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# Analisis Of Important Factors Evaluation Criteria For Green Building

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**----------ABSTRACT----------**

*The concept of Green Building is one of the energy saving measures that can be applied to a building. This concept will be more energy efficient because they are designed, constructed and operated to minimize the total environmental impact. The concept of Eco-campus,one of which includes the application of green building have started to be developed in several universities since the past few years. This research is a case study of the application of the assessment criteria of green building in the Wijaya Kusuma University Surabaya (UWKS) campus buildings. The purpose of this study was to assess the rating criteria and the application of green building criteria in buildings on UWKS based on the national standard of Green Building Council Indonesia (GBCI). The method of research is done in stages, firstly, major building criteria selected by respondents according to GBCI standard criteria by interview or Likert scale (1-5) questionnaire. Secondly, based on the main criteria chosen, then direct measuring is done in some buildings that was selected by sampling purpose. The study concluded that the main criteria that is required UWKS building to have in order to perform as a green building according to GBCI includes: 1) the condition of temperature and humidity 2) room lighting levels, 3) water use efficiency 4) utilization of alternative water resources, 5) the efficiency of energy usage and 6) natural lighting. The results of the study also concluded that the campus buildings UWKS at this time has rating value of 65.22% (gold) according to GBCI. To raise the rating to green campus (eco campus) in the future, suggestion was given to the manager of campus buildings in order to undertake real efforts to improve the campus infrastructure according to GBCI.*

***Keywords*:** *eco-campus, green building,* GBCI, UWKS.

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## I. INTRODUCTION

The level of global awareness about the environment and climate change in recent years increased sharply. Various green movement was done to protect the earth by implementing various efforts of energy usage efficiency and environmental damage minimalization (Barbour, 2004; Ding, 2007). The global warming anticipation effort was also done by the construction sector, given the fact that the construction industry is the largest contributor of greenhouse gas emissions in the earth. Thirty to fourty percent of all $CO_2$ emission in the world was generated by construction waste, so every emmision reduction in a building will be a great leverage to the global warming anticipation effort (Firsani & Utomo, 2012).

The Indonesian government urrently also has announced to launch a national movement of energy savings, both in the efficient use of materials and the use of electricity and water savings in government offices, state enterprises, enterprises, and street lighting. A real effort to do is to apply the concept of Green Building (Aristia Princess A, et al., 2012). The concept of Green Building is one of the energy saving measures that can be applied to a building, because the building will be more energy efficient, designed, constructed and operated to minimize the total environmental impact. Green building is a building in which since the start of the process of planning, construction, operation, maintenance attention to the operational aspects of protecting, saving, reducing the use of natural resources, maintain quality, both in the building and the quality of indoor air quality and occupant health attention that all must adhere to the rules of continuity (GBCI, 2010).

The concept of Eco-campus, one of which includes the application of the green building concept or sustainable campus began to be developed in several private and public university since recent years. Eco-Campus aims to encourage individuals in the campus and campus guests to maintain the resilience of energy resources, water and natural resources and protect the environment through waste management, energy saving and environmentally friendly change behavior over campus. According to Thomashow (2009), sustainable campus is a campus that is implementing the vision of an ecological region with technology, character, community, programs that create and establish an environmentally friendly lifestyle to people who are part of the campus. There has been many ways to conduct an assessment of the buildings that will or has been constructed for commercial buildings, offices and campus buildings (Prayogo & Utomo, 2011). So now it is deemed necessary to get the method / model for measuring the performance of the buildings that already exist on UWKS campus.

This research is a case study of the application of the assessment criteria of green building in the buildings on UWKS campus referring to national standards (GBCI, 2010). The purpose of this study was to assess the rating criteria

(certification) and the application of green building criteria in buildings on UWKS campus based national standard Green Building Council Indonesia (GBCI, 2010). This research can also be used as a reference step of Eco-campus programs in the future.

## II. METHODOLOGY

This study is an assessment to measure and analyze the performance of *green building* of UWKS campus buildings based on standard criteria of national *Green Building Council Indonesia* (GBCI). The criteria measured are 31 of 41 criteria, because the 10 criteria could not be measured after the building stood (Aristia Putri A.. et al., 2012). The method of research is done in stages, firstly, major building criteria selected by respondents according to GBCI standard criteria by interview or Likert scale (1-5) questionnaire. Secondly, based on the main criteria chosen, then direct measuring is done in some buildings that was selected by sampling purpose.

The first phase done is by questionnaire to the respondents with a *random sampling* method. The number of respondents defined is 100 respondents that consists of board of trustees, chairman of the University / Faculty, staff academics, faculty, students, and employees. The respondents were asked to rate the level of achievement that will indicate which criteria are most important. After the preliminary survey data collection was completed, the data then analyzed to identify any criteria that specifies in the implementation of the *Green Building*, using the mean and standard deviation statistics.

Mean ; $Mean = \frac{\sum xi}{n}$

Standard deviation : $S = \sqrt{\frac{n\Sigma x^2}{n-1}}$

Based on the mean and SD values of each criterion, grouping then performed to determine the most important criteria.

The second phase was direct measuring of several buildings selected by purpose sampling based on the criteria selected of the first stage. In this study the observed variables on performance measurement criteria for *Green Building* in the UWKS campus buildings refers to the national certification body *(Greenship-GBCI)*, namely: 1) Appropriate Site Development 2) Energy Efficiency & Refrigerant, 3) Water Conservation 4) Material Resources & Cycle, 5) Indoor Air Health & Comfort and 6) Building & Enviroment Management.

In the second phase, observation was done quantitatively and qualitatively. Quantitative observation was done by direct measurement on the object of study, which is the buildings on UWKS campus to measure the level of *green building* assessment tools with commonly used medium. While the qualitative observations was done by verification interview, which utilizing the potential sources of information and opinions from the resources that have been described previously, namely: board of trustees, chairman of the university / faculty, faculty, staff or students who know the Green Building concept in general and observe / occupied buildings on UWKS campus daily to get information.

The data and information that has been collected from direct observation either by qualitative or quantitative analysis which resulting in an evaluation criterion of performance measurements on green building to UWKS buildings with the weight rating in accordance to the observations of researchers who refers to *Greenship* criteria. After the measurements made by the researcher through observation and verification interviews conducted then the assessment results collected will be analyzed by the rating results obtained according to the *Greenship* standard ranking.

## III. RESULTS AND ANALYSIS

### Preleminary survey

The initial survey carried out by spreading a questionnaire containing 31 green building criteria according to Greenship (Aristia, et al., 2012). The purpose of this survey is to find out the respondents' assessment of the main criteria in applying green building criteria. Respondents' assessment results can be seen in Table 2

### Mean test and standard deviation

Based on the results of the initial survey, then the average (mean) and standard deviation (SD) were calculated for each green building criteria based on the answers of the respondents above 86. The results of the calculation of the mean and SD for each criterion and their average can be seen in Table 2.

Based on the mean and SD of each green building criteria, then grouped into four groups:

1) Quadrant I ; mean ≥ 3,673 and SD < 0,801
2) Quadrant II ; mean ≥ 3,673 and SD ≥ 0,801
3) Quadrant III ; mean < 3,673 and SD ≥ 0,801
4) Quadrant IV ; mean < 3,673 and SD < 0,801

Green building criteria grouping results in detail can be seen in Figure 1 below. The main and most important group (quadrant I) according to the respondent's answer consists of:

1) Thermal Comfort.
2) Natural Lighting.
3) Water Use Reduction
4) Alternative Water Resource.
5) Energy Efficiency Measure
6) Visual Comfort

Table 2, Green Building Criteria and Calculation Results

| No. | Criteria for Green Building | Mean | SD | Group |
|---|---|---|---|---|
| 1 | Site Selection | 3,100 | 0759 | IV |
| 2 | Water Fixtures | 3,450 | 0507 | IV |
| 3 | Thermal Comfort | 4000 | 0615 | I |
| 4 | Rainwater Harvesting | 3,575 | 0626 | IV |
| 5 | Site Landscaping | 4075 | 0907 | II |
| 6 | CO2 Monitoring | 2,925 | 0803 | III |
| 7 | Storm Water Management | 3,825 | 0847 | II |
| 8 | Environmentally Friendly Proccesed Product | 2,850 | 0819 | III |
| 9 | Natural Lighting | 4,200 | 0664 | I |
| 10 | Ventilation | 4,325 | 1,093 | II |
| 11 | Regional Material | 3,175 | 0791 | IV |
| 12 | Advance Waste Management | 3,500 | 0629 | IV |
| 13 | Water Use Reduction | 4,300 | 0702 | I |
| 14 | Micro Climate | 3,850 | 0834 | II |
| 15 | Non ODS Usage | 4,275 | 0877 | II |
| 16 | Alternative Water Resource | 4,175 | 0551 | I |
| 17 | Energy Efficiency Measure | 4000 | 0765 | I |
| 18 | Water Efficiency landscaping | 3600 | 0724 | IV |
| 19 | Community Accessibility | 3,100 | 0868 | III |
| 20 | Chemical Pollutants | 4,175 | 0961 | II |
| 21 | On Site Renewable Energy | 3,950 | 0.850 | II |
| 22 | Certified Wood | 2825 | 1,177 | III |
| 23 | Water Recycling | 4075 | 0.860 | II |
| 24 | Pollution of construction Activity | 3,625 | 0.490 | IV |
| 25 | Building and Material | 3,625 | 1,184 | III |
| 26 | Public Transportation | 3,125 | 0.730 | IV |
| 27 | Visual Comfort | 4,150 | 0747 | I |
| 28 | Climate Change Impact | 3,150 | 0973 | III |
| 29 | Acoustic Level | 3,225 | 0898 | III |
| 30 | Bicycle | 3,475 | 0571 | IV |
| 31 | Environmental Tobacco Smoke Control | 4,175 | 0997 | II |
| | **Average** | **3,673** | **0801** | |

Source: Results of analysis

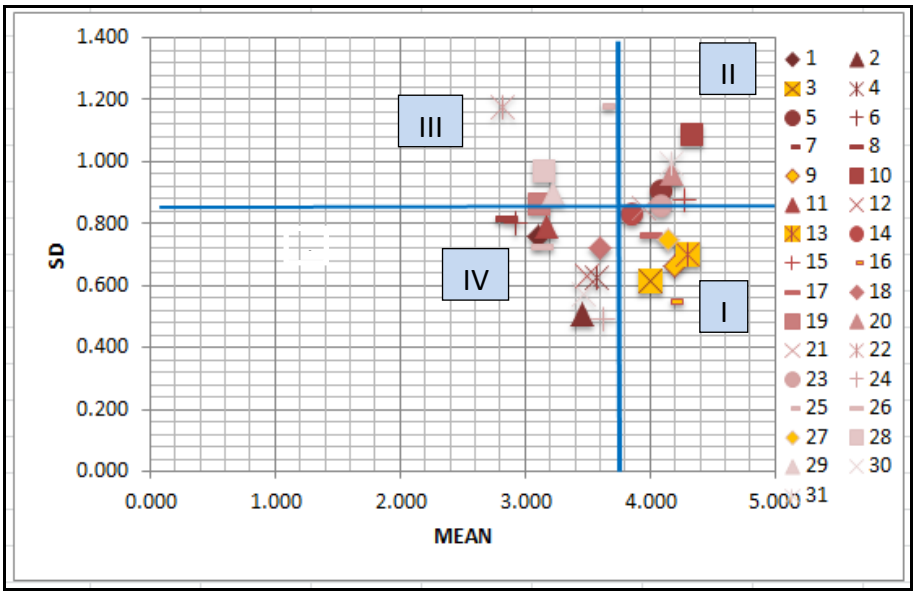


**Fig 1.** Relationship Diagram of Mean and SD
Source: Results of analysis

## Analysis of the most important criteria

### 1) *Thermal Comfort*

Is one of the green building criteria that define planning of general indoor thermal conditions at a temperature of 25° C and the air relative humidity (RH*)* of 60%. The results of temperature and humidity measurements of the rooms in some buildings are described in Table 3 below.

### 2) *Natural Lighting*

The existence of lux sensors for automation of artificial lighting when the natural light intensity is less than 300 lux, will get 2 points (GBCI). The results of measurements and their average for lighting levels in some buildings in UWKS can be seen in Table 3 below

Table 3, Temperature and Humidity and Lighting Level Measurement Results

| No. | Building Function | The average of Each Building | | Lights off (lux) | Lights off (lux) | Lights off (lux) |
|---|---|---|---|---|---|---|
| | | (O C) | RH ( %) | Day | Morning | Afternoon |
| 1 | Rectorate | 25.3 | 48% | 38.6 | 40.2 | 2.78 |
| 2 | Post Graduate | 24.6 | 47% | 23.3 | 54.2 | 2.78 |
| 3 | Library | 27.8 | 49% | 141.2 | 32.8 | 2.82 |
| 4 | Multipurpose Building | 27.5 | 52% | 113.3 | 22.7 | 2.81 |
| 5 | Faculty of Medicine | 24.7 | 47% | 124.8 | 22.8 | 2.77 |
| 6 | Faculty of Economics | 26.4 | 48% | 73.0 | 19.2 | 2.76 |
| 7 | Faculty of Engineering | 27.1 | 51% | 173.7 | 30.3 | 2.78 |
| 8 | Faculty of Law | 27.9 | 54% | 152.4 | 33.5 | 2.80 |
| | **Mean** | **26.41** | 49,5 % | **105.04** | **31.96** | |
| Note ; Temperature and RH standards GBCI | | | | 20-170 | 20-50 | 2-3 |

Sources: Direct Measurement Results.

### 3) *Water Use Reduction*

The average number of building occupants of UWKS campus during the last five years is about 7,500 people (UWKS profiles, 2012). The water requirement per day is assumed as follows;

The number of occupants is considered 75% on work / day. The water requirement = 75% x 7,500 people x 80 liters / day / person = 450,000 liters / hr. Effective needs per month = 450,000 x 22 days = 9.9000.000, - liters (75% taken from taps and 25% of drilled wells). So the water taps needs = 75% x 9.9 million = 7.425 million liters (7,425 $m^3$). Based on the water taps payment account from March to August 2013, the usage volume of water in UWKS and its savings can be seen in Table 4 below

Table 4, Water Usage Saving in UWKS Every Month

| Month /Year (2013) | Use the volume ($m^{3)}$ | Volume Needs (M3) | Saving (%) |
|---|---|---|---|
| March | 4,167 | 7,425 | 43.88 |
| April | 3,796 | 7,425 | 48.88 |
| May | 4,189 | 7,425 | 43.58 |
| June | 4298 | 7,425 | 42.11 |
| July | 4,291 | 7,425 | 42.21 |
| August | 4338 | 7,425 | 41.58 |
| | | **Mean** | **43.71** |

*Sources:* BAU UWKS, 2013 *(processed).*

### 4) *Alternative Water Resource*

Field observations indicate that the existing buildings on UWKS campus already utilize secondary water source as the alternative water source for saving water resources. It's estimated that 75% of the source water is from taps and 25% is of the drilled wells.

### 5) *Energy Efficiency Measure*

OTTV Value *(Overall Thermal Transfer Value)* and RTTV *(Roof Thermal Transfer Value)* according to SNI 03-6389-2000 is a maximum of 45 W/m2. The formula for calculating OTTV wall with a particular orientation is:

$$\mathbf{OTTV = \alpha\,[(Uw \times (1 - WWR)] \times TDek + (SC \times WWR \times SF) + (Uf \times WWR \times \Delta T)}$$

where:
OTTV = price on the overall thermal transfer happen outside wall that has a certain direction or orientation (W/ $m^{2)}$.
Î ± = solar radiation absorbtance
Uw = thermal transmittance opaque wall (W / $m^{2.}$ K).
WWR = ratio of the window with an area around the outer wall at the specified orientation.
TDek = equivalent temperature difference (K)
SF = factor of solar radiation (W / $m^{2)}$
SC = coefficient shade of tenestrasi system.
Uf = fenetrasi thermal transmittance (W / $m^{2.}$ K).
Î "T = temperature difference between the outside and the planning of the inside (taken 5K).
The formula for calculating OTTV entire outer wall:

$$OTTV = \frac{(Ao1 \times OTTV1) + \cdots + (Aoi \times OTTVi)}{Ao1 + \cdots + Aoi}$$

where:
Aoi = wall area on the outer wall i ($m^2$). Total area including all opaque wall surfaces and window surface area contained in the section of the wall.
OTTVi = overall thermal transfer value on the wall i.
The results of measurements on the energy efficiency of each building can be seen in Table 5. Average OTTV measurement results on 8 buildings (35 points) is equal to 26.08 W/m2 <45 W/m2 (GBCI).

Table 5 Use of Energy Efficiency

| No. | Building Function | Total Project Point Measurement | Mean OTTV |
|---|---|---|---|
| 1 | Rectorate | 3 | 30.5 |
| 2 | Post Graduate | 3 | 25.3 |
| 3 | Library | 6 | 35.3 |
| 4 | Multipurpose Building | 4 | 20.5 |
| 5 | Faculty of Medicine | 7 | 22.5 |
| 6 | Faculty of Economics | 4 | 24.5 |
| 7 | Faculty of Engineering | 4 | 25.4 |
| 8 | Faculty of Law | 4 | 24.6 |
| | **Mean OTTV** | | **26.08** |
| Standard GBCI = 45 W/m2 | | | OK |

Sources: Direct Measurement Results (processed)

6) Visual comfort *(*Rate of Lighting)

Is one of the green building criteria that define the planning of room lighting levels as recommended by SNI 03-6197-2000. Room lighting level for education institutions are shown in Table 6 below.

Table 6, Level Lighting Education Institute

| No. | Building Function | Lighting levels (Lux) |
|---|---|---|
| 1 | Classroom | 250 |
| 2 | Library | 300 |
| 3 | Laboratory | 500 |
| 4 | Canteen | 200 |

Sources: SNI 03-6197-2000, Table 1

The measurement of lighting levels (Ilumination) in 3 different time, which are morning (08:30), noon (13:00) and afternoon (17:00). The results measurement of lighting done can be seen on Table 7.

Table 7, Lighting Levels of Lecture Room

| Building Function | Lighting Conditions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Morning | | | day | | | afternoon | | |
| | On | Off | Dimmed | On | Off | Dimmed | On | Off | Dimmed |
| Faculty of Medical | 365 | 110 | 175 | 375 | 55 | 180 | 260 | 2.88 | 150 |
| Faculty of Medical | 360 | 115 | 165 | 380 | 50 | 175 | 260 | 2.90 | 120 |
| Faculty of Economics | 375 | 45 | 165 | 390 | 45 | 170 | 295 | 2.75 | 148 |
| Faculty of Engineering | 368 | 55 | 135 | 377 | 35 | 170 | 265 | 2.75 | 115 |
| Faculty of Law | 375 | 45 | 165 | 388 | 45 | 170 | 239 | 2.60 | 140 |
| Post Graduate | 355 | 75 | 150 | 370 | 50 | 160 | 230 | 2.65 | 100 |
| **Mean OTTV** | **366** | | | **380** | | | **259** | | |

Sources: Direct Measurement Results

Table 7 shows the lighting level of lecture halls in the morning, day, and afternoon. The average OTTV on lights on condition > 250 Lux, meaning that it meet the requirements of SNI 03-6197-2000. However, to save energy, in the morning and afternoon turning on all the lights are not necessary. In the same way, the calculation of the lighting level for the library, laboratory and cafeteria can be measured as Table 7. The results of measurements of the library, laboratory and cafeteria also meet the requirements of SNI 03-6197-2000.

**Value rating analysis**

Value Rating Analysis (certification) aimed to compare the *green building* criteria based on national standards point value (GBCI) with a point value based on the results of field measurements. The comparative results obtained is 47.8% (silver) by GBCI, as described in Table 8.

Table 8 Comparison Criteria *Green Building*

| No. | CRITERIA | GBCI POINT | UWKS POINT |
|---|---|---|---|
| 1 | Thermal Comfort | | |
| | Establish planning in general indoor thermal conditions at a temperature of 250 C and 60% relative humidity. | 1 | 1 |
| 2 | Natural Lighting | | |
| | Optimal use of natural light so that at least 30% of the floor area can used to work in natural light intensity of minimum 300 lux | 2 | 0 |
| | If the first point is filled and coupled with the lux sensors for automation of artificial lighting when natural light intensity is less than 300 lux, obtained the additional value of 2 points | 2 | 0 |
| 3 | Water Use Reduction | | |
| | Water consumption by 80% the number of primary sources without reducing the amount needed per person in accordance with SNI 03-7065-2005 as the attached table. | 1 | 1 |
| | Any reduction in water consumption of primary sources by 5% according to the reference in the first point will get the value of 1 with max value by 7 points | 7 | 5 |
| 4 | Alternative Water Resources | | |
| | Using one of the three alternatives as follows: AC condensation water, used ablution water, or rain water. | 1 | 0 |
| 5 | Energy Efficiency Measure | | |
| | Each decrease of 3 W/m2 from 45 W/m2 OTTV value (SNI 03-6389-2000) scored 1 to max 5 points | 5 | 5 |
| | Using the lamps with 30% lighting power, which is more efficient than the lighting power that is listed in the SNI 03-6197-2000 | 1 | 1 |
| | Lighting zoning for the entire workspace is associated with motion sensor | 1 | 0 |
| | Lamp switch placement is within arms distance when the doors open | 1 | 1 |
| 6 | Visual Comfort | | |
| | Using the lamps with room illumination (light levels) according to Table 1 SNI 03-6197-2000 | 1 | 1 |
| | TOTAL | 23 | 15 |
| | **Percentage** | **15/23 = 65.22%** | |

Sources; GBCI & measurement results

Each certified building must meet the pre graduation requirements (pre-requisite) of the six categories above. GBCI gives green building rank assessment based on the points. Greenship *platinum* building has 74 points, gold 58 points, *silver* 48 points, and bronze 35 points value. Thus the buildings on UWKS campus are included in *gold* category according to GBCI as it has 65 points.

## CONCLUSION

1. Measurement criteria of green building assessment on campus buildings UWKS concluded that there are 6 green building criteria considered most important by measurements on each criteria, ie; Thermal Comfort (temperature and humidity conditions), Natural Lighting (indoor lighting levels), Water Use Reduction (water use efficiency), alternative water resource (utilization of alternative water resources), Energy Efficiency Measure (energy use efficiency) and Visual Comfort (natural lighting).
2. The Green Building rating level certification on UWKS buildings amounted to 65.22%, or gold categorized by GBCI.

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