

Influence of Project Delivery Methods on Achieving High Performance, Sustainable Buildings: Preliminary Results Based on a Pilot Study

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Abstract

Growing environmental awareness has resulted in the increased global demand for high performance sustainable buildings. Such buildings are recognized by green building assessment systems, which certify a building as environmentally responsible, energy efficient, and a healthy place to inhabit. However, on the assessment scale, the factors lining the level of sustainability achievement are mostly product based. They do not consider the level of team integration in project delivery processes, which has been shown to result in optimized project outcomes, and increased value to the owner with maximized efficiency. Projects are typically delivered through design-bid-build, construction management at risk, design build, or a variation of these methods. These project delivery methods (PDM) facilitate various levels of team integration in building projects. Therefore, project stakeholders such as owners, government, architects, engineers, constructors and industry must understand the influence that PDM's have on achieving sustainable goals in buildings. This paper presents the results of a pilot study in pursuit of this investigation that helps to select the study metrics to understand project sustainability outcomes and measure the level of team integration in project delivery processes facilitated by different PDM's. The paper also presents the case study selection criteria and potential respondents from project teams to guide this research in data collection and analysis stages. The lessons learned of the pilot study are also presented.

Keywords

High performance green buildings, Integrated design, Project delivery methods, Performance metrics

1. Introduction

Concern for sustainable development is growing as corporate buildings in the United States (U.S.) attribute to 40% of all energy consumption, 71% of electricity consumption, 38% of CO₂ emissions and 36% of all green house gas emissions (Smart Market Report, 2007). Sustainable development is defined as “*those paths of social economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their own needs*” (Brundtland Report, 1987). Currently, high performance green buildings have added to the above definition by addressing implications in a global context. Title IX, Subtitle A, Section 914 of the 2005 The Energy Policy Act defines high performance buildings as “*building that integrates and optimizes all major high-performance building attributes, including energy efficiency, durability, lifecycle performance, and occupant productivity*” (The Energy Policy Act, 2005).

The level of excellence that a building achieves in the categories presented above is evaluated by green building assessment systems. Presently, worldwide, the most accepted assessment models are BREEAM (BRE Environmental Assessment Method), Energy Star, USGBC's (United States Green Building Council) LEED® (Leadership in Energy and Environmental Design) and Green Globes. Although the assessment systems represent an 'industry standard' of the constituents of a green building (Cole R.J. et al. 2005), they have been critiqued on being product based primarily assessing building features such as energy performance and materials used and not providing guidance on how project teams can comply with certain standards in these buildings through utilization of multidisciplinary collaboration, integrated design, and contractual arrangements (Korkmaz et al. 2007). The pre-occupancy stage literature significantly supports that decisions made early in the design process have considerable impacts on the final outcome. Earlier the decision is taken in the design phase; bigger will be the impact on the building performance (OGC, 2005). Similarly, Figure 1 shows that opportunities to implement cost-effective energy savings decrease as design develops (DOE, 2001).

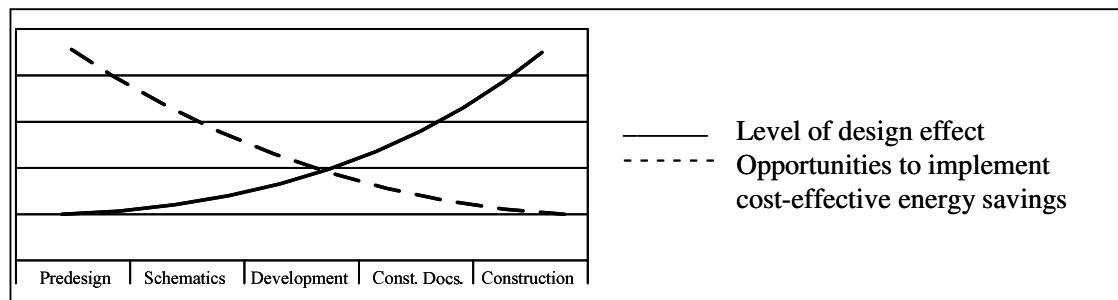


Figure 1: Change in Energy Saving Opportunities According to the Phases of Design Process (DOE, 2001)

It is suggested that approx. 20-25% of the total construction period is wasted due to design deficiencies arising from clashes amongst disciplines with designers investing 40-50% of the total project time in working on such changes (Alarcón, L. F. and Mardones, D. A., 1998). However, early incorporation of design integration in the project facilitates lower clashes and results in better project outcomes. Integrated design can be defined as a process constituting teamwork between multiple disciplines to achieve optimized solutions in coherence with the design requirements for better project outcomes (BCBC, 2001). It is used extensively in sustainable construction, as a green building requires optimum building system solutions/balance, achieved only by close working relation between multidisciplinary teams (Zimmerman, 2005).

As defined design integration advocates early involvement of participants, however, considering the unique requirements of individual projects, the timing of the involvement of participants can be altered. Project delivery methods (PDM) and contractual arrangements are responsible for this alteration. PDM's and contracting strategies define the formation of project teams, their working relationships and levels of involvement over project timelines (Korkmaz, 2007). Commonly three PDMs are used by the industry; these are Design/Bid/Build, Design/Build and the Construction Management at Risk (CMR) methods (Konchar and Sanvido, 1998). Each of these methods provides varied levels of integration due to their unique contractual arrangements.

Design Bid Build (DBB): This is a traditional process in the US construction industry, where the owner contracts separately with a designer and a contractor. The owner normally contract with a design company to complete design documents. The owner or his/her agent then solicits fixed price bids from contractors to perform the work. One contractor is usually selected and enters into an agreement with the owner to construct a facility in accordance with the plans and specifications.

CM at Risk (CMR): The owner contracts with a design company to provide a facility design. The owner separately selects a contractor to perform construction a 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.

Design Build (DB): This 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.

The alteration in the timing of the entry and exit of the participants established by the contractual arrangements affects the level of integration achieved in a project. However, integration also gets significantly affected by the relationship that the participants share with each other. Although the sustainable industry and literature points towards integration and close relationships between players, a dearth of literature was found when the guidelines to achieve the same were researched upon. Recent research piloted evaluation metrics for HPG building project delivery, verified a data collection tool and analysis methods to improve the understanding on HPG buildings (Korkmaz, 2007). To understand (1) the level of project team integration achieved under each project delivery method in sustainable buildings and (2) if better project team integration leads to better project outcomes (e.g. higher sustainability achievement, lower cost, better construction schedule), this research will utilize the findings of Korkmaz's pilot study (2007). The research will build on this study by employing its data collection tools and methods and verifying its findings through utilizing a well thought case study selection process and analysis. Figure 2 below illustrates the steps to be followed for this research.

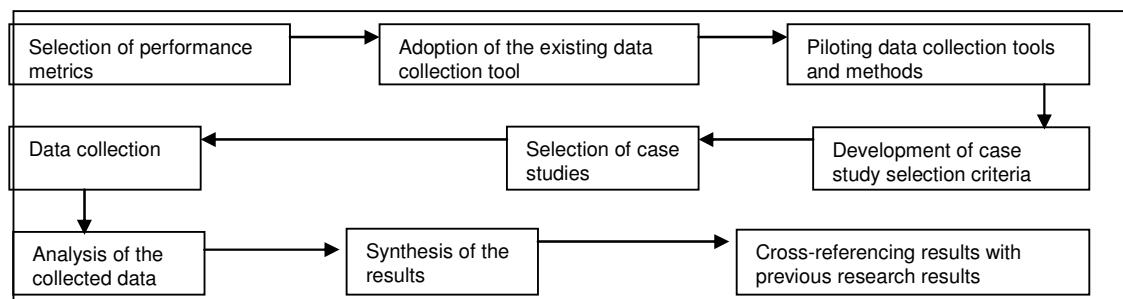


Figure 2: Research Process Map

2. Building Evaluation Metrics

As the first step in this effort, building evaluation metrics were to be identified. Traditionally, project delivery research is limited to understanding the relations between the selected delivery methods and project outcomes such as cost and schedule. However, project delivery methods selection itself is inadequate in describing the delivery process and its mechanics. Therefore, project delivery and performance metrics need to be defined. A literature review helped in classifying the building evaluation metrics. These are: 1) project delivery attributes; 2) project performance upon the completion of construction or building performance in the pre-occupancy stage; and 3) post-occupancy stage performance (e.g. user satisfaction and building performance).

Project delivery attributes: Korkmaz et al. (2007) defined seven process indicators to identify project delivery attributes. Five of those are adopted for this research: project delivery system selection, owner commitment, contract conditions, integration in the design process, project team characteristics. Project delivery system selection addresses the selection of three main PDMs within a project: design-bid-build, design-build, construction management at risk. Owner commitment evaluates level of an owner's dedication towards high-performance green features in a building project. Contract conditions includes evaluation of contractual terms of the project such as the importance of "green" in the contract, established criteria for communication, and for the shift of liability of safety, productivity and quality. Integration in the design process includes timing of project

participants' involvement in the project and method of communication amongst participants, and facilitation of design charrette. Project team characteristics evaluate the level of compatibility by measuring communication and chemistry amongst project team members (Korkmaz, 2007; Chan et al. 2002).

Project performance (upon construction completion): There are commonly used metrics in the literature to measure project performance. This research primarily followed Korkmaz et al. (2007) in selecting those metrics, which included: cost, schedule, quality, construction safety, and levels of high-performance green (Table 1). Additionally productivity is included to the list of performance metrics for this study. Moreover, additional cost metrics such as the magnitude of change orders and design-build unit cost are adopted in this study based on the literature review to better understand the cost performance of projects.

Table 1: Evaluation Scope of the Project Performance Metrics

Performance Metrics	Focus	Measurement techniques
PM# 1 – Schedule	Schedule performance of a project	Schedule growth, construction speed and delivery speed
PM# 2 – Cost	Cost performance of the project	Cost growth, change orders, unit cost, design-build unit cost and intensity
PM# 3 – Quality	Owner's level of satisfaction with the project characteristics	Turnover quality and value of the cost and schedule growth for the project owner.
PM# 4 – Construction Safety	Level of onsite safety achieved by the project	OSHA Recordable Incident Rate (RIR), DART Rate, Lost Time Case Rate and Lost Work Day Rate
PM# 5 – Levels of High-performance Green	Assessment of energy and indoor environmental quality (IEQ)	Energy Performance, Indoor Environment Quality Performance, Level of Green and Level of High Performance
PM# 6 – Productivity	Achieved Productivity	Earned labor-hours/ Expected labor-hours

Building performance (post-occupancy stage): Similar to project performance upon construction completion, there are commonly used metrics in the literature to measure project performance in the post-occupancy phase. These include actual energy and water consumption, user satisfaction with indoor air quality, lighting, acoustics and thermal quality of the building. Except for energy and water usage that will be based on actual meter readings the other metrics use a Likert scale for evaluation.

After the building evaluation metrics for this study are identified, a data collection tool is developed based on the literature (Ling, 2004; Konchar and Sanvido, 1998; Korkmaz, 2007; Molenaar, K.R. et al. 1999; Gransberg, 2002).

3. Analysis Method

Korkmaz (2007) pointed to the challenges of high performance, sustainable building project delivery research mostly due to the small population of sustainable projects, the variety of building types within the population, and a lack of a database to store building project delivery information. Quantitative type of research is still challenging to conduct causal research in this area. However, qualitative analysis can benefit the industry, and expand the knowledge on project delivery process, project team integration, and project performance relations with careful case study selection. Pattern matching and cross case synthesis methods in qualitative analysis offer the opportunity to: (1) identify the project delivery process patterns in similar case studies in terms of project performance such as level of sustainability achievement and cost growth; (2) realize the differences in project delivery processes of projects with different project performance (e.g. comparing a building with a high unit cost with a lower one).

4. Case Study Selection Criteria

This study will include 10-15 case studies with variability in the sample towards especially project delivery methods employed. This variability will strengthen the reliability of the results. The sample for this study will be limited to green projects in the U.S., those included in the USGBC's database as LEED® certified. The other criteria for choosing the case studies for this research are as follows:

1. The case study must include one of the three PDM's mentioned above;
2. An equal number of PDMs must be obtained within the study sample to eliminate bias towards any of the methods;
3. The projects should be rated as either LEED® certified or LEED® platinum. The two extreme certification levels have been chosen as this would facilitate a distinct comparative analysis to serve the study goals;
4. Certain regions, cities, and states in the U.S. are known to support the sustainability movement with enabling legislation. Location can also make an affect on the project outcomes with the available pool of contractors/designers in the area. Therefore, location variety in the sample will be preferred to eliminate bias in the results towards any city, region, or state;
5. For the purpose of eliminating functional and major construction systems / materials differences in projects selected, the focus will be on the projects that are essentially office spaces. Minimal combination with other functions will be focused upon;
6. Certain projects might pose as good case studies, however due to lack of contacts or respondent disinterest information might be unavailable. Also, as this study is qualitative in nature, respondents might be contacted several times for data. Therefore, this research would prefer case studies where there are preexisting contacts.

For minimum bias, the distribution of the case studies should ideally be based on the following break up. The case studies will be from 6 different locations with 2 Platinum rated buildings belonging to each location. The last three case studies should have rating as certified; each would belong to a different location. The 12 platinum case studies would be ideally equally divided under the three PDM's. Similarly the 3 certified projects would belong to the three different PDM's. This distribution is to maintain minimum variability and bias. After the case studies are selected, data will be collected through structured interviews with various project partners such as designer, contractor, owner's representative, and major subcontractors.

5. Pilot Case Study: The Christman Company

A pilot case study for this research is conducted to verify the data collection tools and methods. The Christman Company in Lansing, Michigan was selected as the pilot case. This project was selected for the pilot case study as it fulfilled the criteria's mentioned above. The PDM used in the project is CMR. It is an office building with an area of 65000 Sqft. It has achieved LEED platinum rating in two areas; core and shell and commercial interiors. Finally personal contact with the respondent and the physical proximity to the research team was a major determining factor. A structured interview was held with the concerned project manager of the facility.

The building is a 1928 landmark and was listed as the Mutual Building on the National Register of Historic Places until 2008 when it was renamed The Christman Building. This case study is exceptional as both the owner and the developer is the same entity. The building has been built and occupied by The Christman Company.

The project delivery method used in this project was construction management at risk. According to the project team, since the company was playing the dual role of the owner and the developer this method allowed them maximum efficiency. It is an understandable choice as amongst the three PDM's, both DBB and DB have more constraints than opportunities. DBB would automatically be a redundant choice as the owner and the developer is the same in this case, however, the choice of DB rejection is slightly more complex. By definition DB is mainly approached in cases where owner has

limited know how of the industry and therefore owner's role ends at the design phase. However in CMR regardless of the level of knowhow of the owner, their role is all the way till the end of the project, which in this case was essential as the owner and the developer was the same entity.

Green goals were of very high importance again from a dual perspective. Being the owner they wanted to include green strategies as the 'market' requires it. From the developers perspective the project team was highly dedicated towards green goals as the owner commitment was of very high degree. The reality that the project was owned and developed by the same entity had immense positive effect. The Christman Company, has previously completed several projects that incorporated green strategies therefore as owners they had a clear vision of their requirements from the building. Green goals were already integrated in their way of working and thinking and hence went hand in hand with the execution of the project.

The project was highly integrated. As the same entity was the owner and the developer the communication was at the highest, positively compelling the project team to interact and reduce the clashes amongst the disciplines. However the interviews suggested a flip side to this arrangement, which was a pre-established level of comfort amongst participants making criticism a lot more difficult. Nevertheless, there was consensus that overall it was easier and more efficient to execute the project when performing all the three roles of the owner, the developer and the contractor.

For communication other than face to face essentially phone calls followed by emails were used. Also regular team meetings were organized. They started as once every few weeks however as the requirement increased it was escalated to once a week and at scheduled intervals. Collaboration sessions or design charettes were held at the initial stages of the project with the owner and the designer/architect as attendees. Also for certain areas, within the company specific subcommittees were established.

Most of the consultants held a long-term relationship with the owner/developer; this helped in maintaining the quality of the project. Also, both the developer status and the long-term relationship with the consultants affected the timing of entry and exit of the participants. Although for the pre-design phase only the designer and the contractor and a green design facilitator were contracted with, mechanical and electrical contractors were also invited informally quotes.

There was no formal program conducted by the company to educate the subcontractors about the green strategies. However, once the subcontractors were contracted with a preconstruction meeting was held with their project manager, superintendent and foreman to walk them through the project and the owner expectations. It was important that the subcontractors understood the unique features of the project and ways to deal with them because the project was to follow strict guideline from several agencies. For example in this case as there was a sidewalk around the building. The subcontractors especially the demolition crew had to make sure that the pedestrian traffic would not be obstructed by the construction. Also, it was very important that the subcontractors understood their roles lucidly before they joined the team. As the project aimed at achieving a LEED® certification therefore the subcontractors and the project team itself was walked through the extensive documentation process required.

The project held many unique features one of the main one's being its fast paced schedule. The project was undertaken and finished in approximately than two years. The project experienced many challenges such as getting the national park service approval and being a historic building, historic tax credits was one of the primary sources for financing that required comprehensive documentation. To obtain the funding and the LEED® certification strict guidelines of both agencies had to be followed. The project also experienced unanticipated delays and exposure mechanical units. To obtain the national park service the installation of the roof and the extra atrium piece had to be delayed. This pushed the schedule back by four weeks. Also the delivery of certain mechanical units got delayed pushing the schedule further by two weeks. During this period the under floor air distribution system got exposed that had to be sealed and cleaned at regular interval to maintain the quality of the unit in the post-occupancy phase.

6. Lessons Learned

This pilot study evaluated the validity of the building performance metrics and the data collection tool and methods. Lessons learned from the pilot study are as follows:

- 1) *The results show that the identified evaluation metrics is entirely useful and collectible:* As the project followed the guidelines of several agencies, most data was well documented and since rest of the information requested from the respondent was intended to be more of an opinion than a fact the respondent felt comfortable in responding.
- 2) *The data collection method was successful in gathering information:* A personal relationship with the respondent was significant in data collection. Since the respondent already knew the research team the data was shared willingly. Structured interview was a successful form of data collection as a lot of the respondent's reaction could be documented unlike other quantitative measures such as a survey. Moreover, contacting various participants of the project for different sections of the project helped to minimize the time for the survey completion for each participant, improved the participants; willingness to participate, and decreased the number of non-response questions within the survey due to lack of knowledge in the area.
- 3) *The data collection tool requires follow up questions depending on the project:* Many unpredictable events can occur in a projects life. These events can have significant affects on project performance such as a weather change can cause schedule delay and consequent cost escalation or removal of a team player due to extreme situations can cause not only a schedule delay but loss of morale for the team members. Therefore depending on the preliminary interview, follow up questions will be added such as "Did anything extreme and out of the project team's control happen during the delivery process that affected project performance outcomes such as schedule and cost or team chemistry?"

7. Discussion

The identified metrics was not only useful but also collectible. The availability of information in the pilot study was mainly due to the personal contact with the company and the respondent. This increased the willingness of the respondent to even provide critical information. Unlike the challenges faced by Korkmaz (2007) of unavailability of data due to the need for high documentation of the projects, all the data was available for this study. Therefore it is recommended that the same metrics be used for the full study as well.

The data collection method of structured interview and Likert scale survey questions have been very successful as these methods have the potential to document subjective reactions of the respondents. Likert scale helped in quantifying certain information so as to make data analysis easier. Interviewing various project participants with different roles for each project was found to be a valid method to maximize the response rate in data collection process. This method also increases the internal validity of the collected data. For team characteristics related questions within the survey, this method helps to eliminate respondent bias and provides a rank of all project participants' evaluation and therefore, is highly important to employ. The next step is to conduct a full study after selecting the case studies using the criteria and analysis methods mentioned earlier.

The study intends to validate the expected outcomes in high performance, sustainable buildings that are:

1. PDM's and contractual arrangements affect the level of integration achieved in a project;
2. Personal relations and chemistry among the participants affect the level of integration achieved in a project;
3. Higher levels of project team integration results in better project outcomes.

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