Analyzing the occupant’s awareness, behavior and obstacle in achieving energy efficiency in a campus building

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Abstract. Campus building is essential to be the pioneer of the energy saving-system in the society. Occupant’s behavior should be considered to better formulate an appropriate energy-saving strategy in the campus building. This paper identifies the social parameters in achieving energy efficiency in campus building using a quantitative approach. Data will be collected through survey involving the campus building’s occupants. Series of statistical tools consists mean ranking, Analysis of Variance (Anova) and factor analysis will be applied in this research. It is expected that this finding can be used to formulate an appropriate energy-saving system based on the occupant’s behavior evaluation.

Keywords: sustainable construction, awareness, behavior, building occupant, energy efficiency, green building

1. Introduction

Buildings contribute to energy consumption and gas emissions which have a significant impact to the environment. According to EPA (Environment Protection Agency), the building sector contributes to 39% of total energy use, 12% of total water consumption, 68% of total electricity consumption and 38% of total carbon emissions in all of America. In Indonesia, this sector is responsible for 50% of total energy use, and more than 70% of overall electricity consumption (EECCHI, 2012). From the amount of total energy use, the building sector contributes 30% of gas emissions in Indonesia.

Various programs have been established to anticipate the environmental problems mentioned above. The Ministry of Public Works and Public Housing has set the guidelines for implementing the sustainable construction principle in infrastructure (Permen PUPR No. 5, 2015). Sustainable construction is the implementation of the principle of sustainable development in the construction industry with one of aspects considered is environmental aspect. In building sector, the concept of green building is one of the solutions to environmental aspects.

Green Building is a building concept that is based on the principles and methodology of sustainable construction [1]. Green Building Council Indonesia (GBCI) states that a building that follows the Green Building standard that refers to Greenship is able to make energy savings between 26% to 40% every month. However, although green building principle come with solution to environmental aspects, more attention should be given to social parameters such as awareness and behavior of building occupant as part of a comprehensive energy-saving effort [2]. The energy-saving systems would not be enough to reduce energy consumption if the building occupant were not involved in the process [3].
This research will investigate the social parameters of Institut Teknologi Sepuluh Nopember (ITS) building occupants. As academics, the future thinking about environmental issues is most awaited by the community, because good environmental quality will sustain a good life [4]. Universities have a unique characteristic which require the development of specific research agendas for promoting pro-environmental behavior to achieve sustainability goals [5]. ITS has an initiative in creating a sustainable development with the Smart Eco Campus strategy that has been developed since 2011. Smart Eco-Campus, defined as reflection of the participation of the entire occupant to give more attention in creating safety environment around them, have a program to evaluate and revitalize ITS with a green building standard. However, as highlighted before, the energy-saving systems would not be enough to reduce energy consumption if the building occupant were not involved in the process. Rhodes University recorded more energy reductions of up to 9 percent when student change into greener behavior [6]. It shows that occupant behavior influence energy-saving achievement. As it is important to know the social parameters of the building occupant, this study includes measuring awareness and behavior of ITS building occupant which is conducting of lecturer, staff and student [7] and comparing based on the socio-demographic factor such as gender, age and education which also influence the green living behavior [8].

2. Literature review

Three theories underpinning this research are the principle of green building, energy saving as sustainable goal and energy-saving awareness and behavior as part of the social parameters of energy-saving. To get similar understanding about the concepts, these three theories are reviewed next.

2.1. The principle of green building

Green building is a philosophy and associated project and construction management practices that seek to: (1) minimize or eliminate impacts on the environment, natural resources, and nonrenewable energy sources to promote, the sustainability of the built environment; (2) enhance the health, wellbeing and productivity of occupants and whole communities; (3) cultivate economic development and financial returns for developers and whole communities; and (4) apply life cycle approaches to community planning and development [9]. The reference for green building application in Indonesia refers to GREENSHIP which was formed by Green Building Council Indonesia (GBCI). Green building assessment aspects that refer to GREENSHIP are: 1) appropriate site development (ASD); 2) energy efficiency and conservation (EEC); 3) water conservation (WAC); 4) material resources & cycle (MRC); 5) indoor air health & comfort (IHC); 6) building and environment management (BEM). Therefore, the terms of green building sometimes also referred to as sustainable design, sustainable construction, and other terms previously listed.

As it became part of sustainable construction, a building which referred to green building concept built with an emphasis on seven core principles across the building’s life cycle such as reducing resource consumption, reusing resources, using recyclable resources, protecting nature, eliminating toxics, applying life cycle costing, and focusing on quality. It is showed in Figure 1.

![Figure 1. Framework for green building as sustainable construction](image-url)
In the context of ITS, Smart Eco Campus Program has been initiated to promote energy efficiency across the campus building. Furthermore, several studies had also been conducted to evaluate energy consumption based on the Greenship Standard such as Civil Engineering Department building [10] and Rectorate building [11].

2.2. Energy-saving as sustainable goal
Although sustainable construction generally referred to sustainable development which is considered to environment aspect, social aspect and economic aspect, in 1994, Conseil International du Batiment (CIB) explained that the ultimate goal of sustainable construction is to create and operate a development environment based on resource efficiency and ecological design. Therefore, green building as part of sustainable construction also has a responsibility in achieving resource efficiency such as energy efficiency.

The Green Building Council Indonesia explains that energy efficiency and conservation in the application of green building concepts refers to the aim of encouraging energy savings and encouraging the use of new and renewable energy sources sourced from within the building site. As defined by IEC (Indonesia Environment and Energy Center) in 2018, efficiency is related to the use of less energy to get the same or even more benefits, or use the same energy but produce more benefits.

2.3. Social parameters of energy-saving
This can be possible to gain successful in sustainable construction if all stakeholders cooperate in its implementation and be supportive to changes. As showed in figure 2, not only client and contractor but also government, consultant, and end-user have a responsibility to creating sustainable in construction. The first factor that will start sustainable movement are awareness and knowledge, then behavior changes will only come when stakeholder commitment to it. Two main problems associated with the lack of a user’s knowledge about sustainability design and operation with regards to performance are: (1) lack of occupant knowledge about environmental control and operation of the building systems affecting the energy efficiency of the building as originally intended by architects and (2) occupant poor understanding about why the building was designed in a particular manner and how to operate the appliances of the buildings which impact on comfort and satisfaction levels in a sustainable building [12]

![Figure 2. The path for achieving sustainable construction [13]](image)

In social psychology, because there are several things that influence human behavior such as attitudes towards behavior, perceived behavior control, subjective norm, and intention, sometimes it’s caused complexity [14]. Several literatures explain that social parameters have become a fundamental barriers in achieving sustainable in construction because its complexity [15][16].

However, in relation to the success in achieving energy saving, the behavior of building occupants has a very important role. In the building sector, social parameters, such as behavior, lifestyles and
culture, are one of the factors that most influence energy consumption [2]. Energy-saving behavior refers to consumer decision-making processes related to energy consumption practiced to reduce energy consumption [17]. Energy-saving behavior changes of building occupant can save electricity consumption by up to 10% [18].

Within Indonesia context, there is still limited research has been conducted to investigate energy-saving behavior from the building occupant’s perspective. One of the study, Rohi etc in 2013, is measuring the green living behavior in Surabaya residential [19]. The finding of the research shows that there is a not too large gap between the knowledge and the behavior of electricity use. But, the research does not discuss why there are behavior that are contrary to energy saving efforts. Therefore, this research is needed because universities have an opportunity for promoting pro-environmental behavior to achieve sustainability goals, especially in Indonesia. As academics, the future thinking about environmental issues is most awaited by the community.

3. Research methodology
The research consists several steps such as variable identification, preliminary survey, main survey and data analysis.

3.1. Variable identification
Variables identified on this study are awareness and behavior variables that reflect energy efficiency efforts. In this research, will also be investigate the obstacle in green behaving which might be faced by the occupant. These variables are the results of literature review at the initial identification stage, it is showed in table 1, 2 and 3. Table 1 shows the awareness variables, table 2 shows the behavior variables and table 3 shows the obstacles variables from the literature review. These variables will be used in preliminary survey to determine the variables relevance was then performed by interviewing experts.

Table 1. Awareness variables from the literature review

| No | Awareness Variable                                                                 | Source |
|----|------------------------------------------------------------------------------------|--------|
| 1  | I know that energy saving influences the economic development of a nation         | [20]   |
| 2  | I should recognize the seriousness of resource depletion and make efforts to prepare for it | [20][21] |
| 3  | I know most of the energies we use are imported from overseas                     | [20]   |
| 4  | I know that it is important to practice energy saving to solve the issue of energy-resource depletion | [20][21] |
| 5  | I am interested in environmental issues                                           | [20]   |
| 6  | I have information and knowledge on energy saving                                 | [20][21] |
| 7  | I want practice energy saving cause it will help reduce energy imports, even though it is only I who practices this | [20][21] |
| 8  | If I practice energy saving, it will help solve the weather problems resulting from global warming | [20][21] |

Table 2. Behavior variables from the literature review

| No | Behavior Variable                        | Source |
|----|-----------------------------------------|--------|
| 1  | Turning off the tap after use           | [22]   |
| 2  | Alerting staff of a damaged tap          | [22]   |
| 3  | Take shorter shower                     | [23]   |
| 4  | Turning off the lights when leaving the WC | [22] |
| 5  | Turning off the lights when leaving the classroom | [22][23] |
| No | Behavior Variable                                                                 | Source |
|----|-----------------------------------------------------------------------------------|--------|
| 6  | Alerting staff of a blown lamp                                                   | [22]   |
| 7  | Checking if the computer is off when leaving the classroom                        | [22]   |
| 8  | Checking if the projector is off when leaving the classroom                       | [22]   |
| 9  | Turning off the computer when it is no longer necessary in the classroom          | [22]   |
| 10 | Turning off the projector when it is no longer necessary in the classroom         | [22]   |
| 11 | Turning off the public computer after using it                                   | [22]   |
| 12 | Unplug chargers and devices when not in use                                      | [6][19]|
| 13 | Full use of daylight                                                              | [6]    |
| 14 | Install low energy bulb(s)                                                        | [19][21]|
| 15 | Use a proper reading lamp                                                         | [21]   |
| 16 | Turn off laptop when not in use                                                   | [6][19]|
| 17 | Apply electricity-saving mode in laptop/computer if possible.                     | [18]   |
| 18 | Set temperature of AC as high as possible                                         | [18]   |
| 19 | Turn off AC when leave the room                                                   | [21]   |
| 20 | Close the windows and the doors when the AC in use                                | [21]   |

**Table 3.** Obstacles variables from the literature review

| No | Obstacle Variable                                             | Source |
|----|---------------------------------------------------------------|--------|
| 1  | Lack of environmental concern                                | [24]   |
| 2  | Lack of awareness of energy saving                           | [15][16]|
| 3  | Lack of policy and legislative measures                      | [15][24]|
| 4  | Lack of communication from stakeholders                      | [24]   |
| 5  | Objections from the vested interests groups                  | [15]   |
| 6  | Inadequate data and information                              | [15][16][24]|
| 7  | Lack of incentive support and motivation                     | [15][16][24]|
| 8  | Lack of social norms and lifestyles                          | [24]   |

3.2. Preliminary survey
As we highlighted before, the variables from literature review will be used in preliminary survey to determine the variables relevance by interviewing experts. Expert is individual who were knowledgeable about energy issues including the role of energy in the design and operations of buildings at least in five years of experience. The number of expert who will be used to preliminary survey is minimum of three people [7]. By using valid and reliable variables, it is hoped that the results of the research will also be valid and reliable [25]. The finding of this stages is used to develop the main survey questionnaire which will distribute to the respondent.

3.3. Main survey
Primary data is the perception of respondents, where data collection carry out at the main survey by distributing questionnaires to the respondent. The respondent of this study is ITS building occupant which is referred to lecturer, staff and student. Secondary data is electric and water consumption bills of ITS for around 1-2 years. The secondary data is used to do energy consumption audit. In this study, the number of sample is taking from certain population, so the sampling method refers to the model
developed by Isaac and Michael [25].

In this main survey will be carried out an assessment of the behavior of ITS building occupants in energy efficiency efforts. The questionnaire had closed-ended questions using a 1-5 Likert Scale with 1 representing as “strongly disagree”, 2 as “disagree”, 3 as “neutral”, 4 as “agree” and 5 as “strongly agree”.

3.4. Data analysis
Based on the background and the purpose, this study was categorized in descriptive-quantitative. Some explanation techniques of observed data can be explained by using table or diagram. Furthermore, it can be explained by using mean, modus and median [25]. But previously, data analysis would begin with a factor analysis process. Generally, factor analysis is used to reduce and summarize the data. [25] Factor analysis can be done with statistical software such as Statistical Product and Service Solutions (SPSS) using the KMO and Bartlett's test and Anti-image test. [26]

4. Conclusion and recommendation
From the literature review, the research gap has been identified that need to measure the social parameter such as awareness and behavior of the occupant building, especially in campus building. It is also identified that the measurement of energy-saving social parameter in Indonesia has not been widely explored, especially in campus building sector. It is expected that this research finding explains the ITS building occupant’s awareness and behavior in supporting energy-saving system. This finding can be used as the improvement tool as well as help the decision-maker to formulate appropriate energy-saving strategy based on the obstacles found to achieve energy-saving target.

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