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Integrating BIM and Web Map Service (WMS) for Green Building Certification

Po-Han Chen, Thanh-Chuong Nguyen

Department of Civil Engineering, National Taiwan University,
No. 1, Sec. 4, Roosevelt Road, Taipei, 10617 Taiwan (R.O.C.)

Abstract

LEED (Leadership in Energy and Environmental Design) is one of the most popular and globally recognized green building standards. In LEED, evaluating the sustainable effects of site location and transportation to the ecosystem and human life is a critical and difficult task. Credits regarding these matters require experience, time, labor, and manual calculations. In recent years, many studies have been conducted to enhance the application of Building Information Modeling (BIM) in the LEED certification. However, the application of BIM to LEED's site location and transportation analysis is usually considered impractical due to the lack of a powerful map application in present BIM products. The aim of this research is to develop a framework for the integration of BIM and Web Map Service (WMS) technologies for LEED's location and transportation analysis. Using Autodesk Revit API and Google Maps API as the development tools, this research converts the integration model into the LEED-BIM plugin in Autodesk Revit to streamline the certification process of site location and transportation analysis in LEED.

Keywords: LEED, BIM, Green Building certification, Building Information Modeling

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 [1].

Project location and transportation are the critical components of a green building project. A building in developed land or near dense residential areas can make more intensive use of existing infrastructure, increase development density, and conserve construction material and land resources for future use. A building near essential services such as banks, parks, doctor's offices, schools and restaurants… can help reducing the use of vehicles, time for parking and increase levels of physical activities, which can improve occupants' health. In regards to project transportation, it can help reduce CO2 emission as well as improve resident's health. Convenient access to bus or rail stations can promote the use of public transportation means, hence reduce vehicles' gas use, pollution and optimize the use of the existing transportation infrastructure. In addition, it can help reduce traffic congestion, noise pollution and improve resident' health by promoting physical activities such as walking or bicycling.

In LEED 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 22. Sustainable Sites Credit SSc2 and SSc4.1 (LEED NC 2009)

Credits	Intents	Options	LEED Pts
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-Map Service (WMS) is the process of using the web interface to request map images delivered by a map server using geographical information systems (GIS) database [2]. 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. [3] 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. [4] revealed that Sustainable Sites was not considered not having high level of BIM application compared to other categories in LEED [4]. Azhar et al. [5] presents a conceptual framework to establish the relationship between BIM-based sustainability analyses and the LEED® certification process.

Regarding site location and transportation analyses in LEED, studies also indicate that BIM has very low capability of LEED application. Unlike building performance characteristics such as lighting, thermal, energy consumption, etc.…that may potentially use BIM analyses, location and transportation has fewer direct connection with BIM software. In the survey conducted by Bynum et al. [6], most of the responders still regarded the Sustainable Sites category to have lower capability of BIM application than other categories. Azhar et al. [5] and Wong and Kuan [7] also discuss about the application of BIM in Hong Kong's BEAM-Plus Green Building certification, which was also developed based on the LEED standard. While his study concluded that 26 BEAM-Plus credits could be assisted by BIM, only 4 out of 17 credits in Site Aspect category (identical to LEED's Sustainable Sites) can be achieved by BIM. Credit SS2 Local Transport (identical to LEED's SSc4.1) and SA3 Neighborhood Amenities (identical to LEED's SSc2) are marked as not applicable to be achieved by using BIM. In conclusion, construction professionals are exploring the application of BIM in Green Building certification analysis. However, due to the missing map and calculation tools in BIM software, location and transportation analyses are impractical using BIM solutions.

3. Research objectives

The focus of this study is on the Location and Transportation analysis related to credits SSc2 and SSc4.1 of LEED for New Construction v2009. Autodesk Revit (BIM software) and Google Maps (WMS) are adopted in this study due to their popularity. Plugins for Autodesk Revit will be developed to help with credits SSc2 and SSc4.1 in Location and Transportation analysis. The plugins will automatically calculate SSc2 and SSc4.1 points (Note: These two credits are the major ones in LEED's Sustainable Sites (SS) category, accounting for 11 out of 26 points in SS), help prepare documents for LEED submittal, export proof map images with all required information marked on them, and generate an Excel file containing all location-related data. With the plugins, no manual switching between software and manual calculation of LEED points are needed.

4. Research methodology

The C# programming language together with Autodesk Revit API and Google Maps API are used for the integration of BIM, WMS and green building (GB) standards (Figure 1).

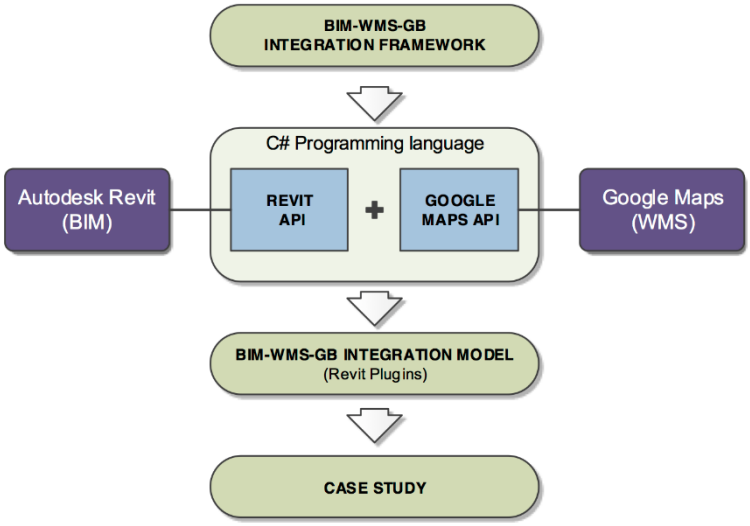


Figure 29. Flow of BIM-WMS-GB integration

The integration model includes 3 modules (figure 2):

- **BIM information module:** Extracts project information (location longitude/latitude, site area, building area…) from BIM model and synchronizes location information between UI and BIM model.
- **Web Map Service 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.
- **Green Building module (LEED):** Incorporates green building certification (LEED) requirements, formula and automatically calculate and show calculation 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.

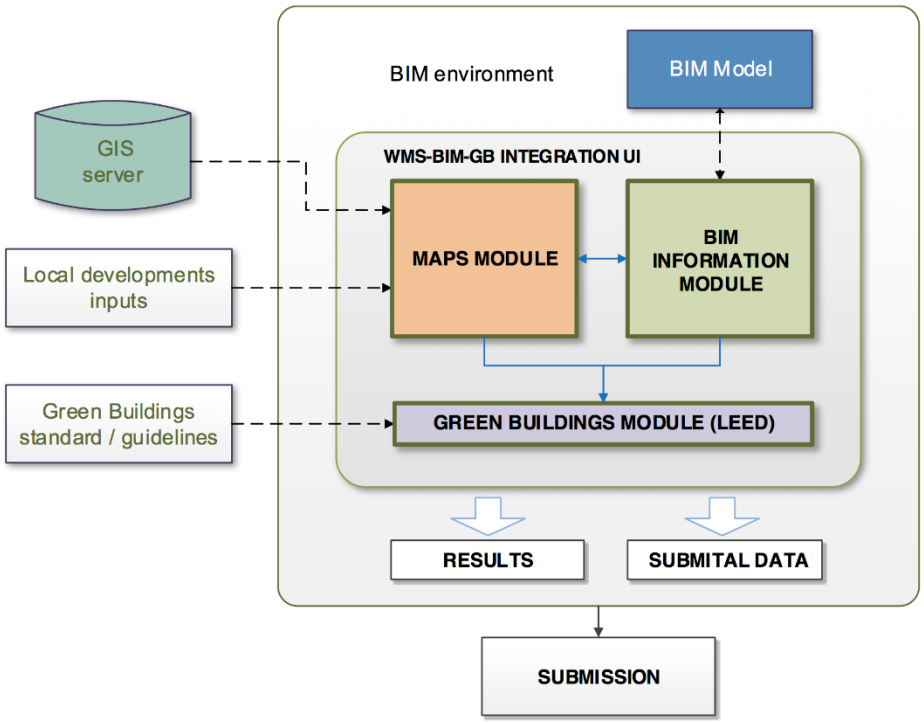


Figure 30. BIM-WMS-LEED integration framework

5. Integration model demonstration

5.1. *SSc2 credit – option 1:*

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 [8]. 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 formula:

$$\text{Density Radius (lf)} = 3 \times \sqrt{\left[\text{Site Area (acres)} \times 43{,}560\ \text{(sf/acre)}\right]}$$

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

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

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

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

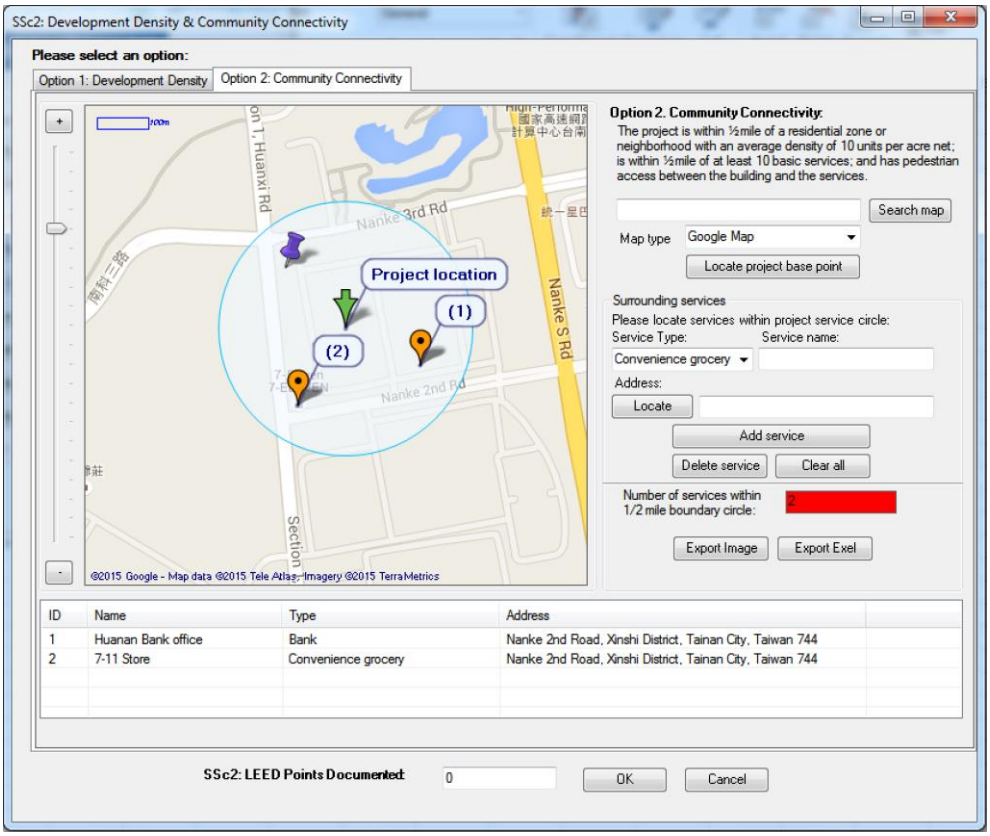


Figure 31. BIM integration model in LEED credit SSc2 – option 1: Development density

5.2. *SSc2 credit – option 2:*

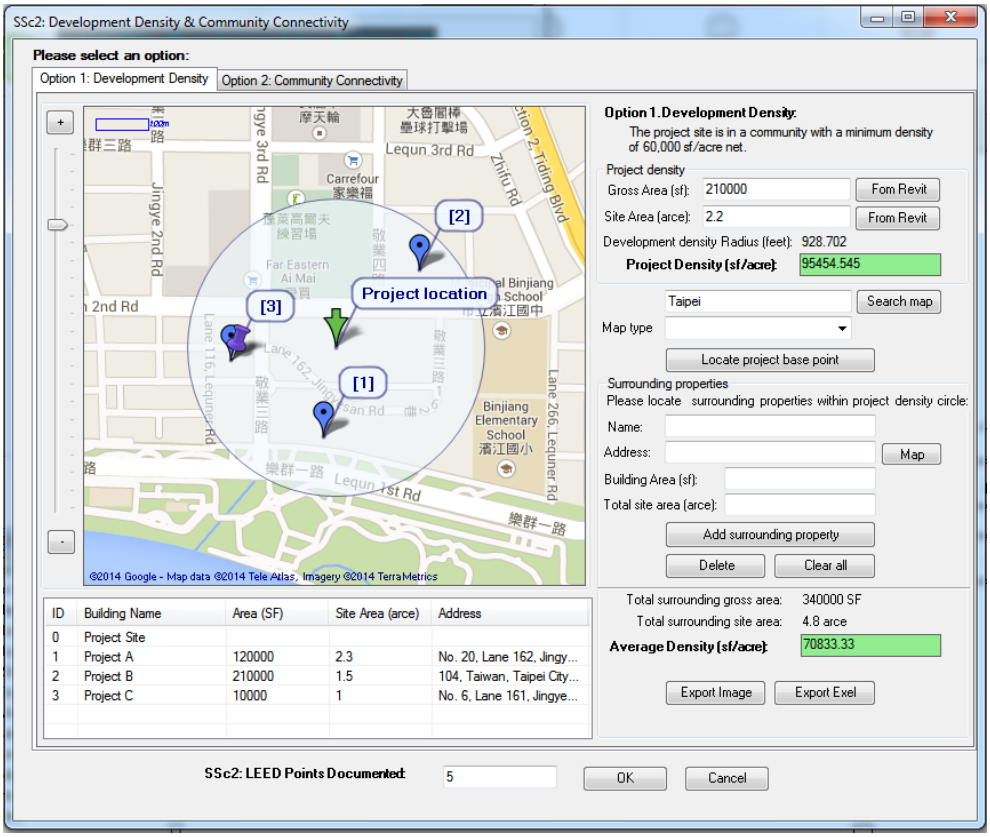
This option requires the project building to be constructed or renovated on a previously developed site within half a mile of at least 10 basic services with pedestrian access between the building and the services. The density circle is generated by the WMS module, with the density radius fixed at half a mile, as specified in LEED.

$$\mathrm{SR} = 0.5\ (miles)$$

Combining the map and the generated density circle, the user can input each of the surrounding services, such as school, laundry, etc., by placing a marker on the map. If Number of Services >= 10, then LEED points are obtained.

The following figure demonstrates the user interface of LEED SSc2 – option 2 location analysis in Autodesk Revit:

Figure 32. SSc2 Option 2 user 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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