LEED CERTIFICATION REVIEW IN A VIRTUAL ENVIRONMENT

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ABSTRACT: The excessive use of energy, water, and regional materials are becoming a worldwide concern. This has led to councils around the world to develop standards and guidelines for review processes to help manage these global concerns and promote the design and development of sustainable built environment. These guidelines and standard review processes are used to reduce the depletion of natural resources, and to make the world healthier and more sustainable for future occupants. The authors propose a new and innovative way of managing and harvesting sustainable data for the purpose of LEED (Leadership in Energy and Environmental Design) certification review. Conventionally, changes to the LEED certification review are sometimes made to compensate for over expenditure of revenue, but these changes could not be analyzed early in the project life cycle. The authors is developing a 5D BIM model that allows the viewing and reviewing of LEED information in a VE (Virtual Environment), allows the analysis of cost to be interoperable with the BIM and the LEED certification review process, and also allows the analysis of how changes made over time affect the total cost of the LEED review.

KEYWORDS: 5D, BIM, LEED, virtual environment.

1. INTRODUCTION

Around the world, people are concern about energy, water, carbon footprint, indoor and outdoor air quality, harvesting of regional material, and disposal of waste. Buildings around the world affect the livelihood of all living species through their consumption of energy, resulting to pollution and ozone depletion. Buildings are also consuming 5 billion gallons of potable water per day (Krygiel et al, 2008). In the USA, buildings consume approximately 37% of the world energy, and 68% of the world electricity (LEED-NC V2.2, 2007). For LEED certified green buildings, Capital E (a premier provider of strategic consulting, technology assessment and deployment, and advisory services to firms and investors in the clean energy industry), has reported an average energy savings of 30%, average carbon reduction of 35%, a savings of 30-50% on potable water use, a reduction of land filled waste of 50-97%. In 2003, Capital E developed an average first cost premium of 2% based off 33 LEED certified buildings in California (Krygiel et al, 2008).

Selecting regional materials and developing buildings that are sustainable is a huge change for the AEC industry. Sustainable buildings are not something new, but only recently have governments made sustainable development mandatory. In 1987, the World Commission on Environment and Development stated to the United Nations that sustainable development must meet the needs of the present without compromising the ability of future generations to meet their own needs. A good analogy and example of sustainable design is the Native American teepee (Krygiel et al, 2008). The teepee is designed using regional materials and it does not compromise the future of the land, deplete the natural material sources, and the people who will inhabit that land. Teepee materials are recycled back into the native environment without waste. Currently, a typical USA construction project generates 2.5 pounds (~1.13 kilograms) of solid waste per square foot of floor area. Forty percent of total waste in the USA is caused by construction and demolition, and LEED is helping some project to achieve an 80% waste diversion rate (LEED-NC V2.2, 2007).
The statistics bring forth a need to provide an efficient way to review sustainability information using Building Information Modeling (BIM). In this paper, the authors propose the use of Virtual Environment (VE) and 5D-BIM concepts for LEED certification review. The authors envisioned that this approach would reduce the duration of certification process, provide certification information that can be achieved in a timely manner, and able to select different types of material and how they affect cost. By doing so, the AEC industry in general and project stakeholders in particular, can benefit from better tracking and forecasting of sustainability information, and construction events early on in projects life cycle. By reviewing specific LEED credits within a VE, a standard review process working in parallel with the BIM model can be achieved, unlike the traditional paper-based LEED review method for certification.

2. 5D-BIM PROTOTYPE FOR LEED CERTIFICATION REVIEW IN VE

The 5D-BIM is a construction–time-simulation model of a virtual building that contains cost and other project related information (Jernigan, 2008). 5D is the linking of the design and construction model (3D), schedule (4D), and cost (5D). When utilizing a 5D model, users can change any aspect of the three-dimension (3D), with the other two remaining dimensions (4D and 5D) be automatically updated to accommodate the change (Jernigan, 2008). 4D and 5D allow AEC professionals and the project owner to utilize simulations to ensure a project plan is feasible and efficient (Eastman et. al., 2008). The benefits of using a 5D model include: the improvement in communication and collaboration among stakeholders; and better analysis of site logistics, trade coordination on site, and comparisons of schedule and tracking of construction progress (Eastman et. al., 2008).

A prototype 5D-BIM model is being developed using a suite of software by Vico Software. Sustainability information for LEED certification purposes is furnished and included in the prototype 5D-BIM model. Besides being utilized for LEED certification, the sustainability information can be used for GREEN building record such as construction material usage and cost, duration of which GREEN materials are installed, CSI (Construction Specifications Institute) Uniformat Methods of Installation, Task Progress of Material Installation, and when the materials are completely installed (see figure 1). The 5D-BIM model can also be used for Earned Value Analysis (EVA). The EVA allows the user to simulate “what-if scenarios” and see how cost is affected over time. Inside the EVA viewer, the 5D cost related information includes Labor, Material, Sub-contract, Equipment and Other, (see figure 2). Reports of all EVA query can be exported to Microsoft Excel spreadsheet that allows for further interoperability and data sharing with other software tools. Users can navigate in real-time through the 5D-BIM model and access the LEED sustainability information.

For LEED certification review performed within a VE to be successful, a LEED-AP\textsuperscript{1} or designated person by the Owner must have an early relationship with the AEC professionals involved in the project, specifically the designers during the early phases of the project life cycle. Currently, to certify a project, a LEED-AP does not have to be hired or recognized as the party to make submittals to the Green Building Certification Institute (GBCI). A non-accredited project member can submit to the GBCI if appointed by the Owner to do so. A LEED-AP certifying a project should have experience and have officially certified a Green Building meeting the standards given and developed by the USGBC.

\textsuperscript{1} A LEED-AP is a person who has passed the LEED-AP exam given by the Green Building Certification Institute (GBCI), a third party organization that handles the accreditation process for the USGBC. A LEED-AP is accredited by the USGBC to streamline and complete the LEED certification process.
A LEED Project can be certified as one of four different levels of certification depending on how many points are achieved from the GBCI. The four levels of certification are: Certified; 26-32 points, Silver; 33-38 points, Gold; 39-51 points, and Platinum; 52-69 points. Type of LEED Project certification depends on what category the project falls under: LEED for New Construction (NC) and Major Renovation, LEED for Neighborhood Development (ND), LEED for Schools, LEED for Existing Buildings, LEED Core and Shell, and LEED for Existing Buildings Operation and Maintenance. The prototype for this paper utilizes the LEED – NC Version 2.2. There are over 900 certified buildings and almost 7,000 more registered seeking certification as of June 2007 (LEED-NC V2.2, 2007).

Figure 3 shows a workflow diagram for a successful inclusion and use of LEED information in a 5D-BIM model. The LEED information can be viewed and reviewed in real-time within a VE. To include the LEED information into the 5D-BIM model, a new custom recipe must be created for the model's elements (see figure 4). The recipe is then saved in the standard and project database and will now contain not only the LEED information, but also labor.
methods, cost, and sustainable resources. The standard and project databases allow the model element's recipe to be interoperable among the Vico software suite. The authors used the Vico software suite to produce an interoperable information workflow for a LEED-ready 5D-BIM model; i.e. between the 3D model, the estimate, the schedule and the cost analysis (see figure 5). Figure 5 shows the relationship between cost and LEED credits viewable via the Vico Cost Explorer Software. The LEED-ready 5D-BIM model can then be viewed and reviewed within a VE using the 5D Presenter software. In the 5D Presenter, users can access and visualize the cost, the LEED information for certification, the 4D schedule, and the Earned Value Analysis (EVA). Users can also watch the 5D-BIM model develop over time (see figures 1 & 2).

1) In Constructor recipes are assigned to model elements and the model must be linked to the project database and standard database.
2) An Estimator project is created and linked to the project database and standard database.
3) The link is verified to ensure connection between Constructor and Estimator.

4) In Estimator, the model data is exported to Cost Explorer.
5) The link is verified to ensure connection between Estimator and Cost Explorer.

6) In Constructor, the WBS (Work Breakdown Structure) is used to create project Task and Task Summary.
7) In Control, a new project is created.
8) In Constructor, the model data is published to Control.

9) In Constructor, the LEED-ready 5D-BIM model is published to a VE in 5D Presenter.

FIG 3: The workflow

The information necessary for the review of LEED certification is provided by the USGBC. The authors have embedded LEED information into the model element parameters so that the model element parameters contain a “credit number” that can be referenced to a digital or paper-based LEED summary checklist. The checklist contains the credit title, intent of credit, requirements, strategy, and submittal documents. Each credit number has a specific number of points. Using the LEED-ready 5D-BIM model for certification, users are allowed to access the LEED credits and points in real-time in the VE. The LEED certification process can be done in a VE if the Credit Numbers and requirements are embedded into the BIM model during the Design Development Phase of the Project Life Cycle.
3. CONCLUSION AND FUTURE WORK

The authors believe that it is necessary to innovate and improve the LEED certification process. LEED review within a VE allows the AEC industry to move forward to a more integrated approach. The review for LEED certification in a VE will help the AEC manage sustainability information when utilizing a BIM model, and the BIM model can supplement the certification process. LEED certification in a 5D-BIM model provides various benefits including the reduction of cost of sustainable design, providing various "what-ifs" scenarios to achieve better sustainable designs, improving real-time communication of certification intents, and reduction of the time wastage that occurs when waiting for submittals to be approved for certification. Overall, this could lead to healthier and more efficient built environments. The authors are still working and improving the LEED certification process in a VE that will lead to a more automated approach. Current ongoing work includes proposing a sixth dimension (6D) which is energy (see figure 6).
The idea of new dimensions for the AEC industry is not new. Lee, et al. (2005) proposed nD modeling as an enabler for construction improvement. An nD model is an extension of the BIM that incorporates multi-aspects of design information required at each stage of the overall project life cycle. The authors are proposing a new 6th dimension for the AEC industry. The proposed new dimension is energy and its purpose is to assess the energy cost, energy standards, and energy efficient quality of all AEC related projects to provide humans with healthier and more sustainable built environments. Figure 7 below partially shows how 6D can be directly related to 2D, 3D, 4D, and 5D, and also shows the direct link between LEED certification and 6D. The authors believe 6D is a vital and sustainable part of nD modeling, sustainable design and construction, and BIM.

4. REFERENCES


