achieved by a project. The case studies demonstrated that sustainable strategies increase complexity within projects and therefore, require increased interdisciplinary interaction to develop optimized solutions.

Table 5: Level of Integration Achieved and Sustainability Outcome

Projects	Intended vs. Achieved LEED®	Level of Green	High performance (IEQ + ENERGY)
D1*	+1	+1	+1
C2*	+1	+1	+1
C1	+1	0	+1
D3	0	+1	+1
B3	+1	-1	-1
D2**	+1	+1	+1
A3	0	-1	-1
B2	0	-1	-1
B1	0	-1	-1
A2	-1	-1	-1
D4**	+1	+1	+1
A1	0	-1	-1

* Exemplary Projects
 ** Outliers

High Integration
 Medium Integration
 Low Integration

Structured interviews consistently showed that under integration, early involvement of participants was a significant metric. It facilitated timely inclusion of suggestions from all participants, thereby, resulting in adoption of more efficient alternatives. Apart from timing,

other themes recurred in the dataset, such as communication and collaboration among participants. First, a pattern emerged that suggested all high and the two medium integrated projects used more than one method of communication; i.e., apart from e-mail, fax and phone, project management software (scheduling and estimation), and/or online databases and/or building information modeling (BIM) were also used. These methods increased efficiency and reduced conflicts in the transfer of information. Second, a conscious effort made certain that all the participants focused toward the same goals. One owner reported:

“ . . . we spend a lot of time in the programming of the building, being very clear about what our goals and objectives are, writing those down in clear and concise terms so that we can communicate to everyone. And that is probably the most important step because it gives us something to go back to check ourselves, if we tend to wander. It also allows us to identify when we are done with a certain step, have we accomplished it consistently.”

This focused the thought process of all the participants and assisted them in working toward a common goal. Conversely, another project that did not have an aligned team did not perform as well. The owner reported that participants could not exceed the intended certification target because the general contractor (GC) was not committed to the project.

Project Delivery Methods and Design Process Integration

Proposition 2 - CMR and DB will provide higher levels of integration in the design process compared to DBB: To test this proposition, the projects in the study received a ranking according to the level of integration achieved in their design processes. Table 6 lists their respective project delivery methods.

The trends seen within this data are:

- CMR and DB project delivery methods facilitated higher levels of integration;
- In general, DBB provided a low level of integration within the project design process;
- Medium level of integration could be an outcome from any of the three delivery methods including in DBB through informal involvement of the constructor prior to construction documents phase, and
- Although cost growth appeared from every project delivery method, projects executed with traditional DBB displayed a trend in cost growth.

The collected data suggests that DB and CMR facilitate constructor's involvement early on in the design process and lead to higher integration and better results in LEED® projects. The one criterion that could result in lower performance was the owner's requirement for the “*lowest price*,” thus choice for DBB or low-bid procurement. The designer for project A1 suggested:

“ . . . well, especially with a LEED® building it would have been far preferable to have the builder on the team prior to it going out to bid. I think a lot of the bidders were [bidding] their first LEED® project so they really didn't know what they were getting themselves into. I'm not sure if the general contractor really understood [the LEED® process] so DBB did not benefit in any way other than getting a **fixed price and presumably a low price**”(emphasis added).

Table 6: PDM's and the Design Process Integration

PDM	Projects	High Performance Green	Intended vs. Achieved.	Cost	Schedule	Post-occupancy	Quality	Total
DB	D1*	+1	+1	0	0	+1	+1	4
DB	C1*	+1	+1	0	0	+1	0	3
DB	C2*	+1	+1	0	0	0	+1	3
DB	D3	+1	0	-1	0	0	0	0
CMR	D2	+1	+1	-1	-1	0	+1	1
CMR	A2	-1	-1	0	0	+1	0	-1
CMR	A3	-1	0	0	0	+1	-1	-1
CMR	B2**	-1	0	-1	0	-1	-1	-4
DBB	B1	-1	0	0	0	0	0	-1
DBB	D4**	+1	+1	-1	0	-1	0	0
DBB	A1	-1	0	-1	0	0	0	-2

* Exemplary Projects
 ** Outliers

High Integration
Medium Integration
Low Integration

Note: Project B3 is eliminated due to lack of survey response.

This project performed at a low level, not only with the sustainability metric but also with the combined project success metric. The responses from the participants suggested that the poor performance was mainly because the contractor only became involved at the bidding phase. The contractor suggested that earlier involvement would have facilitated constructability reviews. The contractor reported:

“ . . . if any team can facilitate the design constructability from a builder or someone from a building background earlier in the phase other than the bidding and once it’s awarded will streamline and effectively smoothen out the project delivery and construction of the job.”

The contractor of another DBB project suggested:

“ . . . It would have been better to have been involved earlier. In terms of a better way to do it... I think in design-build, the contractor is on board ahead of time or you can have input in being involved in LEED® decisions. **And looking at the cost impact of the items is tremendous benefit over the DBB process**” (emphasis added).

It should be noted that the three DB projects (D1, C1 and C2) had somewhat different organizational structures, but all projects are considered to be DB. For example, the owner functioned as the designer or constructor in some instances rather than having a separate design-builder. All of these structures facilitate a form of DB delivery, thereby, increasing communication, expediting the decision process, and consequently resulting in higher levels integration achieved by the project.

Project Delivery Attributes and Final Outcomes

Proposition 3 - Project delivery attributes affect final project outcomes: Testing of this proposition was the result of evaluating various combinations of independent and dependent variables. More specifically, case studies, grouped according to various stages of the selected independent variable (e.g., the level of integration achieved in a project can be high, medium, or low as a project delivery attribute) allowed for the calculation of dependent variables, by summing and normalizing the overall project outcome scores which are a combination of all outcome metrics (i.e., level of sustainability, high performance, quality, cost, schedule, and post occupancy). The magnitude of the scores' differences among the determined levels of independent variables shows the strength of that particular project delivery attribute in potentially influencing the final project outcomes. The findings of this testing procedure, listed according to their strengths, are classified into four categories: 1) integration in the delivery process; 2) contractual terms; 3) contractual conditions; and 3) owner commitment. The concept, "strength," represents the differences between the normalized total scores of the categories.

Integration in the delivery process

The results in this section rely on the data in Table 7. This table is a two-level sort: (i) according to the level of integration of the projects; and (ii) within each level of integration, in descending order of the total scores achieved by the projects.

Table 7: Integration in the Delivery Process

PDM	Projects	High Performance Green	Intended vs. Achieved	Cost	Schedule	Post-occupancy	Quality	Total
DB	D1*	1	1	0	0	1	1	4
DB	C1	1	1	0	0	1	0	3
DB	C2	1	1	0	0	0	1	3
DB	D3	1	0	-1	0	0	0	0
CMR	D2	1	1	-1	-1	0	1	1
CMR	A2	-1	-1	0	0	1	0	-1
CMR	A3	-1	0	0	0	1	-1	-1
CMR	B2 **	-1	0	-1	0	-1	-1	-4
DBB	B1	-1	0	0	0	0	0	-1
DBB	D4**	1	1	-1	0	-1	0	0
DBB	A1	-1	0	-1	0	0	0	-2

* Exemplary Projects ** Outliers	High Integration	Total Score	10	Normal-ized Score	2.5
	Medium Integration		-6		1.2
	Low Integration		-2		-1

Note: Project B3 is eliminated due to lack of survey response.

The following patterns appeared:

- Projects with a high level of integration displayed better performance;

- The constructor should be on board by the design development phase (contractually or informally) for successful outcomes; and
- Cost growth was mainly apparent in projects with low or medium integration.

Within the exemplary projects, strong emphasis was attributable to team collaboration and participants' focus on common goals. The open ended responses emphasized that the success of projects depended on the, "*degree to which the team is aligned around the purpose*" (emphasis added). The owner of project B2 reported:

"... I really wasn't happy because the subcontractors in my opinion were not really committed to it as much as the owners were and so **they didn't work with us** to try and develop solutions that would enable us **to keep a reasonable cost** on the building and so perform adequately" (emphasis added).

The owner also reported:

"... my initial goal would have been gold but the project costs drove us to silver and we barely made silver, and I had to appeal one of the points to get to silver. **It was a failure of the GC that I think significantly affected us**" (emphasis added).

This expressed attitude shows that commitment from the GC is a significant factor in influencing project success. Compared to other participants, apparently, contractors were most insistent on joining the project early and involving themselves in the design process. They advocated that the result would be better performance for the success metric. Supporting the results, a contractor stated:

"... in our opinion the sooner you bring on the GC the better the project goes, so that you get the team work aspect of it. But at the point that we were brought in the project, we offered a lot to the team. We provided a lot of estimating services, so I think it had a lot of positive effect over all. It would have a more positive effect if they would have brought us in at the very beginning."

Contractual Terms

Table 8 shows the contractual term patterns. Here, the owner's commitment is tested according to the contractual terms followed, and finally, according to the total score achieved by projects, measured against dependent variables (i.e., final project outcomes). The contractual terms seen here are: cost-plus-fee (Cost); lump sum (Lump); and guaranteed maximum price (GMP). Table 8 also shows normalized scores of projects according to the three levels of owner commitment. Note that the rankings are displayed according to the total project outcome scores. The following patterns appear in the analysis table:

- Projects displaying better outcomes and higher certification mostly adopted the cost-plus-fee contractual terms;
- The lump sum contractual term was more common in projects with low certification and lower owner commitment; and
- Cost-plus-fee terms are more common in projects with high owner commitment.

Although, the survey data shows trends that, in some instances where the contractual terms were cost-plus-fee, projects outperformed others according to the success metrics. Positive and negative arguments for each type of contractual term arose in the open-ended responses.

Table 8: Owner’s Commitment and Contractual Terms

PDM	Projects	Contractual Terms			Total
		Designer	Contractor	D-B	
DB	D1	----	----	COST	4
DB	C2	----	----	COST	3
DB	C1	----	----	COST	3
CMR	D2	COST	COST	----	1
DB	D3	----	----	LUMP	0
DBB	D4	COST	LUMP	----	-1
DBB	B1	LUMP	LUMP	----	-1
CMR	A3	LUMP	GMP	----	-1
CMR	A2	----	LUMP	----	-1
DBB	A1	LUMP	LUMP	----	-2
CMR	B2	LUMP	GMP	----	-4

High Owner Commitment	Total Score	9	Normalized Score	2.25
Medium Owner Commitment		-6		-1
Low Owner Commitment		-2		-2

Note: Project B3 is eliminated due to lack of survey response.

For example, an owner suggested:

“ . . . GMP and lump sum are simply not as good. They are old school, old thinking, and they do not allow the embracing of innovation and new technologies.”

The owner suggested that both GMP and lump sum tend to make the stakeholders focus more on protecting their own interests. However, cost-plus-fee terms remove this contention and assist the participants’ adoption of a common direction. In contrast, one contractor stated:

“ . . . Actually a lump sum made it clear and definitive on whose responsibilities the financial and cost fell in. When you get into a GMP then you get owners who feel that you present them with a change and the change should be incorporated in the GMP and that you should have picked it up in the GMP. Cost-plus-fee is the same way, where on the lump sum you issue it and it’s either shown in your contract documents or not shown and is straight forward.”

Similarly, a designer stated:

“ . . . We prefer lump sum because it allows us to manage our risks. If we know what are paid up front, we can budget accordingly on occasions. GMP we don’t like because it works for the owner but it cannot work for us if the scope starts to deviate, scope creep for instance.”

However, the designer later reported that lump sum became a “big” problem because the owner refused to pay the additional fees that were incurred by including LEED® requirements. Finally the cost-plus-fee structure received significant criticism from one designer stated:

“ . . . cost-plus-fee for the most part implies a percentage of the construction cost. That, by far, is the absolute worse way to do it because, in my view, there are

perverse disincentives to achieving performance for all parties because if the idea is to try and reduce the size of systems they cost less and if, in fact, my fees are based on cost, I'm therefore not incentivized for efficiencies."

The designer further suggested that GMP/lump sum terms provided a fixed value reflecting a clearly defined scope. If following an integrative design process, then any upcoming contingencies could be adjusted and the project would not cost more.

Contractual Conditions

This section compared contractual relations among project participants with scores achieved according to sustainability and total final project outcome score. Table 9 presents the projects in descending order of their achieved total scores.

Table 9: Contractual Conditions

PDM	Projects	Contract Held By						Sustainability		Total
		Mech. Sub.	Elec. Sub.	LEED [®] AP	Energy Cnsl.	Lighting Cnsl.	Comm Ag.	HPG	Intended vs. Achieved	
DB	D1*	DB-O	DB-O	DB-O	DB-O	DB-O	DB-O	1	1	4
DB	C1**	DB-O	DB-O	D	D	D	DB-O	1	1	3
DB	C2	DB-O	DB-O	DB-O	DB-O	DB-O	DB-O	1	1	3
CMR	D2	C	C	O	D	D	O	1	1	1
DB	D3	DB	DB	DB	DB	DB	O	1	0	0
CMR	A2	C	C	D	----	----	----	-1	-1	-1
CMR	A3	C	C	D	----	----	D	-1	0	-1
DBB	B1	C	C	D	D	D	D	-1	0	-1
DBB	D4	C	C	D	D	D	O	1	0	-1
DBB	A1	C	C	D	D	D	O	-1	0	-2
CMR	B2**	C	C	O	O	O	O	-1	0	-4

* Exemplary Projects ** Outliers O= Owner C= Constructor D= Designer DB = Design-Builder	Mech. Sub: Mechanical Subcontractor Elec. Sub.: Electrical Subcontractor Energy Cnsl.: Energy Consultant Lighting Cnsl.: Lighting Consultant Comm Ag.: Commissioning Agent HPG: High Performance Green	High Integration
		Medium Integration
		Low Integration

Note: Project B3 is eliminated due to lack of survey response.

As mentioned earlier, the owner and the design-builder were the same entity (DB-O) in projects D1, C1 and C2. This distinction is important as it has affects on the results that are listed next.

The patterns observed in Table 9 are:

- Projects in which a green design coordinator/LEED[®] accredited professional (AP) was not privy to the contract with the owner or design-builder resulted in lower sustainability and success outcomes;

- Projects displayed better outcomes when all primary participants (including mechanical and electrical subcontractors, LEED® AP, commissioning agent, and energy and lighting consultants) contracted directly with the owner or design-builder; and
- When the LEED® AP contracted directly with the owner or the design-builder, the chances of exceeding the intended certification target increased.

The patterns observed in this section show that a whole system thinking approach established through contracts is essential in pursuing sustainability goals. In the industry, designers commonly take the lead for LEED® certification and include the contractor only for achieving specific points. In such cases, the chances of falling short of the intended levels of certification is higher in CMR and DBB arrangements since the contractor is not fully involved in the decisions made and not fully responsible for the achievement of the assigned points. In contrast, when a LEED® AP has a contract with the owner or the design-builder responsible for carrying the project to the intended levels of sustainability, the AP tends to manage all project parties for achieving the set sustainability goals through facilitating an integrated approach using LEED® guidelines.

Owner Commitment

Table 10 is the basis for the study’s results concerning owner commitment. Projects’ rankings are listed in descending order of total scores.

Table 10: Owner Commitment

PDM	Project	Primary Reason	Mandating Green	Timing of Green	Sustainability		Cost	Total
					HPG	Intended vs. Achieved		
DB	D1	VS	Contractually	Con.D.	1	1	0	4
DB	C1	VS	Verbally	Con.D.	1	1	0	3
DB	C2	VS	Contractually	Con.D.	1	1	0	3
CMR	D2	VS	Contractually	Sch.D.	1	1	-1	1
DB	D3	VS	Contractually	Sch.D.	1	0	-1	0
DBB	D4	VS	Contractually	Con.D.	1	0	-1	-1
CMR	A2	Learning Grounds, LEED®	Verbally	Sch. D.	-1	-1	0	-1
CMR	A3	LEED®	Contractually	Con.D.	-1	0	0	-1
DBB	B1	LEED®	Verbally	Con.D.	-1	0	0	-1
DBB	A1	Grants	Verbally	Design D.	-1	0	-1	-2
CMR	B2	VS	Verbally	Design D.	-1	0	-1	-4

*VS: Vision Statement
 Sch. D.: Schematic Design
 HPG: High Performance Green
 Con.D.: Conceptual Design
 Design D.: Design Development

High Commitment
Medium Commitment
Low Commitment

Note: Project B3 is eliminated due to lack of survey response.

Strong patterns were not apparent from the data for this category. However, certain relevant findings are worthy of discussion.

- High owner commitment increased the probability of exceeding the intended sustainability target as seen through the two outlier projects, D2 and D4.
- The green metric was generally a verbal mandate in low certification projects and generally a contractual mandate in higher certification projects. Contractual terms mainly included achievement of USGBC’s green certification; however terms did not necessarily include the level of certification to be achieved. Two outlier projects to this trend were A3 and C1.
- Projects achieving the high success metric and higher certifications had owner vision statements as the reason to pursue sustainability. Open ended answers suggested that, due to the complexity of the sustainability process, the owner should have an interest in the concept of green itself, instead of “chasing points” under the USGBC’s LEED® system.
- Including green in the design development or later phases of the project can result in cost growth and achieving lower certification.

Open-ended responses repeatedly reported that owner commitment was a significant attribute in influencing the success metric. The first suggestion was for inclusion of green earlier in the project. One designer stated:

“. . . clearly if the owner had embraced the concept prior to design and if the owner had made the decision to commit to LEED® earlier, I think it would have been a better building.”

Although not clearly stated, comparison of open-ended responses and projects’ performances in the success metric shows that the reason to pursue green was a strong indicator of owner commitment and in certain cases affected the level of sustainability achieved. The data shows that projects with a stronger commitment toward green itself, rather than the incentives that came with a sustainable building, performed better. One owner reported:

“. . . we did not want to use the green scorecard as a design directive, because then you start chasing points, and cost effectiveness of your design direction becomes quite a challenge, because you start spending money in pursuit of points.”

Another owner reported on a successful project: “... we used LEED® as a marketing tool and secondly we did it because it is the right thing to do.”

Project Delivery Methods, Design Process Integration and Final Outcomes

Proposition 4 - PDMs affect project outcomes through the level of integration in the project delivery process: Revisiting the overall project goal in the light of the tested study propositions, the conclusion is that project delivery methods do influence project outcomes through the level of integration in the project delivery process. More specifically, from the study’s data set:

- Projects adopting the DB method mostly ranged at the high end of successful outcomes. Most of these projects had high levels of integration in the delivery process, high owner commitment, and adopted cost plus fee payment arrangement.
- Projects adopting CMR demonstrated medium success in project performance. These projects had medium levels of integration in the delivery process and owner commitment. Additionally, they adopted either lump sum or GMP as the payment method.

- DBB displayed medium and low levels of integration and all three levels of owner commitment. The payment method was lump sum. The results ranged from medium to low.

Explanation Building for Outlier Projects

While conducting pattern matching, apparently, certain projects performed differently (better or worse) than expected. These were categorized as outliers. A discussion includes these projects to gain a more meaningful and deeper understanding of the other variables that have the potential to affect the success metrics.

Project D4

This project is an outlier since it displayed a low level of integration. However, its performance outcomes as evaluated by the study metrics were exceptional. The project was delivered by the traditional DBB method, which involved the contractor in the bidding phase. The contractor reported that due to their late involvement in the project, they were not privy to all the information. Although the project experienced higher cost growth than expected, both the owner and the designer stated that the contractor's commitment to the project's goals became instrumental in achieving better outcomes. The designer stated, in particular:

“... we had the contractor come early, interested in learning about sustainability and worried about how to make a building with LEED® practices. They really took it on with a high level of dedication, commitment. We were very satisfied with the way the project was executed from all the way from the bidding, contracting, to construction. The contractor did a great job dealing with subcontractors' work, potential changes, scope, changes, and cost, keeping the team moving forward and cooperative.”

Project B2

This project was an outlier since it displayed a medium level of integration. However, its position is very low in the performance outcome metrics. This project was delivered by the CMR method, and the contractor's involvement was at the schematic design phase. Unlike project D4, the project did not have a committed contractor. According to the owner the contractor had the opportunity to be involved early in the project, but declined to do so. Contentions were that the contractor failed to provide sufficient cost estimation and value engineering services to develop optimized solutions. Although the owner acknowledged market changes, at the time, influenced exceeding the cost of the project, the owner placed significant responsibility on the contractor for the project's under-performance.

Project A2

In this project, the stated primary reason to pursue green was two-fold: 1) marketability; and 2) the owner's desire to use this project as an ongoing laboratory to educate staff for future projects with outside clients. The owner reported a lack of experience for this kind of construction and wanted “*practice*” with a self-owned building, and therefore, was pursuing silver certification. Primarily, this project under-performed only in one metric: the level of sustainability achieved. The project intended a silver certification. However, it received only a certified rating. The reason for the reported under-performance was the loss of certain points that the team had originally assumed to be achieved. The owner stated satisfaction with the project in general, as it achieved the intended needs, and blamed the under-performance on the entire team's

inexperience with LEED®. Another suggestion was that the gained experience ensured a better position future delivery of sustainable projects.

Comparison of Good and Exceptional Projects

Three pairs of projects (i.e., with good and exceptional final project outcomes) represent examples for conducting cross-case synthesis and for identifying differentiating project delivery characteristics among them. The basis for the choice of projects was three primary variables: 1) project delivery methods (i.e., DBB, DB, and CMR); 2) certification achieved (i.e., platinum, gold, silver, and certified); and 3) size (i.e., small, medium, and large). Other control variables used to choose the three sets of projects are:

Set 1: Both projects in this set are platinum certified and large in size (i.e., between 120,000 to 180,000 square feet). The difference between them is that the project with exceptional outcomes was delivered by the CMR method, while the other used DBB.

Set 2: In this set, the control variables were size and project delivery method utilized. Both projects were medium sized (i.e., 60,000 -100,000 square feet) and were delivered by the CMR method. By LEED® certification, the exceptional and good projects achieved platinum and certification, respectively.

Set 3: Small sized (25,000-35,000 square feet) projects represent this set.

Table 11 shows an example of the analysis method.

Table 11: Cross-Case Synthesis Analysis

Projects	Owner Commitment			Integration in the delivery process			
	Green incorp. by	Reason to Pursue Green	Timing of Green	Green design cord.	Design Charette	Collab. Sess.	Timing of constructor involvement
Exceptional	Owner	Vision Statement	Con.D.	Yes	Yes	Yes	Pre-Design (Cont.)
Good	Designer	Grants	Des.D.	No	No	No	Bidding

This study, especially the cross-case synthesis, includes a small sample size. Therefore, the generalization of results is a limitation. However, some of the characteristics of good projects - in other words the ones with less than exceptional outcomes - in the dataset were seen as red flags in the project delivery process of a sustainable, high performance project. These characteristics could increase the probability of shortcomings in project outcomes. Therefore, these characteristics can be generalized.

Owner Commitment

- *Reason to pursue green:* The delivery process of a sustainable, high performance building is complex in nature owing to required interaction among multidisciplinary teams. Due to increased complexity, owners, as primary decision makers, must demonstrate high commitment toward the project and inclusion of green strategies. Especially for sustainability metrics, ten respondents reported that, since employing green strategies in projects is not a mandatory requirement, owners must show strong interest and belief in the concepts of green if the project is to be

successful. Apparent in the less than exceptional projects of the dataset is that the reason for including green strategies was mostly LEED[®] certification leading to financial remuneration and marketability. Also, these projects generally occupied the lower end of the certification metric indicating that the owners did not pursue higher levels of certification due to lack of incentives.

- *Timing of including green strategies:* Pattern matching results show that projects performed better when incorporating green strategies in the conceptual or schematic phases. Cross-case synthesis suggests that projects categorized as flawed included the concept of green at the design development phase leading to projects performing low on the success metric.

- *Mandating green verbally:* In the dataset, most projects that achieved low certification and low success did not mention green intentions in the contracts with participants. This indicates unclear mindsets that affect participants' commitment toward green as influencing their roles and responsibilities, scope of the project, and financial remunerations.

Project Delivery Method

All the delivery methods have the potential to facilitate *at least* a medium level of integration by informal involvement of the constructor at earlier phases of the design process (i.e., prior to construction documents). Projects delivered purely by the DBB method (i.e., contractor involvement at the bidding phase) resulted in low integration and also lower overall success because the contractor could not provide input at the design phase.

Contractual Conditions

- *Contractual Terms:* In the good projects (i.e., less than great), the common practice was to use lump sum as a contractual term for both designer and constructor. This indicates that cost is a priority for the owner, thereby placing other success factors such as level of high performance achieved and quality at a lower priority. Also, the nature of the contractual term reduced the commitment of the team toward over-reaching the intended LEED[®] target if the result was cost growth. Cost-plus-fee terms were more common in projects that performed better on the sustainability metric. The open-ended responses suggested that this contractual term allowed innovation within the thought process of the design team since they were not constantly under the pressure of rising costs.

- *Contractual relationship of LEED[®] AP:* When the LEED[®] AP was not directly under contract with the owner or design-builder, the result was a less successful project. This attribute is indicative of the importance of green strategies for the project. A direct relationship between the owner or design-builder and a LEED[®] AP allows the latter to orchestrate the inclusion of green more efficiently because the contractual relationship demonstrates the importance of green goals for the owner.

Integration in the Delivery Process

- *Timing of constructor involvement:* For successful outcomes, the literature strongly suggests early involvement of the constructor in the project (7 Group and Reed 2009). Cross-case synthesis shows that good projects involved constructors, contractually, or informally after the schematic phase (considered late for sustainable projects) in the design process. Also, the open-ended responses show that constructors should be involved from the pre-design or conceptual phase to facilitate clarity of common goals and higher commitment from the constructor toward the project's goals.

- *Green Design Coordinator*: The good projects – the ones showing less than exceptional outcomes either did not have a green design coordinator or coordinators were part of the designer’s team. This lowered the priority of green inclusion as no direct coordination existed between the owner and the green design coordinator.

- *Design charrettes*: For less than exceptional projects, these either did not occur or if conducted only included the owner and the design team, thereby, excluding the contractor and the mechanical, electrical and, plumbing subcontractors who are significant members of the team as they physically execute building construction and could provide important suggestions in the design process.

- *Prior experience of the team members*: Previous experience of the project team with each other, their communication, and compatibility among participants did not rate highly on the Likert scale, in “only good” projects. This indicates that previous working relationships are important because then the team is more focused on the goals rather than on developing relationships with other participants.

Additional Lessons Learned

Apart from the findings achieved from the case study questionnaire, certain repeated themes appear from open-ended responses.

- The construction contractor is a significant member of the team and needs to have a high level of commitment toward the project.
- The first LEED® project built by an owner tended to achieve a lower rating due to the project’s experimental nature.
- Cost is of high priority in low LEED® certified projects. Many projects chose not to pursue higher certifications due to rising costs which also indicates a residual industry concept that LEED® projects cost more than traditional projects.
- Project delivery attributes affect final project outcomes more than the project delivery methods utilized (e.g., DBB, DB, CMR). The main project attributes identified by this study are:
 - a. *Timing of participant entry*: Project delivery methods suggest contractual relationships between participants and also to some extent direct the timing of entry of the participants. However, the informal involvement of project participants as early as the beginning of projects is a commonly occurring practice in the industry.
 - b. *Team characteristics*: Thorough team procurement utilizing qualifications-based selection should occur, not only to assure qualifications and capabilities of the participants, but also to align their commitments with the project and green strategies to avoid compatibility issues.

VERIFICATION OF THE RESULTS

Due to the small sample size in this study, generalization of its results is limited. However, recent research, conducted in the same field, has arrived at similar conclusions. Therefore, this study compared its results with four recent research studies for further external validation and to facilitate relevance. The four recent studies selected for the comparison of results are:

- Lapinski et al (2006) Lean Processes for Sustainable Project Delivery: The purpose of this study was to evaluate the life cycle of Toyota's capital facility delivery process to empirically identify the critical activities and capabilities that led to success of Toyota's South Campus project. The Lapinski study utilized a process-based analysis looking back in time to identify the generation point of value and waste in Toyota's delivery system.
- Korkmaz (2007), Piloting Evaluation Metrics for High Performance Green Building Project Delivery: This research provided a foundation for future research by defining meaningful evaluation metrics, methods, and tools to collect and analyze high performance green building project delivery data.
- Enache-Pommer (2008), Lean and Green Healthcare Facilities: Improving the Delivery Process in Children's Hospitals: The main aim of this study was to understand the building delivery process in green children's hospitals, starting from programming, and extending through design, construction, operations and maintenance.
- Molenaar et al. (2009) (also referred to as Charles Pankow Foundation [CPF] Thrust-I report), Sustainable, High Performance Projects and Project Delivery Methods: A State-of-Practice Report: This study was the initial stage of research that sought to determine project delivery methods' influences on an owner's ability to achieve sustainability goals in delivering building projects. This discussion described the state-of-practice in project delivery methods for achieving sustainable, high performance building projects through content analysis and a nationwide survey of LEED® APs.

Strong or medium level similarities exist among the findings of the current study and previous research. No contradicting results were detected. However, some results in previous research do not appear in the current study, potentially due to the small sample size and the sample being skewed towards private office building projects. The summary of the results from the four previous studies appears in Table 12, which illustrates the degrees of alignment among the studies. The verification of the findings is discussed next under the identified study metrics.

1. Owner commitment: Within this metric all four studies report that for better project outcomes, green strategies should be included early in the design process. In particular Enache-Pommer (2008), Korkmaz (2007), and the current research report that these aspects should be included as early as the pre-design phase.

Requirement of strong owner commitment in terms of being a driving force in the project is a clear pattern in the majority of the open-ended responses and is a characteristic in exemplary projects in the current study. Korkmaz (2007) and Enache-Pommer (2008) report similar findings. Enache-Pommer (2008) reported that, "*dedication, belief, commitment, and executive mindset play a very important role in the delivery of the four case studies investigated.*" Also, all the three studies suggest that inclusion of green should be an owner driven pursuit.

Next, Molenaar et al. (2009), Korkmaz (2007), and the current study all suggest that mandating green requirements, contractually, can result in better outcomes. According to Korkmaz (2007), "*project green specifications should be included in the request for proposals,*" and the cross- case synthesis in that study's results showed that, "*achievement of the project "green" goals was inserted in the design-build team's contract.*" Lapinski et.al. (2006) reported,

Table 12: External Validation of the Study Results

Current Study Metrics	Findings	Lapinski et al. (2006)	Korkmaz (2007)	Enache-Pommer (2008)	CPF Thrust-I (2009)
Owner Commitment	Early inclusion of green (pre-design); The reason to pursue green should be owner driven factor; Owner to be the project driving force; Mandating green contractually;	●	● ● ●	● ● ●	●
Project Delivery Methods	CMR and DB out perform DBB; DB outperformed CMR	●	●		●
Contract Conditions	Cost plus fee outperformed other contractual terms; LEED® A.P. to be directly contracted to the owner; All the primary participants to be directly contracted to the owner		● ○ ●		● ○ ○
Project Team Procurement	No pattern was seen;		●		
Integration in the Delivery Process	Constructor is a key factor in the success of a project; All primary participants should be on board early in the design process; Low integration can result in rework leading to cost growth; A project must have a LEED® A.P.; Design charrette's must be conducted at the start of the project; Prior experience of the team members with green strategies and LEED®	● ● ● ● ● ○	○ ● ● ● ● ●	● ● ● ● ● ○	○ ● ● ● ●
Project Team Characteristic	Better evaluation metric is required for this metric; High commitment required from the project team;		●	●	

● Strong similarity ○ Medium similarity ○ Slight variation
Blank space represents no comparable results were available

*“All Requests for Proposal (RFP) respondents should discuss relevant experience with sustainable facility delivery and **how they will help achieve environmental goals**”* (emphasis added). This shows that previous experience is important for team procurement. However, the latter study also indicated that the owner has to consciously introduce the concept of green as early as compiling the RFP.

2. *Project delivery method selection:* The current study, Korkmaz (2007), and Molenaar et al. (2009) suggested that CMR and DB methods outperformed the DBB method. Although, apparently, DBB projects can lead to exemplary performance in the sustainability metric, achieved through early informal involvement of the constructor in the delivery process, when examination of these projects in detail might show low performance in other categories. Specifically, a DBB project that achieved LEED® Platinum certification has higher cost growth than expected. Therefore, the current study concludes that the possibility exists for achieving high LEED® certification via any project delivery method. However, the chances are low to minimal for attaining high performance in all outcomes such as cost, schedule, and quality.

3. *Contract conditions:* Korkmaz (2007), Molenaar et al. (2009), and the current study consistently suggest that contract conditions are important project delivery attributes that can potentially affect project success. Korkmaz (2007) piloted evaluation metrics and broadly suggested that negotiated contractual terms performed better than fixed price.

Differences in the sample characteristics of these studies might influence results. The sample of the current study included mostly private projects, in which the project team was procured mostly through sole source selection. Contrarily, in Molenaar et al. (2009), most projects were public. Therefore, in conjunction with the current results, this aspect cannot yet be generalized over the entire green building population.

Next, the results showed that for better project outcomes, LEED® APs should be directly contracted with the owner. Also, all the primary participants, including MEP subcontractors, should hold contracts with the owner. Korkmaz (2007) supports these results. Perhaps, direct contract between the LEED® AP and the owner would assist the former to effectively coordinating inclusion of green strategies in projects. Korkmaz (2007) supported direct contract between owners and other primary participants for higher communication and transparency in the delivery process.

4. *Project team procurement:* Korkmaz (2007), Molenaar et al. (2009), and the current study suggest that procurement of project teams have the potential to affect project outcomes. Both Korkmaz (2007) and Molenaar et al. (2009) specifically reported that a low bid procurement method should be avoided since such that practice can lead to unexpected cost growth. However, discrepancies appear in the results of the two studies. Molenaar et al. (2009) reported that most exemplary projects adopted qualifications-based selection; whereas the Korkmaz (2007) sample inclined towards sole source and best-value selection (both of which contain significant aspects of qualifications based selection). The current study cannot contradict or support these findings because of the small sample size. The current study detected no patterns, since most of the projects procured participants by the sole source selection method. Therefore, in the absence of conclusive results this attribute cannot be generalized to the whole population.

5. *Integration in the design process:* Under this metric results of all studies strongly align with each other. Lapinski et al. (2006) reported that all primary participants should have early involvement in the project in the design phase. Molenaar et al. (2009), Korkmaz (2007), and the current study support this finding and additionally suggest that early involvement of the

constructor is a key factor for project success. Based on all the studies, the inference is that constructor's involvement should be as early as the pre-design or conceptual phases to effectively include all value engineering and constructability reviews.

Lapinski et al. (2006) also suggested that team members' prior experience with LEED® could result in positive outcomes and an experiential lack can create delays. This finding has strong support from Enache-Pommer (2008). Although the current study, agrees with this finding, based on the open-ended data, no apparent patterns appeared in either survey responses or comparison with project outcomes.

Other results for this metric include:

- Green design coordinators are key members for guiding the project team for the inclusion of strategies and documentation processes, and therefore, are critical to project success.
- High cost growth is apparent in projects with low integration, mostly due to rework.
- Design charrettes and collaboration sessions are important aspects that assist focusing the project team on common goals.

The last three findings listed from the current study have support in Korkmaz (2007) and Enache-Pommer (2008).

6. *Project team characteristics:* Korkmaz (2007) and Lapinski et al. (2006) suggested that project team characteristics (e.g., past experience with sustainable buildings, project delivery methods, and with other team members) can potentially affect the final outcomes of a project. However, Korkmaz (2007) also suggested that the Likert scale evaluation adopted to collect data was not the best method since it included significant bias from the respondents. The current research supports this statement because no strong pattern appears within the Likert scale responses.

Next, Enache-Pommer (2008), reported that for successful outcomes, apart from the owner's commitment, the project requires increased commitment from the team members. The current study supports this result, since the results suggest that strong commitment, especially from the constructor, leads to significantly improved outcomes.

The external validity procedure, shows that most study findings of owner's commitment, project delivery method selection, and integration in the delivery process can be generalized. The other findings show variation when compared to previous research; however, the variations do not constitute rejection of the current findings whose sample characteristics are different.

SUMMARY OF THE RESULTS

The findings of this research suggest that owner's commitment, contract conditions, and integration in the delivery process are critical project delivery attributes influencing project outcomes such as cost, time, quality, and sustainability goals. The findings also report that, an owner's strong commitment to sustainability, early involvement of the constructor in the project delivery process, and early inclusion of green strategies in the project are crucial to the delivery process for successful outcomes. Other factors affecting outcomes include constructor's increased commitment to sustainability and the project, previous experience of the team members with each other, arrangements, and successful execution of design charrettes, and project team procurement. A detailed list of these findings and their explanations follows.

Owner Commitment

- Owners of large projects in this study generally mandate the achievement of sustainability goals in their contracts with design and constructor teams.
- Sustainability is an extensive concept and includes complex processes that require close multidisciplinary collaboration among project participants to optimize systems in high performance building projects. The processes these buildings require are very different from traditional design and construction practices. The study results lucidly demonstrate that an owner's strong commitment is a requirement to satisfy even minimal aspects of sustainability. However, observations indicate that achieving or exceeding high sustainability targets (i.e., USGBC's LEED® gold and platinum certifications) requires exceptionally high owner commitment. Some of the benefits of highly sustainable buildings do not always result in obvious financial returns to the owner (e.g., low energy consumption, market credibility, occupant's increased productivity, etc.). Therefore, owners need to believe in the concept of green as the "right thing to do" and understand that green buildings can have important and positive consequences for occupants and the environment.
- Green strategies should be included to the project not later than the schematic design phase to make them fundamental to project--not add-ons. However, earlier inclusion of green concepts is only possible if an owner, the primary stakeholders and decision makers demonstrate a high-level commitment.

Project Delivery Method

- Based on the literature and the collected data, this study defines the level of project integration primarily on the basis of timing of the constructor's entry. The data shows that both CMR and DB can provide high or medium levels of integration as they inherently facilitate early involvement of constructors. On the other hand, DBB provides a low level of integration since the constructor's becomes involved at the bidding phase. However, DBB too has the potential to provide higher levels of integration if it involves the constructor in the earlier phases of the project.
- The only trend found between project delivery methods and cost growth suggests that projects adopting the DBB method display higher cost growth. This mainly occurs from constructors' suggesting changes to be incorporated at/after the bidding phase.

Contractual Conditions

- A majority of the exemplary projects adopted a cost plus fee contract provision for the project participants, such as the designer, constructor, or design-builder.
- In exemplary projects LEED® APs adopted contracts directly with the owner. This indicates that a direct contract between LEED® APs and owner, who is the primary decision maker, raises the importance of including green strategies, considered an owner priority, among the project team members. Also, orchestration of green implementation occurs from central source as opposed to constructors' following the lead of the designer.

Integration in the Project Delivery Process

- Early involvement of the constructor appears to be a key factor in the success of a project as well as defining the level of integration in the project delivery process.

- High levels of integration in the project delivery process (e.g., involvement of the constructor in the project informally or contractually, until the schematic phase) mostly occurs in exceptional projects (i.e., projects that outperformed and achieved/exceeded intended targets in terms of sustainability and success metrics such as cost, schedule, quality and owners perception of post-occupancy performance).
- Projects that have low or medium levels of integration in their delivery processes resulted in more cost growth than others. Late involvement of participants in the design phase resulted in rework and provided the rationale for cost growth in the majority of the cases studied.
- The use of design charrette and collaboration sessions resulted in improved performance. Consistently, positive survey responses arose from a majority of projects that conducted these successfully. However, the open-ended responses revealed more lessons to be learned and stressed the importance and the effect of these sessions on project success. The responses align with the literature (USGBC 2009, Green Globes 2009, DOE 2009, Frej 2005), which reported that these important factors influence the success of a project as they assist project teams to focus on common goals.
- In the metric, “previous experience with team members,” variation in responses from the project members was not apparent. This metric has consistently high rating and reflects the adoption of the sole source procurement method in the majority of the projects. However, open-ended responses explain the importance and need for previous experience with team members and show more variation among projects. This metric is reportedly important for the compatibility of the team and also a determining factor for recruitment of the participants (e.g., owner’s are likely to go through sole source selection of participants if they have previously worked with the owner on a project).

Additional Lessons Learned

- The results show that for successful project outcomes, apart from owners, increased commitment from other team members such as constructors and design teams is desirable. The open-ended responses suggest that each stakeholder must take leadership in delivering the green aspects of buildings instead of following the direction given by an outside entity (e.g., contractors following designers leadership for achieving certain levels of LEED® certification without being contractually obligated or fully responsible).
- Project delivery attributes such as the timing of participants’ involvement, design charrettes and collaboration sessions, contractual conditions and terms, and owner commitment appeared to be more important for a project’s success than the adopted project delivery method itself.
- Finally, results show that LEED® AP and mechanical, electrical, and plumbing (MEP) subcontractors are key participants in a green building project team and therefore, direct contractual arrangements between the owner or design-builder and these participants should be established in green building projects.

CONCLUDING REMARKS

Sustainability is a growing trend in the building construction industry. Currently, most green building assessment systems are product-based. However, a need for rigorous process guidelines

has been recently recognized. This study aims to understand the extent of the effect of projects' delivery methods.

This study follows a case study protocol and qualitative methods of analysis. The primary findings of the study show that the level of integration in the delivery process has significant effects on a project's final outcomes, especially for sustainability goals. Also the study shows that the level of integration is more affected by project delivery attributes, such as owner's commitment and timing of participants' involvement, rather than the selected project delivery method. Even though the sample population for this study is limited to twelve case studies, the majority of the results are verified through external validation with recent research findings. The verified findings include:

- Green projects delivered by CMR and DB outperform DBB projects;
- Early inclusion of the green concept in the project is necessary, as early as the pre-design phase;
- The reason to pursue green strategies should be an owner driven factor;
- The project's LEED[®] AP should hold a direct contract with the owner in CMR and DBB projects;
- LEED[®] certification level should be a contractual mandate for all team members, especially for designers and constructors ;
- The constructor is a key factor in the success of a project and should be involved in the early design phases to increase the probability of meeting green goals, and
- Design charrettes and collaboration sessions assist the project team's focus on specific goals.

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DEDICATION

This report is dedicated to Dr. Michael Horman (1972-2009) who pioneered efforts to demonstrate the impacts of project delivery methods on sustainable, high performance building projects.

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