Integration of Building Information Modeling (BIM) and LEED's Location and Transportation Category

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ABSTRACT

The selection and development of a project location is critical to the success of a green building project. LEED (Leadership in Energy and Environmental Design) is one of the most popular Green Building certification systems in the world. Traditionally in LEED design, architects and designers have to analyze project location based on traditional maps with manual calculations, which require a significant amount of time and effort. In the meantime, the advent of Building Information Modeling (BIM) has brought about a promising new way of improving Green Building's location analysis. This research presents an integration model of BIM in LEED certification to improve the efficiency of LEED's location and transportation analysis. The framework of the integration model is introduced and demonstrated using a user interface for LEED's analysis under the Autodesk Revit environment.

Keywords –
Green Buildings, LEED, Sustainable construction

1 Introduction

In recent years, Green Buildings have been a new trend of the construction industry to promote the eco-friendly design and effective energy consumption. More and more countries have developed their own Green Building certification systems, such as LEED in the U.S, CASBEE in Japan, BREEAM in the U.K, EEWH in Taiwan... to certify buildings in terms of "green" level. LEED (Leadership in Energy and Environmental Design) developed by the US Green Building Council (USGBC) has become one of the most popular certification systems for Green Buildings in the world (Choi et al., 2012).

Project site location plays an important role to the success of a Green Building project. In LEED NC 2009, project location analyses are included in credits SSc2 and SSc4.1 in the Sustainable Sites category, which is the second biggest category after Energy and Atmosphere. Credits SSc2 and SSc4.1 has totally 4 options (for projects inside the U.S) as shown in the following table:

Table 1. Sustainable Sites Credit SSc2 and SSc4.1

Credits	Intents	Options	Points
Credit SSc2: Development Density and Community Connectivity	To channel development to urban areas with existing infrastructure, protect greenfields, and preserve habitat and natural resources.	Option 1: Development Density	5 points
		Option 2: Community Connectivity	
Credit SSc4.1: Alternative Transportation - Public Transportation	To reduce pollution and land development impacts from automobile use.	Option 1: Rail station, Bus rapid transit station & ferry terminal Proximity	6 points
		Option 2: Bus stop Proximity	

Nowadays, BIM (Building Information Modeling) is widely used in LEED analyses, such as energy consumption, lighting, and sustainable materials…. Project site location information is usually included in most BIM software; for example in Autodesk Revit, it is included in Project Location under Manage tab. However, due to the complexity of the LEED calculation, architects and designers usually analyze LEED's site location manually.

To calculate LEED results in LEED SSc2 and SSc4.1 credits, designers and architects manually extract the project information (such as project locations, building areas, site area…) from project CAD drawings or BIM model. The map information of project site, including surrounding buildings, traffics, and local services has to be obtained from either paper maps or

online mapping such as Google Maps. Moreover, it also requires the use of graphic software such as Adobe Photoshop to illustrate the map image and local area for LEED submission documents. This manual process requires a lot of time and labor, as well as skill to prepare document submission.

Web-mapping service is the process of using the web interface to request map images delivered by a map server using geographical information systems (GIS) database (Open Geospatial Consortium, 2014.). It has many advance features over traditional maps by providing free online access in a browser application to maps with data associated with roads and traffics. With its strength and flexibility, Web-mapping service is a potential tool to support the map-related analysis in LEED Sustainable Sites credits.

There isn't any comprehensive software that allows users to calculate LEED SSc2 and SSc4.1 score and access by themselves. With the help of BIM and the web-mapping services such as Google Maps, the calculation process can be much faster and more accurate, thus can save significant cost and time.

2 Literature Review

Studies on the integration of BIM in to Green Building analysis have been conducted to find out the experiences of the application of BIM in Green Building analyses. Krygiel et al. (2008) summarized several case studies with successful implementation of BIM in LEED® and other green projects. In his study, an in-depth analysis of BIM application was conducted in various building systems including building envelopes, water harvesting, energy modeling, renewable energy and sustainable materials. However, site location were not a subject of BIM application in his study. Wu et al. (2010) revealed that Sustainable Sites was not considered not having high level of BIM application compared to other categories in LEED (Wu, 2010). Azhar et al. (2011) presents a conceptual framework to establish the relationship between BIM-based sustainability analyses and the LEED® certification process. In his study, 17 LEED credits and 2 prerequisites can prepared by using BIM, but location analysis in credit SSc2 and SSc4.1 are said to be not applicable of using with BIM. It can be seen from the mentioned studies that the integration of BIM into LEED certification process only focuses on certain types of analysis such as water usage, energy consumption, atmosphere and day lighting. For Sustainable Sites in general, and project location in particular, the application of BIM software is very limited.

3 Research Objectives

The main objective of this paper is to develop a Revit plugin program through Revit API to help user in location analysis in Credit SSc2 and SSc4.1. The plugin integrates with online mapping service such as Google Map to help users to retrieve map information from GIS server for locations analysis. Projects location information and data can be extracted automatically, or added manually by users. LEED results can be automatically calculated and shown on the plugin interface. The plugin can help user reduce time, labor and cost in LEED location analysis

4 Research Methodology

The research uses Revit API to and Google Maps API develop an integration model of BIM and LEED location analysis. The framework of the integration model of BIM in LEED location analysis is developed, as shown in Figure 1.

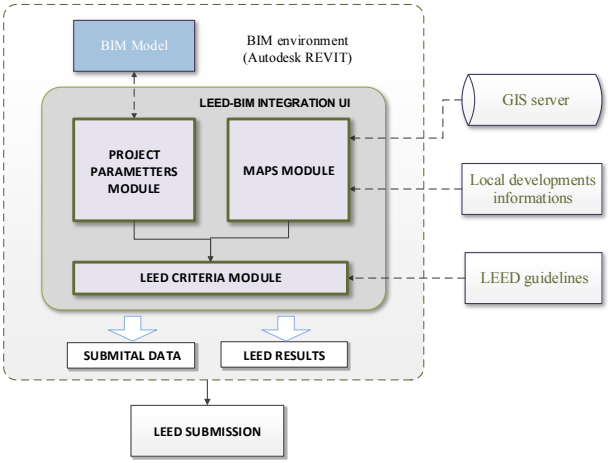

Figure 1. Integrating BIM into LEED SSc2 and SSc4.1 credits

The integration model includes 3 modules:

- **Project parameters module:** Extracts project information (location longitude/latitude, site area, building area…) from BIM model and synchronizes location information between UI and BIM model.
- **Maps module:** Gets maps data from GIS server of multiple providers (Google, Bing, Yahoo…), and shows maps with buildings, traffic, local services.. in the map interface. The module also draws markers, layers (density radius, services radius, route…), and exports Maps image for submission.
- **LEED criteria module:** Incorporates LEED requirements, formula and automatically

calculate and show LEED's points results. The module also help export Excel data table for submission.

Through the integration UI, LEED results can be automatically calculated and shown on the UI to help designers and architect to have a good assessment of the Green Building location.

5 Integration model demonstration

The following figure demonstrates the user interface of LEED SSc2 – option 1 location analysis in Autodesk Revit:

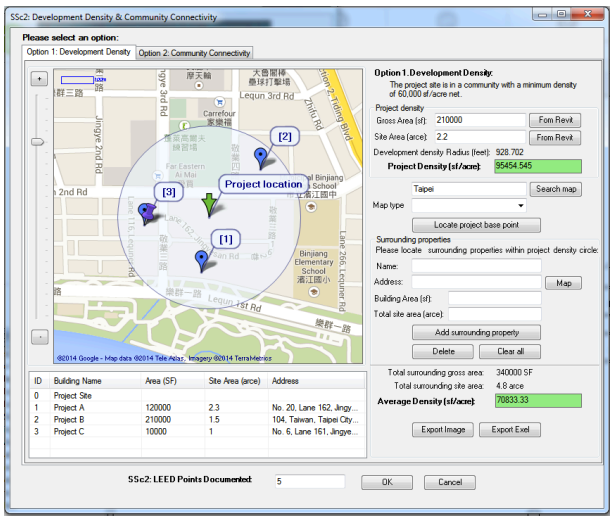

Figure 2. BIM integration model in LEED credit SSc2 – option 1: Development density

This option requires the project building to be constructed or renovated on a previously developed site and in a community with a minimum density of 60,000SF/acre (US. Green Building Council, 2013, p. 3). The integration model can get the project location information from Revit model and show it on the map interface. The project Gross area and Site area can be obtained automatically through Revit Gross Area schedule and Site's Property Line area. The density circle is drawn with the radius calculated by the equation:

$$Density\ Radius\ (f) = 3\times\sqrt{[Site\ Area\ (arcres)\times 43{,}560\ (sf/acre)]}$$

User can mark different building locations on map based and enter its site area and gross area. Development Density is calculated by the formula:

$$Development\ Density\ (sf/acre) = \frac{Gross\ Building\ Area\ (sf)}{Site\ Area\ (acres)}$$

If Development Density of the area within the circle >= 60,000 then the credits is obtained. LEED result is automatically shown on the interface.

6 Conclusions and recommendations

Green building and BIM are rapidly transforming the design and construction industry in the world. However, application of BIM in LEED certification in general, and location analysis in particular, is currently still in its infancy. In this study, the system is developed through integrating BIM and web-mapping service such as Google Map in LEED location analysis in order to simplify and shorten the process of green building planning schedule.

Currently, most countries are promoting the use of new technology in sustainable construction. If we can use the BIM technology efficiently in LEED certification, which information will be automatically reprocessed without additional manual calculation or using other methods, it can reduce costs of calculation and enhance the rates of green building application in the world.

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