

# Green Building Assessment and Recommendations for Optimization - Case Study of the Rectorate Building the University of Lampung

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## Abstract

The Green Building Concept is a concept that offers a method of managing buildings with less energy and resources utilization to minimize the environmental impact. Since its implementation to be mandator, it is time for the University of Lampung to start implementing this concept. This research was aimed at assessing the Rectorate Building rating based on the national standard on Green Building Certification (GreenShip-GBCI). There were several steps in conducting this research. Firstly, an opinion survey was conducted to measure the level of satisfaction of the building's users. Secondly, a series of measurements related to lighting, temperature, humidity, noise, and air quality were carried out. Furthermore, an interview survey related to the operation and maintenance of the building were conducted. Finally, all of these data were entered in the Green Building rating tool for existing buildings. The results showed that the Rectorate Building score was 23 out of 117. This score is way below the score for a bronze rating of 35. Therefore, corrective action must be taken in order the building operation management to meet the GreenShip-GBCI standard. Assessment also needs to be done on buildings throughout the university for a reference in developing the University of Lampung Eco-campus program.

**Keywords:** Green Building, GreenShip, Green Building Rating/Certification.

## I. INTRODUCTION

EXPERT estimates that 95% of human activities contribute to global warming due to CO<sub>2</sub> emissions they release into the atmosphere. Furthermore, buildings and construction activities contribute to global warming and a decrease in the earth's biocapacity since they consume about 35% of the world's energy, 12% of the world's water, produce 25% of the world's waste and emit 40% of the world's greenhouse gas. Meanwhile, world's cities, as well as Indonesia, continue to experience urbanization on a large scale which means an increase in the number of buildings.

The Green Building concept is an energy saving effort that can be applied to a building, new and existing. By applying the concept, buildings will be more energy efficient because they are designed, built and operated with the aim of minimizing the total environmental impact [9]. This concept can be applied to commercial, office and educational buildings. World campuses have long been applying the eco-campus. However, there is no visible sign of the University of Lampung to start applying this concept. In fact, it can

be assumed that the majority of the existing buildings in the university have not been designed according to the concept of an environmentally friendly building. Therefore, a study is needed to assess the application of green building for existing buildings at the university. In this case, it started with the Rectorate Building. The Rectorate Building was chosen since it is the most notable building at the university. The structure of the building is in a very good condition despite it was built 30 years ago. This will make it an interested object to conduct a study.

The reference used to assess the Green Building application of the Rectorate Building is the National Standard of GreenShip-GBCI (Green Building Council Indonesia). There are several stages in assessing the building according to the standard. Subsequently, the results on the Green Building performance of the Rectorate Building can later be used as a reference to review other buildings at the university as well as a benchmark in developing the Eco-campus program.

## II. MATERIALS AND METHODS

### A. Greenship Rating System

According to the GBCI [9], Green Buildings are new buildings that are planned and constructed or existing buildings that are operated by taking into account environmental/ecosystem factors and fulfilled requirements such as wise in land use, save water, save energy, save materials, reduce waste, indoor air quality, etc. A building can be said to have implemented the Green Building concept if it has successfully gone through an evaluation process to obtain Green Building certification. The assessment benchmark used is the Greenship Rating Tools.

Greenship Rating Tools contain rating items and each rating item has a value (point). If a building successfully implements the rating points, then the building will get points from those items. When the sum of all the points collected reaches a specified number, the building can be certified for a certain level of certification. However, before a building can be assessed for Green Building, it must fulfill the initial requirements for the assessment (eligibility) as follow:

1. Minimum building area is 2,500 m<sup>2</sup>.
2. Willingness for building data to be accessed by GBCI related to the certification process.
3. The function of the building is in accordance with the land use requirement based on the Local Spatial Planning (RTRW Bandar Lampung 2010 - 2030).
4. Own documents related to environmental impact analysis (AMDAL) and/or environmental management efforts plan (UKL)/environmental monitoring efforts (UPL).
5. Conform to building to fire safety standards.
6. Conform to earthquake resistance standards.
7. Conform to standards for people with disabilities.

The table below shows the six main criteria of Greenship Rating Tools in which each category consists of several rating items that have point of value. The total maximum point of Greenship final assessment is 117.

**Table 1.** Greenship Main Criteria and Final Assessment Point

Criteria	Point of Final Assessment
Appropriate Site Development/ASD	16
Energy Efficiency and Conservation/EEC	36
Water Conservation/WAC	20
Material Resources and Cycle/MRC	12
Indoor Health and Comfort/IHC	30
Building and Environment Management/BEM	13
<b>Maximum Total Point</b>	<b>117</b>

### B. Building User Questionnaire Survey

Greenship's rating assessment requires a building user survey to be conducted. A questionnaire/opinion survey was chosen because it is suitable for assessing element where there are different perspectives on system performance between different groups [11]. Aspects to consider in conducting opinion surveys such as techniques/methodologies, questionnaire types, and analysis of findings [8]. Adapted from Abernethy, Jinapala, and Makin [8], opinion surveys of building users are useful for gain insight and opinion regarding comfort and health aspects in the workspace. In this study, a quantitative method is utilized because they are easy and fast, reliable and easy. A set of questions was then set up to gain insights and opinions on the selected criteria. The questionnaire was asked randomly based on the people was available at the office since the assessment was conducted in Covid time. Respondents' answers can be classified with the help of a Likert scale, for example: very uncomfortable, less comfortable, quite comfortable, comfortable and very comfortable.

The questionnaires then analyzed using a frequency distribution. Frequency is a number that shows how many times a variable (denoted by a number) is repeated in a series of numbers. Frequency distribution is the arrangement of data into certain classes where each individual or item only belongs to one class. The objectives of the frequency distribution are:

1. Facilitate the presentation of data as it easy to understand and read as information material; and
2. Easier to analyze or calculate data, create tables and graphs.

Frequency distribution analysis is a type of descriptive analysis that includes a general description of the frequency of data variables such as mean, media, mode, deviation, standard, variance, minimum, maximum and so on. The statistical analysis of the frequency description is a descriptive statistic that describes the data in a quantitative form that does not include decision making through hypotheses. There are three types of frequency distribution analysis, namely: ordinary frequency distribution, relative frequency distribution and cumulative frequency distribution. The data used for descriptive statistics can be qualitative and quantitative. Subsequently, the ordinary frequency distribution can be divided into two types, namely: numerical frequency distribution in which class division is expressed in numbers; and event frequency distribution in which class division is stated based on existing data or data groups.

The responds then analyzed using the ordinary frequency distribution. A validation analysis is also carried out to check the missing value i.e. data that is not filled by the respondents.

In addition to user surveys, interviews were also conducted to household staffs managing the Rectorate Building. These surveys are an integral part of the

GreenShip Assessment Matrix since it can only be counted these surveys are done.

### C. Green Building Criteria Measurement

The followings are the explanation of the criteria measurement shows in Tabel 1.

#### 1. Energy Efficiency Measure

Energy efficiency measurement can be done through Energy Consumption Intensity (ECI) and overall thermal transfer value (OTTV). Electrical ECI is a term used to express the amount of energy consumption per square meter of gross building area in a certain period of time. ECI is expressed in kWh/m<sup>2</sup> per year [10]. In 2004, the Ministry of National Education of the Republic of Indonesia set guidelines for the standard value of ECI for buildings in Indonesia. It was acknowledged as quite efficient if the value did not exceed 12.08 kWh/m<sup>2</sup>/month for an air-conditioned room and 2.5 kWh/M<sup>2</sup>/month for a non-air-conditioned room.

#### 2. Indoor Comfort

Indoor comfort (thermal comfort) can be measured from the temperature humidity index (THI) and relative humidity (RH), noise level and air quality.

##### a. Temperature humidity index (THI)

The results of research by Kurnia et.al. [13], stated that the comfort index in comfortable conditions was in the range of THI 20-26. Determination of THI or comfort index can be determined from the value of air temperature (°C) and humidity (RH).

##### b. Thermal Comfort

Relative humidity (RH) and air temperature can be measured directly with the help of a device, namely a thermo-hygrometer (Figure 1). In each room, measurements were carried out in the morning, afternoon and evening, approximately 5 minutes in each measurement (Kurnia, et.al., 2010). In addition, indoor comfort can be achieved artificially by installing an air conditioner (AC).

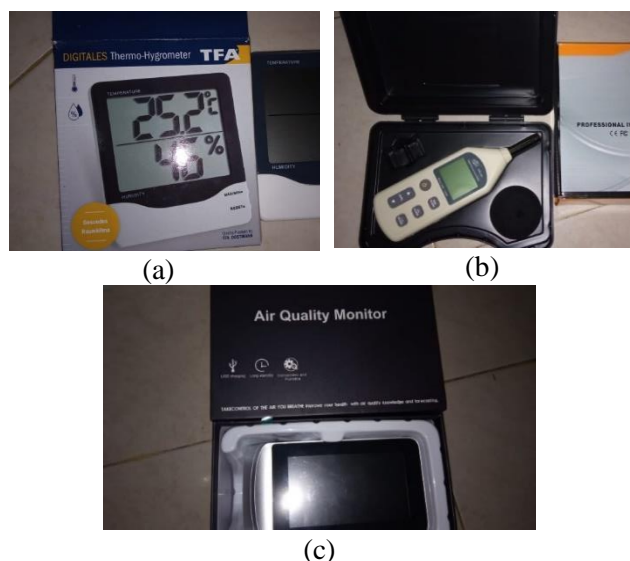
##### c. Noise (Acoustic Level)

SNI 03-6386-2000 regarding Specifications for Sound Levels and Reverberation Time in Buildings and Residential Buildings stated that the maximum recommended sound level should not exceed 65 dB [4].

##### d. Air Quality

Based on SNI 19-0232-2005 regarding Threshold Value of chemical substances in the workplace air stated that rooms with high density (general workspace) are required to be equipped with a carbon dioxide (CO<sub>2</sub>) gas sensor installation. This equipment has a mechanism to regulate the amount of outdoor air ventilation so that the CO<sub>2</sub> concentration in the room is not more than 1,000 ppm. In addition to CO<sub>2</sub> level,

the threshold value for chemicals in the workplace air requires that the maximum concentration for Volatile Organic Compound (VOC) is 0.37 mg/m<sup>3</sup> and Formaldehyde (HCHO) is 0.10 mg/m<sup>3</sup> [5].



**Figure 1.** Indoor Comfort Measurement Tools: (a) Thermo-hygrometer, (b) Sound Level Meter and (c) Air Quality Monitor

### D. GreenShip and Building Feasibility Rating Tools

To assess the Rectorate Building, the matrix used is GREENSHIP ASSESSMENT TOOLS FOR EXISTING BUILDING Version 1.1. [9].

### E. Methods

The object of the Green Building Assessment is the Rectorate Building of the University of Lampung. The assessments are carried out in several stages and utilized a quantitative method through opinion survey questionnaire, household staff interview, observations and measurements [1], [2], [12]. The data used in this study are primary data and secondary data. The primary data are data from direct measurements/observations and surveys, while secondary data is documents regarding the operation of the building.

Firstly, an opinion survey was conducted to measure the level of satisfaction of the building's users. A minimum of 30% of the total permanent users of the Rectorate Building were surveyed (87 respondents out of a total of 260 building users). The questionnaire was designed in the local language (Indonesian) and as short as possible (consisting of 20 questions). Both closed-ended questions and open-ended questions were used in the survey and were divided into two parts. Part A consists of general questions to identify the respondent's profile. Part B is intended to gather opinions of building users regarding the comfort of workspace (air temperature, room lighting levels, sound level, building cleanliness and the presence of pests (pest control)). A statistical analysis of the frequency

description was utilized to determine the distribution of responses from each user of the Rectorate Building. The results of the questionnaire survey were statistically analyzed using the SPSS (Statistical Program for Social Science) program.

Secondly, an interview survey to the building household staffs were conducted to find out information related to the operation and maintenance of the building. This information has to be supported by formal documents.

Thirdly, a series of measurements of indoor comfort and visual comfort were carried out in about 100 rooms located on the I to IV floors of the Rectorate Building. Measures on energy and water consumption were also conducted. Finally, all of these data were entered in the national standard of Green Building rating tool for existing building.

### III. RESULTS AND DISCUSSIONS

#### A. Results on Building User Survey Analysis

The results of the user opinion survey analysis can be seen in the following table:

**Table 2.** Results on Building User Survey

Criteria	Air Temperature	Lighting	Noise Level	Pest Presence	Others	Overall Criteria
Very Uncomfortable	0,0	0,0	0,0	0,0	0,0	0,0
Uncomfortable	0,0	2,3	3,4	1,2	0,0	2,3
Quite Comfortable	4,6	16,1	18,5	10,3	2,3	9,6
Comfortable	64,4	54,0	42,5	48,3	12,6	44,4
Very Comfortable	31,0	27,6	35,6	40,2	85,1	43,9
	100,0	100,0	100,0	100,0	100,0	100,0

The results show that 88,3% of users feel comfortable working in the Rectorate Building. Since it is more than 80% of the total respondents felt comfortable, the rating item related to building user survey received 2 (two) points. In addition to the frequency analysis, a validity analysis also carried out. Since there is no missing value, the analysis is considered valid.

#### B. Results on Parameter Measurement Analysis

The measurement of parameters such as air temperature and humidity, lighting levels, sound level and air quality was carried out using tools such as thermo-hygrometer, light/lux meter, digital sound level meter, air quality monitor, and laser distance measure. This survey was conducted for 10 days from 15 to 24 September 2022. The results of the measurement results can be seen in the following tables:

##### 1. Air Quality Measurement

The results of air quality measurement is shown below:

**Table 3.** Results on Air Quality Measurement

Floor	Room	HCHO		VOC	
1	Main Lobby	0,005	0,001	0,005	0,027
	Bureau of Academic and Student Affairs	0,039	0,026	0,177	0,038
2	Vice Chancellor of Student Affairs and Alumni	0,001	0,015	0,003	0,003
	Vice Chancellor of Academic Affairs	0,001	0,013	0,005	0,006
	Department of Finance	0,019	0,017	0,088	0,008
3	Bureau of Planning and Human Resources	0,001	0,001	0,127	0,127
	Department of Personnel	0,019	0,011	0,05	0,101
4	SDG's	0,03	0,001	0,002	0,008
	Meeting Room	0,001	0,002	0,008	0,076
5	Research and Community Service: Head	0,001	0,005	0,005	0,003
	Research and community service: Secretary	0,001	0,013	0,002	0,005
	Research and community service: Data and Information	0,011	0,019	0,008	0,003
<b>Air Quality Average Score</b>		<b>0,011</b>		<b>0,037</b>	

Measurement results on air quality in all rooms of the Rectorate Building shows the level of VOC and HCHO are below the maximum permissible concentrations. The first and second criteria of the rating item related to sources of indoor are pollution are VOC and HCHO level. Since the level of VOC and HCHO were under the threshold, then the building entitled 2 (two) points for this criterion. The third criteria is related to asbestos levels. This item does not get points because the building has never taken such measurement.

The fourth criteria related to regular maintenance schedule on cleaning filter, cooling coil and VAC (Ventilation and AC). The maintenance of these appliances are aimed at preventing the formation of moss and fungus as a media growth for microorganisms. Based on the interviews and supported by formal documents, cleaning of filters, cooling coils and VAC are carried out once a month. Therefore, for this rating item, the building gets 1 (one) point.

The fifth benchmark is measuring the number of bacteria with a maximum number of 700 bacteria colonies/m<sup>3</sup> of air and free of pathogenic germs in the room. This benchmark does not get points because the building has never taken measurements.

##### 2. Thermal Comfort Measurement

Results obtained from the measurement on the thermal comfort by using thermo-hygrometer are shown in the table below:

**Table 4.** Results on Thermal Comfort Measurement

Floor	Room	Measurement Results	
		Temperature (°C)	Humidity (%)
1	Main Lobby	26.9	66
	Bureau of Academic and Student Affairs	29.3	56
	Sub-department of House hold	25	57
	Sub-department of Government Own Properties	27.3	64
	Administration and Protocol	29.4	66
2	Vice Chancellor of Student Affairs and Alumni	27.2	66
	Vice Chancellor of Academic Affairs	27.6	63
	Vice Chancellor of Planning, Cooperation and Information & Communication Technology	28.5	68
	Department of Finance	25.9	69
	Staff of Vice Chancellor of Academic Affairs	26.3	65
	Bureau of Planning	27.3	53
3	Cooperation and International Services Development	27.7	68
	Department of Personnel	25.9	69
	Educational Development and Quality Assurance	26.9	52
4	SDG's	26.8	61
	Meeting Room	27.8	63
	Foundation Year Course	27.5	61
	Research and Community Service: Head	26.9	63
5	Research and community service: Secretary	29.3	67
	Research and community service: Data and Information	31.8	27
	Research and community service: Meeting Room	28.3	61
	<b>Thermal Average Score</b>	<b>27.6</b>	<b>61.2</b>

SNI 6390 - 2011 regarding Energy Conservation of Building Air Conditioning System stated that a room is considered comfortable if it has a temperature of 24°C to 27°C and a relative humidity of 60% ± 5%. Based on the thermal measurements, the average temperature and the relative humidity of the Rectorate Building were 27.6°C and 61.19% respectively. Since the measurement results are slightly above the SNI, then for this rating item no points are obtained.

### 3. Visual Comfort

Visual comfort in a room is measured through lighting conditions using a lux/light meter. Measurements are taken at a minimum of three location in each room. The table below shows the results of the measurement of the level of

illumination (illumination) which was carried out during the survey at 10.00 – 12.00 WIB.

**Table 5.** Results on Visual Comfort Measurement

Floor	Room	Lighting Measurement (Lux)
1	Main Lobby	328
	Bureau of Academic and Student Affairs	239
	Sub-department of House hold	203
	Sub-department of Government Own Properties	142
	Administration and Protocol	328
2	Vice Chancellor of Student Affairs and Alumni	259
	Vice Chancellor of Academic Affairs	314
	Vice Chancellor of Planning, Cooperation and Information & Communication Technology	288
	Department of Finance	107
	Staff of Vice Chancellor of Academic Affairs	176
	Bureau of Planning	305
3	Cooperation and International Services Development	144
	Department of Personnel	192
	Educational Development and Quality Assurance	172
4	SDG's	241
	Meeting Room	336
	Foundation Year Course	173
	Research and Community Service: Head	315
5	Research and community service: Secretary	234
	Research and community service: Data and Information	308
	Research and community service: Meeting Room	259
	<b>Lighting Average Score</b>	<b>241</b>

Based on SNI 03-6197-2000, the lighting level suitable for office is 150 to 750 lux depending on activities carry out in the room. The measurement taken on Rectorate Building shows an average luminance value of 241 lux. It can be concluded that in general the lighting has met the requirements despite there are still some rooms that less than 150 lux. For this rating item, the Rectorate Building gets 1 (one) point.

### 4. Noise level

Based on SNI 03-6386-2000, the noise level for public offices is < 45 dB. Since the noise level exceeds the requirement, the Rectorate Building do not get point for this item rating. The table below shows the noise level in all room of Rectorate Building exceeds 45dB.

**Table 6.** Results on Noise Level Measurement

Floor	Room	Noise Level Measurement (dB)				
		Location				
		1	2	3	4	5
1	Bureau of Academic and Student Affairs	51.1	60	65.9	67.4	59.3
3	Department of Personnel	54.8	52.1	54.4	52.4	52.7
5	Research and Community Service: Head	48.5	52.3	42.3	46.7	53.1
Average Noise Level		54.2				
Minimum Noise Level		40				
Maximum Noise Level		45				

**C. Results on Greenship Assessment**

All the assessment above then tabulated into Greenship Assessment Matrix. Points are obtained from the assessment process carried out on six criteria as describe in Tabel 1. The rating of a building is awarded based on the following:

1. Greenship Platinum; awarded when a building accumulates a total value of at least 74 points.
2. Greenship Gold: awarded when a building accumulates a total value of at least 58 points.
3. Greenship Silver awarded when a building accumulates a total value of at least 48 points.
4. Greenship Bronze: awarded when a building accumulates a total value of at least 35 points.

A summary of Greenship Assessment Matrix of the Rectorate Building is shown in the following table:

**Table 6.** Summary of Greenshipp Assessment

No.	Criteria	Maximum Point	Point Awarded
ASD 1	Community Accessibility	6	3
ASD 2	Motor Vehicle Reduction	3	1
ASD 3	Site Landscaping	4 - 5	0
ASD 4	Heat Island Effect	2	0
ASD 5	Storm Water Management	3	0
ASD 6	Site Management	2	1
ASD 7	Building Neighbourhood	5	2
<b>SUB TOTAL</b>			<b>7</b>
EEC 1	Optimized Efficiency Building Energy	14 - 27	0
EEC 2	Testing, Recommissioning or Retrocommissioning	3	1
EEC 3	System Energy Performance	6 - 14	1
EEC 4	Energy Monitoring & Control	9	2
EEC 5	Operation and Maintenance	3	0
EEC 6	On Site Renewable Energy	15	0
EEC 7	Less Energy Emission	6	0
<b>SUB TOTAL</b>			<b>2</b>
WAC 1	Water Sub-Metering	1	0
WAC 2	Water Monitoring Control	2	0
WAC 3	Fresh Water Efficiency	4 - 10	0
WAC 4	Water Quality	1	0
WAC 5	Recycled and Alternative Water	6	2
WAC 6	Potable Water	1	0
WAC 7	Deep Well Reduction	3	2
WAC 8	Water Tap Efficiency	3	0
<b>SUB TOTAL</b>			<b>2</b>
MRC 1	Non ODS Usage	3	0
MRC 2	Material Purchasing Practice		
MRC 3	Waste Management Practice	5	3
MRC 4	Hazardous Waste Management	3	0
<b>SUB TOTAL</b>			<b>3</b>

**Table 6.** Summary of Greenshipp Assessment (continued)

No.	Criteria	Maximum Point	Point Awarded
MRC 1	Non ODS Usage	3	0
MRC 2	Material Purchasing Practice		
MRC 3	Waste Management Practice	5	3
MRC 4	Hazardous Waste Management	3	0
<b>SUB TOTAL</b>			<b>3</b>
IHC 1	Outdoor Air Introduction	2	0
IHC 2	Environmental Tobacco Smoke Control	2	2
IHC 3	CO2 and CO Monitoring	5	0
IHC 4	Physical, Chemical and Biological Pollutants	9	3
IHC 5	Thermal Comfort	1	0
IHC 6	Visual Comfort	1	1
IHC 7	Acoustic Level	1	0
IHC 8	Building User Survey	4	3
<b>SUB TOTAL</b>			<b>9</b>
BEM 1	Innovations	3 - 5	0
BEM 2	Design Intent & Owner's Project Requirement	2	0
BEM 3	Green Operational & Maintenance Team	2	0
BEM 4	Green Occupancy/Lease	4	0
BEM 5	Operation and Maintenance Training	2	0
<b>SUB TOTAL</b>			<b>0</b>
<b>Total Maximum Overall Score</b>		<b>117</b>	<b>23</b>

Unfortunately, based on the above assessment, the Rectorate Building of the University of Lampung does not meet the requirement even for the lowest category of Green Building. The minimum point to get a Bronze rating is 35, while the Rectorate Building points only awarded 23 points.

Of the six categories assessed in Greenship, the sixth category that the University received did not score at all, namely the category of building environmental management. In this category there are 5 (five) criteria assessed, namely: innovation; project owner policy and design; environmentally friendly operation and maintenance team; Green contracts and operations, maintenance and training. From this it is known that there needs to be a policy issued to commit to Green Building, forming an environmentally friendly maintenance and operational team as well as training household staff to understand building operations and maintenance according to Green Building standards.

**IV. CONCLUSIONS**

From the results of this study, it can be concluded that the Rectorate Building does not meet even the lowest level of Green Building rating criteria. This also means that the operation of the Rectorate Building is not effective and efficient.

Therefore, the implementation of Green Building at the University of Lampung needs to start immediately as it can save the environment as well as save operational cost.

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