LEED Implementation Guide for Construction Practitioners
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Abstract: Leadership in Energy and Environmental Design (LEED) is a certification program developed by the U.S. Green Building Council for designing, constructing, and certifying green buildings. This paper presents a LEED implementation guide for construction practitioners to assist them in the certification process. The guide was formulated primarily through input, suggestions, and recommendations received from LEED accredited professionals including architects, engineers, commissioning authorities, general contractors, construction managers, and facility managers. Data were collected through four questionnaire surveys where two of which were used for guide development and the other two for modification and validation. General contractors, construction managers, and engineers can use the LEED implementation guide as a reference for managing their LEED certification process. The proposed guide can also assist owners interested in building a LEED certified facility.

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Introduction
Leadership in Energy and Environmental Design (LEED) is a certification program developed by the U.S. Green Building Council (USGBC) for designing, constructing, and certifying green buildings. There are several other systems in the United States that rate the performance of a building’s achieved “greenness,” such as American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Green Guide and Green Globes; however, the popularity of LEED has grown dramatically ever since its inception in 1998 making it the industry standard (Building Design and Construction 2003). Currently, USGBC offers LEED rating for new and existing buildings, commercial interiors, core and shell, homes, and neighborhood development.

With the increasing demand for green buildings and LEED certification, there have been recent research studies conducted to investigate the role of constructors in the green building and LEED certification process. O’Toole et al. (2006) investigated in their case study paper the LEED certification process of an office renovation project through the eyes of the general contractor. The U.S. Army Corps of Engineers (USACE) has recently published an implementation guide to assist USACE Project Delivery Teams meet the Army’s Sustainable Design and Development policy using U.S. Green Building Council’s (USGBC) LEED-New Construction rating tool (USACE 2008). The Associated General Contractors of America has developed a full-day course for their members based on a study exploring the impact of LEED certification on construction management practices (Mago and Syal 2007). Similarly, “LEED for General Contractors/Construction Managers” offered by USGBC is an educational workshop focusing on strategies for project documentation and tracking project costs. It also addresses the technical requirements as they apply to the design and construction team, specifically addressing construction-related credits (USGBC 2008b).

The contracting companies participating in a recent research study conducted by the writers to establish the state-of-practice of LEED usage among USGBC member companies almost unanimously expressed their interest in a LEED implementation guide to assist them in the certification process. They stated that such a practical guide should feature the entire LEED certification process, highlight areas such as the initial and final documentation, present commonly made mistakes, identify areas of difficulty, and offer suggestions for improvements (Owens 2007). This paper presents the results of a research study that address this need by proposing a LEED implementation guide for construction practitioners to assist them in the certification process. The subsequent sections of the paper briefly describe the steps taken to complete the study and provide a detailed discussion of the four different components comprising the proposed LEED implementation guide.

Development and Validation of the LEED Implementation Guide
The LEED implementation guide was formulated primarily through input, suggestions, and recommendations received from construction industry practitioners through a series of questionnaire surveys. This strategy was favored over compiling information through a literature review for two reasons: (1) it allowed for a more practical emphasis and (2) it provided the most up-to-date information for the construction practitioners.
date information. To promote multidisciplinary input, the participants selected to assist with the development of the LEED implementation guide included architects, commissioning agents, construction managers, engineers, facility managers, and general contractors.

**Questionnaire 1: State-of-Practice of LEED Usage**

The LEED implementation guide was created and validated through three steps of development. In Step 1, a comprehensive questionnaire was sent to 655 USGBC member companies with USGBC representatives on staff to ensure that all respondents had at least some experience with LEED certification (USGBC 2008a). A total of 177 responses were received indicating a 27% response rate. The primary objective of the questionnaire was to examine the general contractors’ attitudes toward LEED certification, gather information pertaining to their experiences, and establish the state-of-practice of LEED usage among general contractors in the United States. While findings related to this objective are addressed in another paper by the writers, the secondary objective of the first survey related to this paper was to identify the characteristics which differentiate LEED projects from traditional ones. These differentiating aspects were then used to compile the second questionnaire specifically focusing on the development of the proposed LEED implementation guide.

**Questionnaire 2: Draft LEED Implementation Guide**

Step 2 consisted of an open-ended questionnaire sent to general contractors and construction managers. The survey was administered to 366 construction managers and general contractors listed on the USGBC’s LEED Accredited Professionals (AP) directory; 61 professionals participated in the survey. The respondents expounded upon the characteristics and major aspects identified in Step 1 through text questions which were intentionally open ended to remove any prescriptive responses and receive unique input. The first four questions dealt with the important LEED considerations during the predesign, design, construction, and postconstruction phases. The remaining questions focused on the differentiating aspects obtained from the first survey. For example, the respondents were asked how they approached subcontractor selection on LEED projects and what strategies they used to procure environmentally friendly materials. The results of the questionnaire were then compiled into a draft LEED implementation guide.

**Questionnaires 3 and 4: Improvement and Validation**

Step 3 in the development of the LEED implementation guide consisted of two questionnaires that were used for feedback collection and validation. To be compatible with the software on the on-line survey website, the draft LEED implementation guide was converted from a bulleted list to a survey and then administered for review to 232 professionals selected from the USGBC’s LEED AP directory. As the purpose of this phase was improvement and validation, the survey was submitted to architects, commissioning agents, construction managers, engineers, facility managers, and general contractors to receive a well-rounded response. At the time, however, there were not as many facility managers and commissioning agents available as there were with the other groups. Therefore, to ensure each group was equally weighted, the respondent pool was controlled by the fewer numbers of facility managers and commissioning agents available. As a consequence of this approach, the overall number of respondents (232) was less than with previous phases.

A total of 61 responses featuring a fair representation of all stakeholders of a typical LEED project were received including 10 architects, 12 commissioning agents, 27 construction managers/general contractors, eight engineers, and four facility managers. After the analysis of responses, the draft LEED implementation guide was adjusted and modified to reflect the recommendations provided by the respondents which ranged from changing the title of a subphase to changing the order of occurrence for a task. This step was repeated through a fourth survey using the approach described above. In addition to sending the final validation survey to new participants, the respondents who have participated in the second and third questionnaires were sent a “Thank You” e-mail along with an invitation to complete the final validation survey. In the end, 32 new respondents and 18 previous respondents participated in the survey including architects (three), commissioning agents (seven), construction managers/general contractors (36), engineers (two), and facility managers (two).

The final LEED implementation guide was developed by compiling the recommendations and suggestions provided by participants from the four different surveys discussed above. It is important to note that the proposed LEED implementation guide was prepared from a design/build project perspective. The reason for the design/build focus was that general contractors and construction managers have the greatest flexibility and independence under this project delivery method when pursuing LEED credits. Accordingly, the proposed guide covers a wide array of tasks, strategies, and recommendations related to the LEED certification process, which are also useful with other project delivery systems such as design-bid-build or construction manager at risk. The subsequent sections of this paper feature an overview of the proposed LEED implementation guide followed by a detailed discussion of its components.

**Overview of the LEED Implementation Guide**

The LEED implementation guide, as shown in Fig. 1, is sequentially structured and features the following top-to-bottom hierarchy: phase, subphase, and task. There are four phases included in the LEED implementation guide: program, design, construction, and postconstruction. For example, the design phase has three sequential subphases including schematic design, design development, and construction documents. The schematic design subphase has five sequential tasks: (1) LEED workshop and meetings; (2) develop an initial (BOD); (3) develop conceptual design; (4) value management; and (5) constructability analysis. In addition to providing LEED activities sequentially as described above, the LEED implementation guide also provides strategies and suggestions for completing each phase, subphase, and task. All of this information as compiled from survey responses are discussed below.

**Phase 1: Program**

The program phase consists of three subphases: owner’s project requirements (OPR), scope verification, and design charrette. Each of these subphases as well as their associated tasks are described below.

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Owner’s Project Requirements

The OPR subphase provides the foundation for the project in terms of the owner’s performance expectations. It is a document that is used during the construction documentation phase by the commissioning authority in order to determine whether the building’s design adheres to the owner’s expectation. It is important that the owner be assisted during the development of this document because often times an owner is not experienced in LEED and does not know how to write a good OPR. The nine questions that need to be answered with this process include: (1) what are the owner’s sustainability expectations of the facility; (2) what are the owner’s energy efficient goals and expectations; (3) what are the owner’s system and equipment goals and expectations; (4) what are the expectations of the building occupant’s; (5) what are the owner’s indoor environmental quality requirements; (6) what is the owner’s expected long-term return on investment; (7) what are the financial requirements—budgets and paybacks; (8) what are the scheduling considerations; and (9) what are the operating requirements, operating budgets, and service agreements?

Scope Verification

Scope verification is the second subphase of the design phase, and it consists of four tasks: determine the level of commissioning, formulate a green team, understand the building specifics, and determine level of green commitment.

Determine the Level of Commissioning

The two possible commissioning options available under the LEED-New Construction (NC) 2.2 include fundamental and enhanced. A fundamental commission is one of three prerequisites required in the Energy and Atmosphere section before any credits can be counted toward a project’s overall point score (LEED-NC, U.S. Green Building Council 2005). While this fundamental commissioning plan will not be developed until the construction document phase, the decision to pursue the Enhanced Commissioning credit must be established at this point because of the need to involve a commissioning authority in the formation of the green team. It is optimal to involve the commissioning authority early in a project if enhanced commissioning is sought because this professional can assist the Green Team in understanding the OPR and also later with preparation for developing the BOD. If the enhanced commission credit is not sought, a commissioning authority does not need to be included until the design phase.

Formulate a Green Team

The Green Team needs to include members from construction disciplines as this approach will enhance the integrated design process (Hansen 2005). At a minimum, it should include the following: (1) owner or representative; (2) engineer; (3) architect; and (4) construction manager or general contractor. A Green Team can also include a commissioning authority and major subcontractors [mechanical, electrical, and plumbing (MEP), glazing, concrete, etc.] depending on the scope of the project; however, it is common for these professionals not to participate until the construction phase. Their early involvement becomes important when their area of specialty is being pursued for LEED credit.

The most important attribute to consider when formulating a Green Team is experience as these professionals will generally have more practical ideas and possess a better understanding of successful LEED methods. However, identifying professionals with experience can be deceiving when considering LEED AP. Although these professionals have LEED accreditation, it should never be assumed that they have LEED experience. The only prerequisite to become a LEED AP is knowledge to pass the exam. However, if a LEED AP is used on the Green Team, the project
benefits by receiving one point toward the overall score via the Innovation and Design Credit number 2 (LEED-NC, U.S. Green Building Council 2005).

In addition to formulating a Green Team, it becomes critical to determine its leader. The leader is responsible for holding regular meetings, maintaining LEED documents, ensuring that specified LEED credits are achieved, and serving as a LEED contact. It is important that this person keeps everybody motivated and focused on the LEED aspect throughout the project. The position requires experience to coordinate the design team’s time and document production with the contractor’s costs and implementation issues, so that the owner’s project goals are met. This member must have the appropriate authority to accept or reject ideas and actions. The leader can either be a LEED experienced project team member or a third-party consultant group.

The purpose of the Green Team is to complement the integrated design process by involving input from all disciplines of a building project. To achieve this result, it becomes necessary to have regular meetings throughout the course of the project. A bimonthly meeting is recommended; however, the meeting should have a purpose and be meaningful, therefore it is acceptable to decrease the frequency and maintain on-call meetings as needed. The primary purpose of the meetings is to enhance the communication between the different disciplines, which in turn, will improve the efficiency and performance of a project. The meetings are also used to examine alternative design methods, provide a medium for compromise, resolve potential issues, and track the status of LEED credits.

Understand Building Specifics
The building specifics must be understood by the Green Team to produce the optimal design. At the minimum, the following questions must be addressed: (1) what is the building’s intended size; (2) what is the building’s intended purpose; (3) what type of building will it be; (4) who are the future occupants; and (5) has the project location been established, and if so, where? The answers to these questions will impact the green decision strategies. For example, the size of the building will determine if the commissioning authority has to be a third party, the future occupants (in particular the party paying the utility bills) will impact sustainable design options, and the location of the project will impact LEED credit potential.

Determine Level of LEED Commitment
The owner’s level of commitment to LEED will dictate many of the green decisions and strategies used for the project. To gauge this commitment, the following three questions need to be addressed: (1) how much money is the owner willing to spend for LEED certification; (2) what is the owner’s LEED motivation; and (3) what is the desired level of LEED certification? Cost is obviously the most important factor because it sets the parameters on the LEED options available. The owner’s LEED motivation is also important because it influences the specific LEED credits sought. For example, if the client is motivated by publicity alone, then no-cost and low-cost credits should be sought first. However, if the owner is concerned with reducing the cost of operation, credits that emphasize energy and water conservation should be considered first. In conjunction with the owner’s willingness to pay and his or her LEED motivation, the desired level of certification must be acknowledged. The level of LEED certification will impact the amount of credits required.

Design Charrette
The Design Charrette subphase is a Green Team brainstorming session that takes place before a building’s design. The objective is to collaboratively examine LEED design methods and alternatives. There are five tasks associated with the Design Charrette subphase including: (1) understand OPR and develop sustainable goals accordingly; (2) determine siting; (3) develop LEED Action Plan (LAP); (4) identify unique project issues; and (5) register the project with the USGBC.

Understand OPR and Develop Sustainable Goals
Accordingly
The most important activity during the Design Charrette subphase is to fully understand the OPR. Before any decisions are made or green methods examined, the Green Team must collectively understand what the client wants and expects from his or her LEED project. Fully understanding it prior to design will save the Green Team time and money by reducing the potential need for rework later in the process because the commissioning authority compares the OPR with the design documents to ensure compatibility.

Once the OPR is thoroughly understood, the Green Team must develop sustainability goals (SG) that adhere to it. These SG will be the foundation for the design decisions. The goals need to focus on-site development, energy efficiency, water efficiency, material usage, and indoor air quality. It is important that these goals be made clear and precise as this will improve the prospect of compliance with the OPR.

Siting
If the owner or client has not established a specific location for the project, which is often not the case, it is important to select a site that provides the greatest opportunity to receive LEED Sustainability Site (SS) credits. In particular, there are four SS credits that can be achieved with little or no additional cost to the project such as developing in to urban areas with existing infrastructure or rehabilitating “a damaged site where development is complicated by environmental contamination.” The next sitting consideration is the SS LEED prerequisite that requires an Erosion and Sedimentation Control Plan that adheres to either the 2003 EPA Construction General Permit or a local code or standard. However, the USGBC recommends that a Green Team follow the outline provided by a Construction General Permit (LEED-NC, U.S. Green Building Council 2005). It is important to make an actual site visit to understand the characteristics of the site, such as orientation to the sun, local vegetation, etc. Another strategy to consider during this step is to conduct an Engineers Geotechnical Soils Report which clarifies the locations of buildings, water retention tanks, underground utility lines, etc.

Different regions in the United States are more favorable toward LEED construction than others; therefore, the geographical area surrounding the project must be examined to determine the feasibility of various LEED options. The following list of factors are the minimum that need to be researched prior to developing a LAP: (1) the availability and accessibility of environmentally friendly material; (2) the presence of construction-waste recycling and sorting company; (3) the supply of experienced LEED subcontractors; (4) local constraints (water, energy, transportation, etc.); (5) local or state LEED incentives; and (6) historic weather patterns such as sun, rain, and wind.

LEED Action Plan
The Green Team must first determine how to achieve the prerequisites for each LEED category prior to determining which credits
Table 1. LEED Action Plan

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<td>WE 1.1 Water efficient landscaping (reduce by 50%)</td>
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<td>WE 1.2 Water efficient landscaping (no potable use/no irrigation)</td>
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<td>WE 2 Innovative wastewater technologies</td>
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<td>WE 3.1 Water use reduction (20% reduction)</td>
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<td>WE 3.2 Water use reduction (30% reduction)</td>
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Phase 2: Design

The design phase consists of three subphases: schematic design, design development, and construction documents. Each of these subphases as well as their associated tasks are described below.

Schematic Design

LEED Workshop and Subsequent Meetings

The first activity that needs to take place during the schematic design subphase is a LEED workshop with the Green Team. The objective is to plan all activities for the upcoming schematic design subphase and stress the implications of LEED so that all parties are aware of its importance. Also, the Green Team needs to determine if there are any project changes that will impact the LAP, if so, the LAP needs to be updated. This is also an appropriate time to discuss different LEED strategies and methods for achieving additional LEED points.

Regular meetings must be maintained after the initial LEED Workshop and it is recommended that the meetings take place at weekly intervals. This high frequency allows all disciplines to continually communicate, provide constant feedback, and offer design suggestions which in turn improve the design’s efficiency and performance. These meetings also provide a medium for concerns to be collaboratively addressed and resolved before many major problems can develop.

The Green Team leader needs to host the meetings and create a weekly agenda. It is important to develop goals and action items for each meeting and also to provide a status report of each credit sought. It is essential that team leaders continually keep every-
body motivated and focused on LEED in order to address the sustainable goals outline in the OPR. A good way to keep the team members motivated is to enlist everybody’s help in problem solving sessions. Also, assigning responsibilities to individuals to create accountability is another approach that will improve the involvement of the Green Team members.

**Develop an Initial Basis of Design**

A BOD, or intent of design as it is also commonly known as, is a dynamic narrative of the project that provides the reasoning for making design decisions. It is usually created by an engineer essentially to address both the OPR and LEED certification. This document should be accurately maintained throughout the duration of the project. It is not uncommon for a BOD to be developed at the same time as the OPR; however the findings of this research favor the approach of waiting until after the Design Charrette before developing the plan. The commission authority will use the BOD in conjunction with the OPR to determine if the design complies with the owner’s expectations. At a minimum, the following areas need to be addressed: (1) heating, ventilation, air conditioning systems and controls; (2) indoor lighting system and controls; (3) water heating system; and (4) renewable energy system (if applicable).

**Develop Conceptual Design**

The conceptual design task for a LEED building is where the project parameters are determined. The conceptual design is used to highlight the owner’s need while reflecting the use of the building. It is important to continue the integrated design approach during this task as it is the most appropriate and effective way to design a LEED building (Hansen 2005). The initial decisions made during the Design Charrette are reexamined during this task; for example, teams can decide whether a storm management system is better served by natural or improved grading. Also, ideas are developed and examined regarding mechanical, electrical, and control systems. One of the most important functions of this task is to determine the project cost through traditional construction versus the costs through LEED strategies. This comparison allows trade-off decisions to be made later.

**Value Management**

The goal of value management is to save money by continually analyzing methods and processes to make designs more cost effective and efficient. The term “value management” was favored over the term “value engineering” by survey respondents because of the negative connotation associated with the latter; however, the same general principles are meant. Even if a project is under budget, it is important, especially in a design/build, to continually search for cheaper alternatives and examine those alternatives holistically rather than being isolated, because they may be cheaper in the context of the entire project than what their sticker price indicates, e.g., if an alternative has a higher initial cost, it should still be examined because maybe a different aspect of the design can be reduced through its implementation, thus saving money. Value management needs to be an ongoing project practice that is addressed during the weekly LEED meetings. However, it should not eliminate any LEED design components unless there is contingency plan in place to achieve a different LEED credit.

**Constructability Analysis**

Constructability analysis is the process of examining the design of a building to determine the ease and feasibility of constructing the designed component. Attention should be paid to the details of the design such as the construction layout space, space for installing and maintaining the equipment and controls, choice of framing methods, and materials. There are many benefits to performing a constructability analysis such as increased quality, reduced rework, and quicker production times. The results of this research suggest the need for an ongoing constructability analysis throughout the design phase rather than waiting until the construction document phase. The construction manager or the general contractor is already involved with the weekly Green Team meetings; therefore, there should be no trouble in performing a constructability analysis.

**Design Development**

**LEED Workshop and Subsequent Meetings**

The LEED workshop and regular subsequent meetings need to be held also in the design development subphase with the same outline and objectives as described in the schematic design subphase.

**Energy Modeling**

Energy modeling and simulation is an important tool in quantifying and confirming energy calculations which can be used to determine the design parameters. For example, it enables energy efficiency testing, it can provide the best location for windows, and it can confirm the correctness of the orientation of a building. Modeling and simulation should never be used as a verification tool because the estimates often do not reflect the actual performance of the system; therefore, they should only be used to make adjustments to the design as needed. Modeling and simulation is usually performed by an architect with help from MEP engineer.

**Value Management and Constructability Analysis**

Value management and constructability analysis should be maintained in each LEED meeting pursuant to the instructions provided in the schematic design subphase.

**Finalize Basis of Design**

The commission authority will use the BOD in conjunction with the OPR to determine if the design meets the owner’s expectations. This document should be maintained accurately throughout the duration of the project. It is important to enlist the help of the commissioning authority in finalizing the BOD as they are responsible for reviewing it during the enhanced commissioning task.

**Develop Construction-Waste Management Plan**

Construction-waste management is an important consideration in LEED projects and it is necessary to develop a plan before construction actually begins. There are essentially two ways to control construction debris and waste removal on a project: sort it on-site or hire an independent sorting company (or a hybrid of both methods). This research suggests using a hauling and sorting company to handle construction waste provided the company is available in the locality of the project. Using such a service can save time, labor, space, and enable possible LEED credit. However, each project is unique and this may not be the best strategy. In order to determine which recycling plan to pursue, each of the following factors listed below must be addressed: (1) search the surrounding project locality for local hauling and sorting companies, recycling centers, and landfills; (2) determine if the local hauling and sorting companies and the recycling centers accepts the materials specific to the project; (3) determine if the project...
site has enough space available for sorting the construction waste; (4) determine the goal of what percentage of construction waste will be diverted from the landfill; (5) request a quote from the local hauling and sorting company and determine if they can provide a certified letter indicating how much waste from the project was diverted from a landfill; (6) determine what material (and how much) from the project can be reused; (7) determine the local landfill fees; (8) determine if there are any local or state tax incentives for recycling construction waste; (9) determine how much of the local recycling centers (if any) will compensate for the construction waste; (10) determine how far from the project site the landfill is versus how far the recycling center is; and (11) determine how much labor will be required to manage an on-site a recycling and sorting plan. After all of the factors have been accounted for, a comparative cost-benefit analysis can be conducted by the Green Team in the LEED meeting to determine the preferred construction-waste management plan.

**Construction Documents**

**LEED Workshop and Subsequent Meetings**
The LEED workshop and regular subsequent meetings need to be held also in the construction documents subphase with the same outline and objectives as described in the previous design subphases. The construction documents subphase is where the final design decisions are made. In these meetings, the LAP needs to be examined to determine a final and complete list of the pursued credits.

**Value Management**
It is important to perform the final value management analysis during the construction document subphase as this time is the last chance to make any design changes without issuing a rework.

**Constructability Analysis**
As discussed earlier, this research favors an ongoing constructability analysis throughout the design phase rather than waiting until the construction document subphase. In the construction document subphase, a thorough constructability analysis needs to be conducted at 50 and 100% document completion.

**Develop a Commissioning Plan**
Before any of the credits in the Energy and Atmosphere section of LEED-NC 2.2 can be counted toward the final score, a fundamental commissioning must be performed on the project’s energy systems. If the Green Team opted against the enhanced commissioning, a commissioning authority now needs to be selected. To develop a fundamental and an enhanced commissioning plan, the following items must be addressed: (1) general project information; (2) commissioning goals; (3) systems to be commissioned; (4) commissioning team information; (5) commissioning process activities, schedules, and responsibilities; and (6) determine need or desire for Additional Commissioning.

**Design Review**
Prior to 50% completion of the construction documents, a thorough design review should be performed. This review will ensure that the current designs are compatible with the OPR and the BOD. The entire Green Team should be involved with this process. It is important to conduct this initial design review and fix any problem before the commissioning authority performs an official review as per the enhanced commissioning credit.

**Develop Specifications**
One of the most important aspects of establishing the specifications is to address the sustainable goals outlined in the Design Charrette. If the specifications do not contain the necessary LEED requirements, there will be the possibility of costly change orders later during the project to achieve the necessary certification level. In addition to these goals, the specifications must contain the commissioning plan so the contractors will bid on the project with the understanding of the need to coordinate. It is important to include the material procurement requirements in these documents, as many of the LEED credits are dependent on material characteristics such as low volatile organic compounds (VOC) and local extraction.

**Execute Commissioning Plan**
The action items which are outlined in LEED-NC 2.2 must be executed with both the fundamental and the enhanced commissioning.

**Review the Subcontractors’ Submittals**
Every project is unique and, therefore, has its own requirements related to the selection of subcontractors. “As a general rule, however, experienced construction practitioners recommended selecting the subcontractors at 90 to 95% construction documents completion.”

If a subcontractor is selected prior to this point, any major design change requires a change order, which has the potential to increase the costs and cause a delay. Below is a list of strategies and recommendations to consider during the subcontractor bidding and selection process in a LEED project: (1) make sure to indicate in the prequalification process that the project is a LEED project and the performance level is going to be set high; (2) consider Statement of Qualifications for key trades; (3) make sure the subcontractors have a willingness to work with the general contractor/construction manager (GC/CM) on all LEED related tasks; (4) make sure the subcontractor has a complete understanding of LEED requirements to ensure everything is accounted for in the proposals; (5) when the subcontractors are bidding on the project, if possible, have them submit two cost models one for conventional project and one for the alternate LEED project; (6) ensure that all subcontractors have included LEED costs in their price (or an extra safety factor if they have not) and if they are unfamiliar with LEED, help identify specifications and documents that might impact their prices; (7) include in all subcontractors’ contracts notice that they must document performance for LEED credits; and (8) select subcontractors (if possible) who have previous experience with LEED projects and keep LEED AP’s on staff.

**Phase 3: Construction**
The Construction phase consists of two subphases: (1) mobilization and (2) start-up, check-out, and functional testing. Each of these subphases as well as their associated tasks are discussed below.

**Mobilization**

**LEED Kick-Off Meeting**
Similar to the idea of the LEED workshops during the design phase, the construction teams need to attend a LEED kick-off
meeting prior to the start of actual construction work. The major players involved with this meeting include construction managers, general contractors, and relevant subcontractors. The attendance of the commissioning authority or the owner (or his representative) is also suggested. The main purpose of the LEED Kickoff meeting is to ensure that all of the subcontractors are familiar with the LEED aspects of the project. The following is a list of recommendations and strategies to consider during this initial meeting: (1) make sure everybody involved with the construction process is well versed on all of the construction-related credits located in the LAP and train or educate the subcontractors if necessary; (2) clearly identify the roles and requirements expected from subcontractors; (3) indicate how the subcontractors can contribute to LEED points; (4) install a “Green Board” to referencing all information pertinent to the current project, such as VOC limits for sealants/adhesives/paints/etc., green material suggestions, recyclable materials list, the location of the recyclable bins, etc.; (5) discuss the construction-waste management plan; and (6) conduct site walk through with all of the subcontractors to discuss LEED as a group.

After the LEED kick-off meeting, it is important to maintain regular LEED meetings as needed with the construction team throughout the duration of the project. These meetings will be used to increase communication, facilitate exchange of ideas, solve any potential problems, and keep track of LEED credit status.

**Documentation**

The documentation task includes all of the information and data kept during the duration of a LEED project pertaining to individually pursued credits. When a LEED project is submitted for certification, it is these records that are reviewed for LEED compliance. The following is a list of recommendations and strategies to follow while storing LEED credit data over the course of a project: (1) make the Green Team Leader responsible for the documentation and data storage; (2) keep all data in a central location; (3) thoroughly track system performance throughout; (4) take lots of photographs of credit compliance; (5) create a manageable file system; (6) scan and properly file LEED document throughout the project, not at the end; (7) ask to see other LEED project documentation to understand the format; and (8) hire a LEED consultant for advice on the documentation.

**Site Monitoring**

A site monitoring plan is important throughout the construction phase. The following is a list of recommendations and strategies to ensure a successful plan: (1) determine which areas will be used for storage and sorting for construction-waste management plan; (2) ensure surrounding environment is not disturbed; (3) minimize area to be cleared for actual construction; (4) reuse excavated soil/other material be reused; and (5) ensure LEED credits are achieved.

**Material Monitoring**

It is important to create a verification system to continually ensure the materials used by subcontractors comply with the specifications. Examples include monitoring the VOC levels or verifying that the certified wood is in fact certified. It is also important to make sure that the construction-waste management plan is properly followed. The following is a list of recommendations and strategies to ensure a successful waste management plan: (1) express the importance of the waste management plan to the subcontractors; (2) train subcontractors if needed; (3) do not contami-
leader needs to take the lead with final LEED certification submittal process. All of the credits need to be tallied and all of the relevant calculations and documents pertaining to each credit need to be organized together followed by the on-line submission to USGBC. In addition to credit-specific documents, USGBC requires an overall project narrative including at least three project highlights, photo or rendering of the project, and drawings illustrative of the site plan, floor plan, typical building section, and typical or primary elevation. In the event that the OPR are not satisfied and LEED certification cannot be secured, the owner may exercise the same legal rights and options available as with any other contract breach.

Lessons-Learned Workshop

A lessons-learned workshop with the Green Team is a helpful tool for future LEED projects. Having each Green Team member provide feedback on the successes and shortcomings of the past project offers the potential for preventing mistakes with future projects. It is important to host this meeting prior to the expiration of the warranty in order to allow proper operation time for the building’s systems. Allowing this time to pass will provide a better idea of the systems performances. However, attendance for this meeting is not always practical as the professionals have already received final payment and have moved forward to the next project. To ensure cooperation, it is important for the Green Team Leader to express the importance of the lessons-learned meeting throughout the project during the LEED workshops.

Conclusions

This paper presented a LEED implementation guide for construction practitioners. The content of this guide is a compilation of suggestions and strategies provided by LEED AP including architects, engineers, commissioning authorities, general contractors, construction managers, and facility managers. Data were collected through four questionnaire surveys where two of which were used for guide development and two for modification and validation. The proposed guide focused on all LEED impacted activities during a typical LEED project from the program to the postconstruction phase and provided insight to completing each subphase and task. General contractors, construction managers, and engineers can use the LEED Implementation Guide as a reference for managing their LEED certification process. The framework can also serve as a guide for owners interested in building a LEED certified facility.

References
