Commissioning Green Buildings

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Owners are increasingly recognizing building commissioning as an effective means of ensuring quality and maximizing energy performance. The demand for commissioning new construction projects has increased substantially over a short period of time with the growing demand for LEED certified buildings. Although building commissioning can cost up to 2 % of the total cost of new "green" building projects, it has received little attention from the construction management research community. The benefits of commissioning are very well documented, yet the research described in this paper has revealed that commissioning as a process is not very well understood by owners of constructed facilities. Confusion about the commissioning process has left some owners with bad experiences and has made them more reluctant to seek commissioning services for their future projects. The objective of the research described in this paper was to examine and clarify issues related to commissioning of green buildings. These issues include the LEED requirements for commissioning and commissioning agents' certification requirements. The ultimate goal of the research is to increase building owners awareness of the process to maximize the benefits of commissioning green buildings.

Key words: Building commissioning, energy efficiency, indoor air quality, sustainable construction, LEED.

Introduction

Building commissioning is the process of ensuring that building systems are designed, installed, functionally tested, and capable of being operated and maintained according to the owner's operational needs. The objective of commissioning is to increase the likelihood that a newly constructed building will meet the expectations of the owner, occupants and operators (Dasher, Potter & Stum, 2004).

Until recently, the most frequently mentioned benefit of commissioning was energy efficiency and resulting cost-savings. Organizations such as US Green Building Council (USGBC) and Portland Energy & Conservation (PECI) have calculated anywhere between 15%-30% energy reduction for buildings that are commissioned to buildings that are not (English 2006). Recently, owners are beginning to realize other benefits of commissioning including fewer installation callbacks, improved indoor air quality, reduced equipment replacement cost, reduced maintenance, improved training of operation staff, and increased occupant productivity (Rebuilding America 1998, Mauro 2005, Nicholson & Molenaar 2004).

The USGBC recognized the importance of commissioning and has incorporated it into the Leadership in Energy and Environmental Design (LEED) green building rating system (LEED 2003). LEED is a national standard for rating sustainable buildings that offers certification for the completed building. The USGBC administers LEED and certifies buildings at different levels (basic, silver, gold, platinum) depending on the number of sustainable "green" features they have (Nobe & Dunbar, 2004). The LEED system requires a basic commissioning process

as a pre-requisite for building certification. LEED also awards an additional credit point for a more intense commissioning process (LEED 2003).

By requiring commissioning for LEED certification, the USGBC realizes that the benefits of green buildings are only achieved if the buildings operate according to the anticipated "green" performance. Yet, many buildings in the past have not lived up to their expected performance. A 1994 study of 60 commercial buildings found that more than 50% had control problems, 40% had problems with HVAC, 33% had sensors that were not operating properly, 15% were missing specified equipment, 25% had energy management control systems (EMCS), economizers, and/or variable speed drives that did not run properly (Piette 1994).

Evidence that owners are not getting the specified level of performance or the promised energy savings from buildings is abundant. In some buildings, occupants use space heaters and fans while other occupants cover the diffusers to become more comfortable. In other buildings, outside air fans run more than necessary, lighting controls are disconnected and lights remain on continuously and /or exhaust fans are not properly scheduled for reduced holiday and weekend operations. All these conditions drive up energy cost. Thus, verifying the energy efficiency of "green" buildings is crucial for reducing their environmental impact. No matter how much an owner invests in a green building, if the owner does not ensure that the building actually operates as designed, the building will not produce the anticipated environmental benefits.

The research described in this paper has revealed that commissioning as a process is not very well understood by owners of constructed facilities. Confusion about the commissioning process has left some owners with bad experiences and has made them more reluctant to seek commissioning services for their future projects. The objective of the research described in this paper was to examine and clarify issues related to commissioning of green buildings. These issues include the LEED requirements for commissioning and commissioning agents' certification requirements.

Research Methodology

A literature search was performed to identify issues and current practices for commissioning green buildings. Data was then collected to investigate the existence of these issues and help clarify them. Data was collected using both personal interviews and an online questionnaire survey.

Personal interviews were conducted with 10 commissioning agents to better understand the current commissioning issues, trends and practices. Consistency between the interviews was assured by using a prepared list of questions. Questions were generally open-ended in order to permit the interviewees to elaborate on their answers. Once all the interviews were conducted, the results were analyzed and used to design an electronic questionnaire survey. The online electronic questionnaire survey was developed to increase the efficiency of completing the survey and analyzing the results. The survey was emailed to 160 commissioning agents. 42 respondents completed the survey. The rate of response was 26.25%. After completing the analysis of the survey's results, follow up interviews were conducted with some of the

respondents to clarify the results and assist in formulating the research conclusions. The survey consisted of the following sections:

1. "Respondent Information", which collected contact information from respondents, such as name, email address, position title and organization name.
2. "Company information", which collected information about the size of the company, the number of commissioning projects completed per year, company location and the primary business of the company (i.e. architecture, mechanical design, construction management, mechanical contracting, exclusively commissioning).
3. "Definition of commissioning" which collected information about whether the commissioning process is well defined and understood by the construction industry professionals
4. "Commissioning for LEED certification", which collected information on the percentage of commissioning projects that are registered for LEED certification, and projects that are seeking the additional LEED commissioning credit.
5. "Qualifications of commissioning agents" which collected information about the certification of commissioning agents and how owners currently select commissioning firms.

Research Findings

The research findings have revealed that commissioning as a process is not very well understood by owners of constructed facilities and that several issues exist that add to the confusion. These issues are further discussed in the following sections.

Definition of Building Commissioning

Numerous sources have defined the practice of building commissioning. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has defined commissioning as the process of verification, by documented inspection and testing, that building systems are installed and perform in accordance with approved design criteria, applicable industry standards and local codes (ASHRAE 2005). The Building Commissioning Association (BCA) defines commissioning as a process whose objective is to provide documented confirmation that building systems function in compliance with criteria set forth in the project documents to satisfy the owner's operational needs (Coleman & Coleman, 2004). The US Green Building Council (USGBC) defines commissioning as a process that verifies and ensures that fundamental building elements and systems are designed, installed and calibrated to operate as intended (LEED 2003). All these sources recommend that the commissioning process starts early during the conceptual/schematic design phase since making changes to a project during this phase is more efficient and less expensive than making the change later on.

Although, all the above definitions carry a common theme which is the inclusion of the testing of equipment and building systems performance to ensure they meet the intended building use, analysis of survey data indicated that commissioning as a process doesn't mean the same thing to everyone in the construction industry.

Figure 1 shows the distribution of respondents' opinions regarding commissioning being a very well defined process. As shown in Figure 1, most respondents disagree and strongly disagree that commissioning means the same thing for everyone. Respondents to "Commissioning as a process is very well defined in the construction industry scored 4.395/5 (1=Strongly Agree, 5=Strongly Disagree).

The literature search revealed that one source for this confusion is that historically, commissioning was considered equipment start-up. Some design-build mechanical contractors had separate installation and start-up personnel and used the term "commissioning" to refer to the start-up process. These contractors conducted rigorous performance tests and systematic diagnostic procedures for equipment they installed. While these early attempts at commissioning did help improve the quality of the project, they have many shortcomings when compared to the currently accepted definition of the commissioning process. These shortcomings include (Coleman & Coleman, 2004):

- The conventional commissioning process usually does not start until the installation is nearly complete. Design problems are not identified during the commissioning process and system troubles are not found until the systems are started and balanced.
- There is a conflict of interest when the mechanical or installation contractors are required to objectively test and assess their own work, especially since repairing deficiencies found through the conventional commissioning process can increase the contractors' cost.
- Although mechanical contractors may have the knowledge and capability to test the equipment they install, they may not be skilled at testing or diagnosing system integration problems.

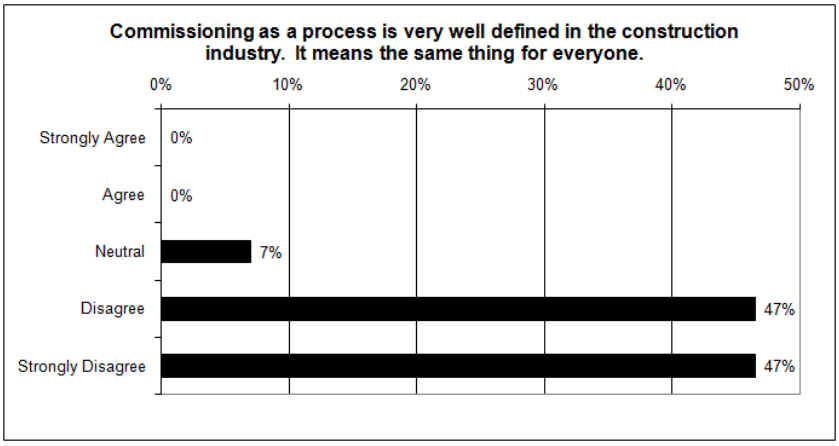

Figure 1

Data analysis has concluded that many individuals in the construction industry still mistake commissioning for equipment start up. Figure 2 shows the distribution of respondents' opinions to "Many people in the construction industry think of commissioning as equipment startup" which scored 1.977/5 (1=Strongly Agree, 5=Strongly Disagree). Building commissioning as defined by ASHRAE Guideline 0 (ASHRAE 2005) goes beyond equipment start-up and start in the early design phase to ensure that the new equipment conform to design expectations in all

modes and conditions of operations. Commissioning also involves system diagnostics to determine how well building systems are working together whereas start-up only checks equipment individually (Rebuilding America 1998).

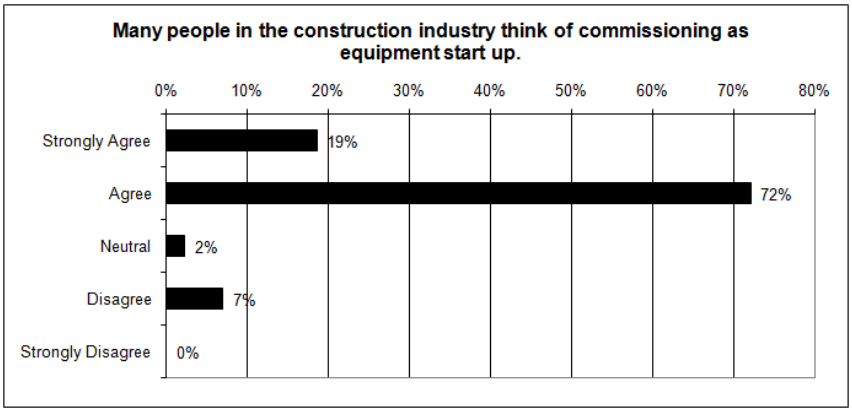

Figure 2

Data analysis has also shown that many people in the industry mistake commissioning for testing adjusting and balancing. Figure 3 shows the distribution of respondents' opinions to "Many people in the construction industry think of commissioning as HVAC Testing, Adjusting and Balancing (TAB)" which scored 2.279/5 (1=Strongly Agree, 5=Strongly Disagree). The commissioning process as defined by ASHRAE Guideline 0 (ASHRAE 2005) is much broader in scope than TAB. It does not only involve adjusting the HVAC duct dampers to ensure the design temperatures are achieved. Rather, it also involves functional testing of equipment to determine whether they meet operational goals or need to be adjusted to work at peak performance. In other words, commissioning ensures that the design criteria (i.e. temperature, humidity, ventilation) are achieved at peak equipment performance resulting in lower energy consumption.

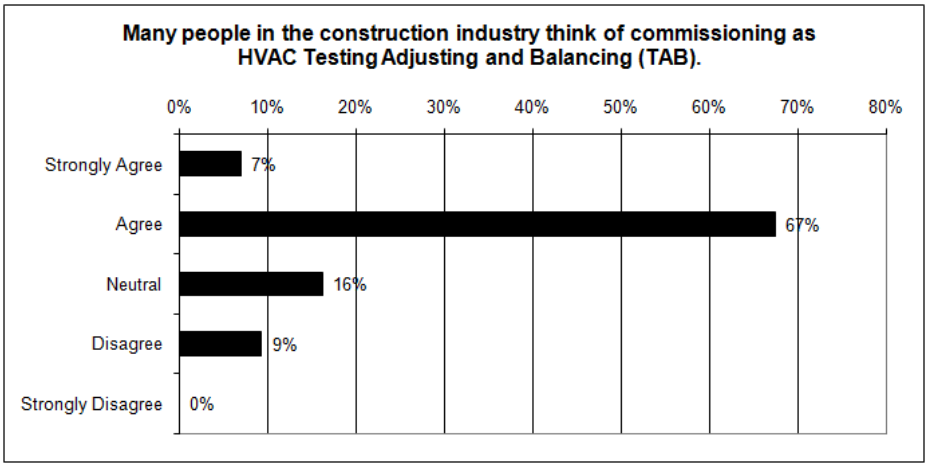

Figure 3

Figure 4 summarizes survey results regarding how people currently define the commissioning process. From Figure 4, it can be concluded that many people in the construction industry are ill informed of what commissioning is. Follow up interviews with several respondents concluded that as a result of the current misconceptions, many owners think commissioning only takes place after the equipment has been installed. Although equipment can be commissioned after their installation, to get the most out of the commissioning process it should start early on during the conceptual design phase and should continue throughout the detailed design, procurement, construction and operation phase. In all phases of the project, the commissioning agent performs several peer reviews to ensure the quality of work of all project participants. Several respondents indicated that commissioning has the most impact in the design phase and that many times the commissioning program has paid for itself by finding design errors and eliminating construction phase change orders.

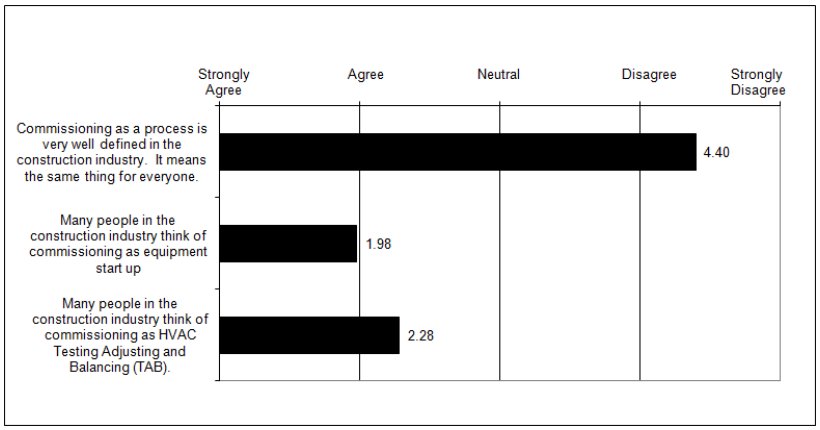

Figure 4

LEED Requirements for Commissioning

Fundamental building commissioning is a prerequisite for LEED certification. To meet the commissioning prerequisite, the building owner must engage a commissioning agent to document the owner's project requirements (OPR) and the basis of design (BOD). The OPR document, also known as "design intent" is usually a 2-3 pages document that summarizes the owner's criteria for system operation, performance and maintainability (English 2006). The BOD document contains an outline of the key mechanical, electrical and plumbing system design approaches considered for the project and a written description of how the systems are intended to operate (Coleman & Coleman, 2004). The LEED prerequisite also requires the commissioning agent to develop a commissioning plan and conduct at least one review of the construction documents to ensure that they incorporate the criteria defined in the OPR and BOD documents. During the construction phase, the commissioning agent should verify systems' installation and functional performance and should submit a final commissioning report (LEED 2003).

In addition to the fundamental commissioning requirements and in order to receive the LEED credit for enhanced commissioning, the commissioning agent should be an independent party and has to be involved early on to conduct at least 2 design reviews; one during the design

development phase and the other near the completion of construction drawings. The commissioning agent should also review the contractor's submittals for the systems to be commissioned and develop systems manuals. System manuals provide future operating staff the information needed to understand and optimally operate the commissioned systems. System manuals are different than the operation and maintenance (O&M) manuals delivered with the equipment in that O&M manuals focus more on maintenance and they do not address the interaction between equipment and building systems (Stum 2006). Finally, to receive the enhanced commissioning credit, the commissioning agent should review building operation within one year after construction completion date.

Survey results indicate that 51.24 % of the building projects that are registered for LEED certification seek the enhanced commissioning credit. Figure 5 illustrates the make-up of responses for the survey question: "Out of the LEED registered projects that your company commissions, how many are seeking the enhanced commissioning credit?"

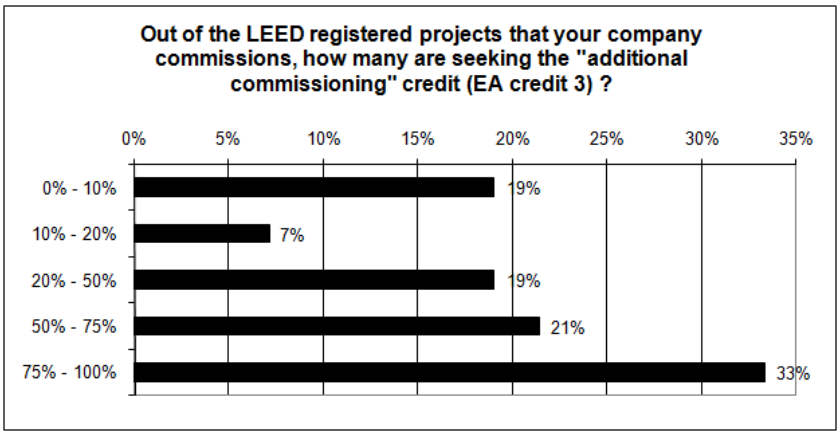

Figure 5

Follow up interviews with survey respondents concluded that the enhanced commissioning effort significantly adds more value to the project for several reasons:

- While commissioning can be implemented late in the design process and still meet the prerequisite, it is much more beneficial to have the commissioning agent involved early during the schematic design phase in order to review the design, verify it meets the design intent and offer suggestions for further savings. Significant energy savings can only be achieved through the incorporation of numerous integrated strategies early during the schematic design phase. These strategies are usually modeled using a whole building simulation tool to ensure their effectiveness. If the commissioning agent is involved late in the design phase, only moderate energy savings can be achieved through minor design changes. Furthermore, design changes recommended late in the design may require expensive re-design effort and may never be incorporated because of time constraints.
- The enhanced process requires the commissioning agent to review building operation within one year after construction completion. This post-construction review is very important as it verifies that the commissioning quality control measurements are actually working and it helps ensure the performance of the building for life. If operators don't understand how to operate the building they may cause significant reduction in its

performance. Verifying post occupancy performance is also important to quantify life cycle savings and to demonstrate the return on investment of the commissioning process.

- There is relatively small cost to completing the enhanced commissioning requirements compared to the achieved benefits. Peterson 2006 estimated the cost of fundamental commissioning to be about 90% of that of enhanced commissioning while the benefits of fundamental commissioning are only 70% of that of enhanced commissioning.

Certification of Commissioning Agents

The literature search has revealed that there are several organizations that certify commissioning agents. These organizations include:

- Association of Energy Engineers (AEE)
- Building Commissioning Association (BCA)
- National Environmental Balancing Bureau (NEBB)
- University of Wisconsin (UW)

Each organization has its unique set of requirements that include professional registration, college education, exams, continuous education and commissioning experience. BCA is considered to be the most stringent (FMI 2005). BCA requires each candidate to have commissioning experience as a lead commissioning provider on at least 3 projects totaling more than 150,000 ft2 and costing more than $30M. The BCA certification program also requires submittals of work products and letters of reference before a provider can sit for the exam.

Survey participants were asked about the influence certification has on the commissioning agent qualifications. Figure 6 shows the distribution of respondents' opinions regarding the importance of certification. As shown in Figure 6 most respondents believe certification is important. Respondents to "Certification is important to ensure that the commissioning agent is qualified" scored 2.3/5 (1=Strongly Agree, 5=Strongly Disagree). Follow up interviews with several respondents concluded that certification is important for preventing individuals lacking proper credentials, education, and experience from entering the market. These individuals can enter the market with minimal initial investments and frequently create confusion regarding the process and sour many building owners to commissioning (FMI 2005).

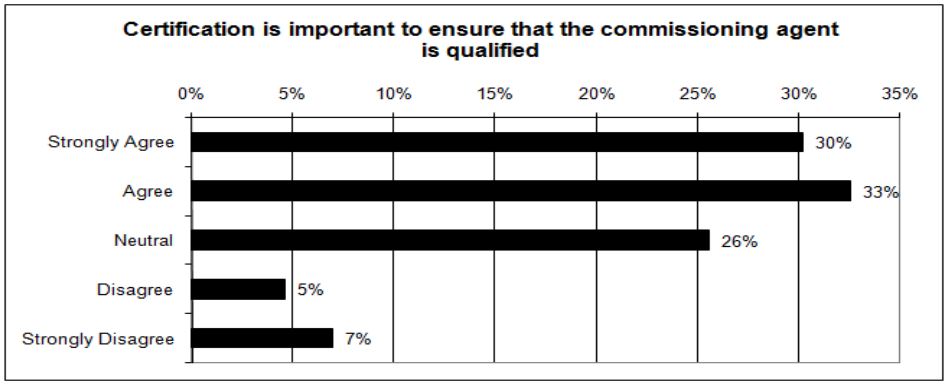

Figure 6

Despite the potential of certification for reducing the entry of unqualified individual to the commissioning market, analysis of survey data on current practices indicated that owners do not usually require certification. Figure 7 shows the distribution of respondents' opinions regarding owners only hiring certified commissioning agents. As shown in Figure 7, most respondents believe that currently owners don't put a lot of emphasis on certification when selecting a commissioning provider. Respondents to "Owners typically hire certified commissioning agents" scored 3.405/5 (1=Strongly Agree, 5=Strongly Disagree).

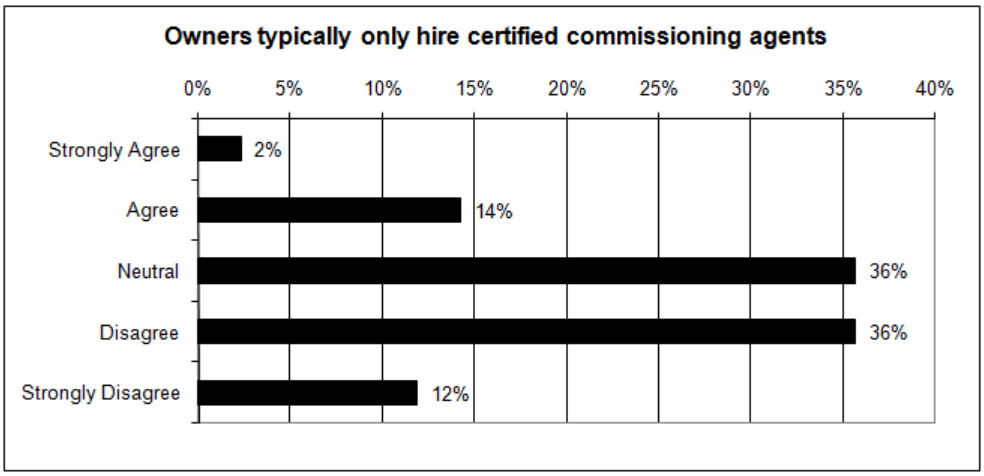

Figure 7

Figure 8 compares survey results regarding the recommended practice of requiring certification of the commissioning provider and the actual practice. From Figure 8, it can be concluded that many owners are ill informed of the benefits a certified provider may deliver. Owners should be aware of that and should require that their commissioning provider be certified.

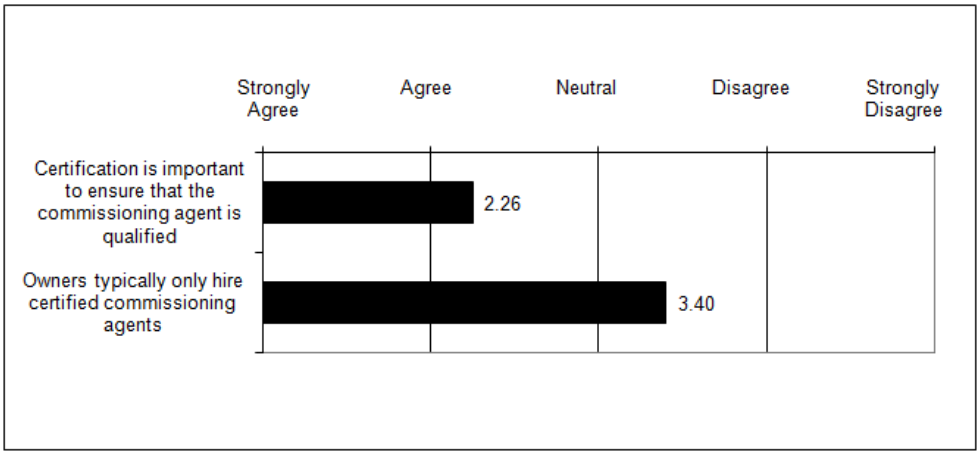

Figure 8

Conclusions

The research described in this paper has examined several issues related to the process of commissioning green buildings. It is apparent from the results that not all individuals in the construction industry have the same perception of the commissioning process and that few comprehend the full extent of building commissioning and its benefits. The research results have also indicated that when compared to the LEED fundamental commissioning prerequisite; the enhanced commissioning significantly adds more value to the building project. Significant energy savings can only be achieved through an enhanced commissioning process where an integrated design approach involving the commissioning agent is used early during the schematic design phase. The added cost of enhanced commissioning is small compared to its additional benefits. The research also concluded that the majority of owners do not require certification of the commissioning agent and a large number of owners are using cost as the only criteria for selecting a commissioning firm. To increase the benefits of commissioning green buildings, the commissioning community should educate owners on the process of commissioning, on the importance of certification and on the added value of enhanced commissioning.

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