# A Survey Regarding the Readiness of Campus in Indonesia on the Adoption of Green Computing

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***Abstract*— Green computing is an effort to utilize information and communication technology effectively and efficiently. Higher Education is an organization that actively and massively uses ICT products, both for educational activities and for its operations. The data for the analysis were conducted through in-depth interviews of executives at 26 universities in Java, Bali, East Nusa Tenggara, Sumatra and Sulawesi. Interviews were conducted to campus executives: Dean, Head of Department or Head of study program. The analysis showed that the common of why some universities have not implemented green computing policies are: Green computing was not the focus of the campus, there have been similar policies but it was ad hoc and not formalized, similar policies were being drafted and reviewed so that the relevant documents were not yet available. The results of the comparative test using Chi Square showed that there was a significant correlation between the number of students and lecturers with the possibility that the campus implement green computing or sub aspects of it in their college curriculum. In terms of e-waste management, Higher Education in Indonesia has started to manage their e-waste, but has not fully used the concept of EPR recommended by the Government of Indonesia.**

**Keywords—green computing, campus in Indonesia, institutional policies**

## I. INTRODUCTION

The excessive utilization of fossil fuels such as petroleum, coal and gas in various activities is a major cause of the release of greenhouse gas emissions into the atmosphere. Power generation, the use of electronic devices such as air conditioners, computers, smartphones, the use of motor vehicles, and industrial activities are examples of human activities that increase atmospheric CO2 emissions. Specifically in the field of Information and Communication Technology, [1] mentions that the ICT industry accounts for up to 2% of global CO2 emissions, which is equivalent to the amount generated by the aviation industry. In the case of environmental damage, any stage of the life cycle of ICT devices for use and disposal may cause environmental damage [2]. However, on the other hand, ICT can also be a tool that can be used to improve and maintain environmental sustainability. Thus, what we need to know is how to apply technology that is good for human, nature and environment. One of them is through green computing.

Green computing is one form of many environmentally friendly programs that focuses on the production and utilization of ICT devices and their infrastructure effectively and efficiently. Green Computing is one of the latest research topic trends and a continuous field that aims towards a sustainable future. A variety of different approaches have been researched and implemented as a possible direction towards maximizing green computing. Some of the thriving developments are virtualization, energy efficiency, reducing the use of hazardous substances in electronic goods, the use of energy monitoring software, etc. Although the main focus of many industrial policies and activities is in terms of energy efficiency, yet another approach has also become a trend, which is Cloud Computing [3,4]. Approaches in energy efficiency include many things. One of them is the formation of various policies that serves as guidelines and rules for the implementation.

Nationally, since 2012, the Indonesian government has issued a policy on energy efficiency, delivered in the "energy-saving movement campaign starting from the government building". The Indonesian government also conducts public campaigns simultaneously in 20 major cities in Indonesia. In addition, the Indonesian government has strictly issued five policy governing energy efficiency and use of energy, including energy conservation policies, especially in the field of energy saving, including, among others obligation to use the power plant technology and energy-efficient power conversion equipment. However, the implementation of existing policies is often not maximized. Every year there is always a growing need for energy that has not been followed by the wise use of energy. As for the hazardous waste (one of them electronic waste), the Indonesian government has issued 15 policies, although explicitly do not mention about electronic waste.

Research on green computing policy in higher education in Indonesia until now has not been found or not socialized properly. Therefore, the development of a green computing policy based on empirically proven research is essential. This research is conducted to maximize the opportunities for higher education in Indonesia to conserve the environment and reduce carbon emissions.

According to the [5], the number of Higher Education under the management of the Ministry of Research, Technology and Higher Education, in Java and Bali are as many as 3225 Higher education institutions. This number consists of Academy, Polytechnic, Institute, High School, and

University, whether private or not. Simply put, if at any higher education there are at least 1 computer laboratory containing at least 40 computer devices, then the total energy consumption required is quite high. In addition, electronic waste generated is also not small. In fact, many campuses have more than one computer lab.

The successful implementation of a green computing policy on higher education can be influenced by various aspects. This research tried to explore the things that made it possible to be part of the green computing policy in college. Data were collected through interviews and direct observation to some campuses on the Java, Bali, East Nusa Tenggara, Sumatra and Sulawesi of Indonesia. The results of this study were expected to be considered when preparing green computing policies in accordance with Higher Education in Indonesia in further research.

## II. GREEN COMPUTING ADOPTION

Previous research, both conceptual and empirical, addresses the subject of adopting the Green Computing or Green IT from a number of perspectives. Various terminologies have been used, such as Green IT adoption [6,7,1,8], Green IS adoption [9,10], Green Computing initiatives [11,12], Green IT Expansion [13,14] and the intent to Adopt the Green IT [8,15]. Until now, in Indonesia the research on Green computing has not been significant. Most of the published researches are about behavior in green computing. The research was conducted by [16] and [17] in West Java, [18] in Bali, and [19]. These studies were conducted to determine the tendency of green computing in companies, government and higher education.

We agreed that green computing adoption studies involved a causal chain that began with motivations and ended with green computing adoption. In this paper, we were inspired by several other studies [11,13,20,21] which had the same final goal of adoption of green computing. The studies are described in Table1.

TABLE I. GREEN COMPUTING ADOPTION

| Citations | Theoretical Foundations | Core Constructs |
|---|---|---|
| Cai, Chen and Bose [20] | Porter's concept of competitive advantage; diffusion of innovation (DOI) theory | Political, Economic, Perceived complexity |
| Kuo [13] | | Motivational factors: competitive pressures, Bottom line considerations, Legitimation pressures, Normative legitimation pressures, Social responsibility pressures.<br>Organizational factors: Organizational capabilities, Management influence<br>Technological constraints |
| Sarkar and Young [21] | Institutional theory; theory of reasoned action (TRA) | Managerial attitudes: Effective cost model, Awareness programs<br>External influence: Customer requirements, Government regulations |
| Bose and Luo [11] | Technology-Organization-Environment (TOE) framework; DOI; process virtualization theory (PVT) | Technological context: Sensory readiness, Relationship readiness, Synchronism readiness, Synchronism readiness, Identification and control readiness<br>Organizational context: Champion support, Resource commitment, Firm size.<br>Environmental context: Regulatory support, Competition intensity. |

## III. RESEARCH METHODOLOGY

This research was done by adopting research design from [22]. The research process can be seen in Fig. 1, which is a series of several studies. This paper discusses the results of processes that are in the oval shape, while the processes that are on the rectangular shape will be carried out in subsequent research.

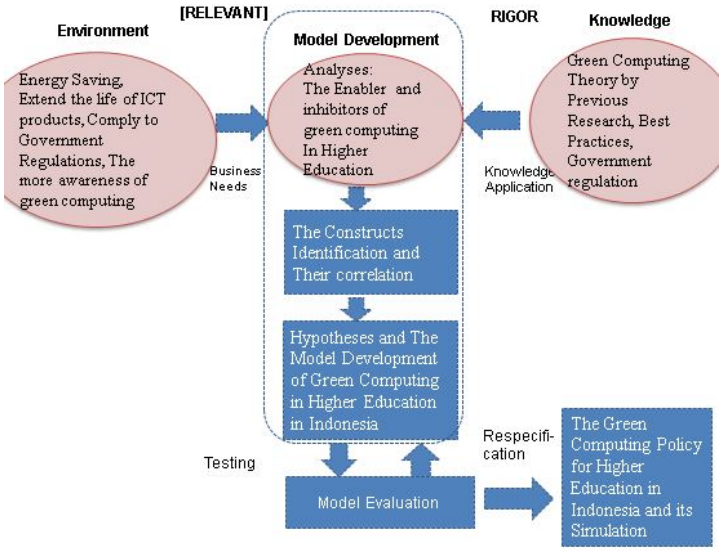


Fig. 1 The Research Method

The data collected for the initial analysis was conducted through in-depth interviews of executives or lecturers from 26 campuses in Java, Bali, East Nusa Tenggara, Sumatra and Sulawesi. Not only interviews, but also filling data through questionnaires has been done to determine the characteristics of the campus. The speakers were the campus executives, which are the Dean and the Head of the Department or the Head of the study program, because generally the campus policy was compiled and endorsed by the campus executives. Some interviews were done by visiting directly to the campus in question, while others were done via telephone. The characteristic of the campus being the object of data retrieval is shown in Fig. 2.

Interviews conducted were based on nine topics: Awareness of campus residents to green computing, existing green computing policies on campus, energy monitoring software, energy saving hardware, knowledge and understanding of campus community on government regulation on green computing, Leadership and role in the success of green computing, the possibility to include green computing on curriculum, strategic plan, and or master plan of campus

development, and e-waste management. However, in this paper the topic about energy and energy-saving energy monitoring software is not submitted, but will be discussed in separate paper. In this research, topic about e-waste is considered part of green computing because good management of electronic waste is one of the efforts to preserve the environment in relation to the age maximization of ICT devices.

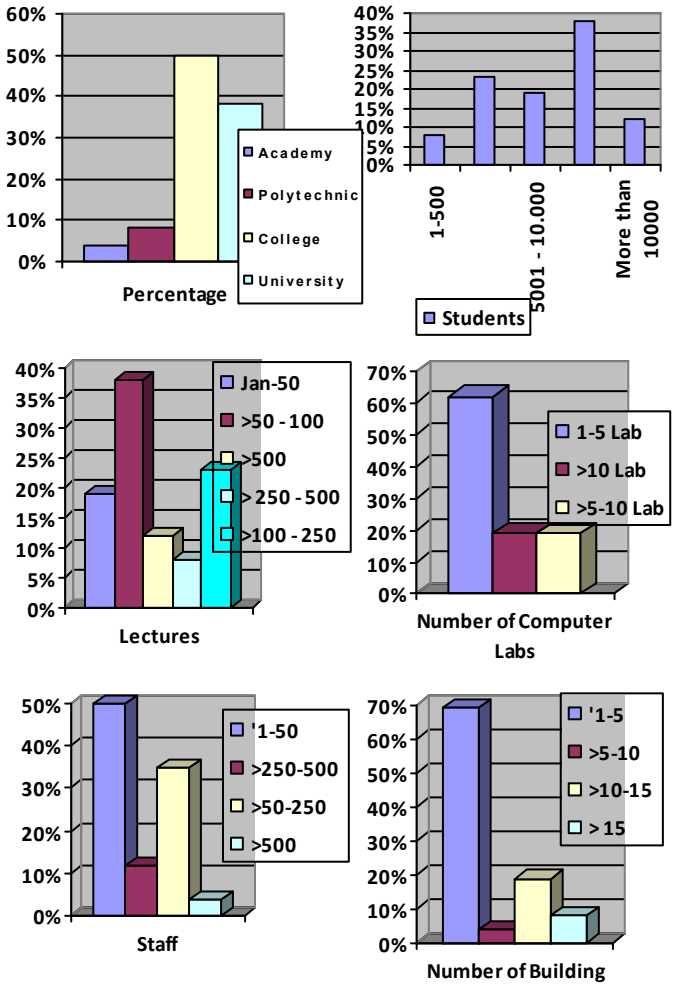


Fig. 2 the Campus Characteristics

Before being interviewed, informants were asked about their perceptions of green computing. This was done to equate perceptions about green computing. Table 1 shows the categorization of informants' perceptions about green computing. Fortunately, all informants mentioned things related to green computing and in accordance with the definition of computing in this study.

TABLE II INFORMANT ANSWERS CATEGORIZATION OF THE TERM GREEN COMPUTING

| Keywords | Number of answers |
|---|---|
| Energy savings of ICT products | 14 |
| The use of bioenergy in ICT | 1 |
| Environmental sustainability | 16 |
| ICT cost savings | 1 |

In this research, green computing is an effort to utilize information and communication technology effectively and efficiently to support environmental sustainability.

## IV. RESULT AND ANALYSIS

### *A. Availability and Direction of Campus Policy to Green Computing*

In order to develop an appropriate green computing policy, the first thing we need to know is whether or not similar policies exist in the Higher Education and understand the existing institutional policies. We tried to look at it from the kind of campus and the campus location. Fig. 3 and 4 show a recapitulation of resource responses on the Existence of Green Computing Policy based on Campus Locations and Higher Education types. Fig. 3 provides information that there is still a Higher Education that does not yet have a policy on green computing, while in Bali Island and other islands all the campus that became the object of research already have the policy. All of the informant (of the campus that already have internal policies green computing) mentioned that generally green computing policy in their Higher Education is about the purchase of energy-efficient computer devices such as LCD monitors, or devices that have digital inverter technology.

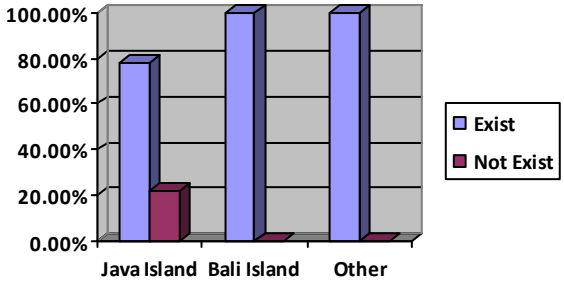


Fig. 3 The existence of Green Computing Policy based on Campus Location

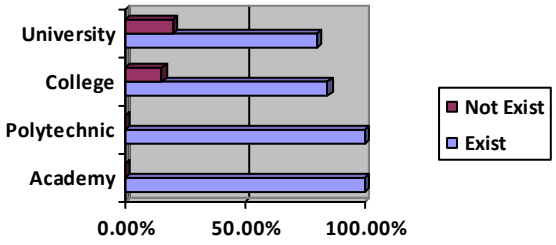


Fig. 4 The existence of Green Computing Policy based on Type of Higher Education

Fig. 4 provides information that there are still 20% of universities and 15.4% colleges of higher education that become research objects do not have green computing policy. It is certain that the Higher Education which has 15.4 % is located in Java Island. Some of the reasons why there was high education that had not implemented green computing policy were:

1. Green computing was not yet the focus of higher education.

2. There was already a similar policy but its nature was adhoc and not legalized, usually determined by the Chairman / Rector or authorized official based on the needs or certain cases. For example the need to buy servers, computers etc. devices.
3. Similar policies were still developed and reviewed so that related documents were not yet available or socialized on campus internal.

*B. Willingness and Possibility for Long-Term Commitment*

*1) Curriculum*

There are various ways for the campus to raise awareness of students, lecturers, and staff on the issue of green computing. Workshops and seminars can be organized on a semester basis or at least annually. Courses can be added to the engineering curriculum on IT investment, enterprise architecture, or solid waste management in general and E-waste management specifically.

Based on a survey conducted on 26 campuses in Indonesia, has not found a campus that specifically includes the topic / subject on green computing and sub aspect in their curriculum. In fact, as many as 34.61% of the informants stated disagree (or not necessary) that the green computing or sub aspect is in the curriculum. The result of non-parametric comparative test using Chi Square shows the result as Fig. 5 and Fig. 6.

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 15.484[a] | 4 | .004 |
| Likelihood Ratio | 15.046 | 4 | .005 |
| Linear-by-Linear Association | 1.576 | 1 | .209 |
| N of Valid Cases | 26 | | |

a. 9 cells (90.0%) have expected count less than 5. The minimum expected count is .38.

Fig. 5 Comparative test results between the Number of Students and the possibility of Green Computing contained in the Curriculum

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 11.622[a] | 4 | .020 |
| Likelihood Ratio | 11.317 | 4 | .023 |
| Linear-by-Linear Association | .275 | 1 | .600 |
| N of Valid Cases | 26 | | |

a. 9 cells (90.0%) have expected count less than 5. The minimum expected count is .38.

Fig. 6 The comparative test results between the number of Lecturers and the Possibility of Green Computing contained in the Curriculum

Fig. 5 and Fig. 6 shows that the value Asymp. Sig (2-sided)> 0.05 so it can be interpreted that there is a significant relationship between the number of students and lecturers with the possibility of applying green computing or its sub-aspects in their campus curriculum. In reality, the availability of expert lecturers in the field does affect a campus to define specific policies in their curriculum. On the other hand, the statistics show that there is no relationship between the number of staff and the possibility of green computing in the curriculum.

Globally, Green computing has already begun to be incorporated into the educational curriculum, although it is explicitly the new Communications of the Association for Information Systems [23] that publishes courses covering specific green computing topics in the field of Information Systems Science. In general, the topics on green computing are about e-waste management, green IT procurement, green data center etc. more are discussed in the clusters of information and communication science or computer science, but these topics are also discussed by other fields of science Such as environmental science (e-waste and environmental sustainability), economics and business (in relation to green IT investment to support business processes), and so on. Other studies that also examine and offer aspects of green computing specifically on curriculum such as: e-waste management [24], green economy [25] In addition to higher education, other studies also discuss the curriculum at other levels of education [26].

Still more in-depth analysis of the extent to which green computing can be part of the Higher Education curriculum is needed. However, the existence of the topic of green computing in the curriculum is a real effort to raise awareness of the importance of environmentally friendly technologies.

*2) Green Computing in the Strategic Plan / Master Plan of Campus Development*

In Indonesia every campus is required to develop a Strategic Plan (SP) containing the medium and short development of the higher education. It is regulated in Government Regulation Number 4 of the Republic of Indonesia Year 2014 on the Implementation and Management of Higher Education. Generally, SP is prepared for campus development over the next 5 years. Based on data collected, as much as 88.46% of the informants mentioned that green computing is one of the most important development agenda in their campus, and need to be included in the SP. Unfortunately, as many as 11.54% say it cannot be done. A further in-depth analysis is needed to find out the causes of the difficulties of higher education to discuss Green computing in their Higher Education Strategic Plan. A non-parametric comparative test using Chi Square did not found any variables that were significantly related to the strategic plan or master plan of Higher education. In reality, SP is a long-term thinking that involves a large number of parties including all stakeholders of the Higher Education. Since the SP changes the mandatory artifact of a higher education, it is natural that the SP variable is not influenced by other variables such as the number of students / lecturers / staff, the location of the campus, the physical number of the campus (laboratory / building), etc.

*C. The current e-waste scheme and its possible changes*

*1) The As Is of E-waste Management*

Observations have been made directly on 1 Higher education in Java and 4 Higher educations on the island of Bali on e-waste management. Fig. 7 shows a summary of the general e-waste process in those Higher Educations.

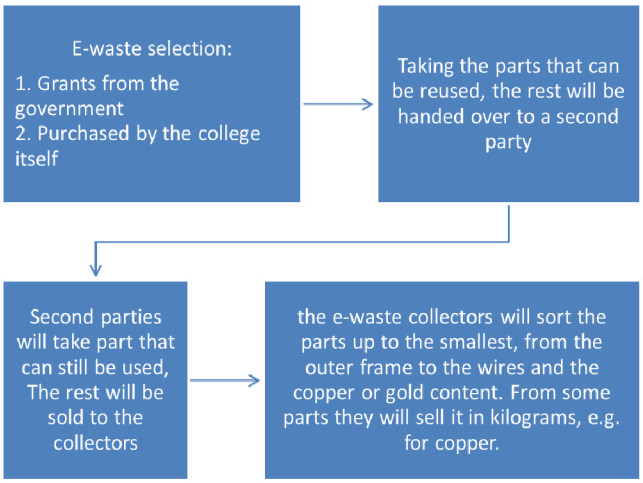


Fig. 7 The proccess of *E-waste Management* in higher education

The e-waste process in Fig. 7 can be explained as follows:

1. The first stage of PC or computer is sorted out between the government grant computer and the campus's own computer. For government grants computers, they will not be sold, even if they are damaged. They will still be stored.
2. Next, PC will be checked, which one can still be used or not. Parts that can still be repaired will be used again; parts that cannot be used will be collected and submitted to the second party by the campus management.
3. The second party will still re-check if there are any parts that can be reused or repaired it will be in use again. The unused portion will be sold to the collectors.
4. In 5 years on average there are 10-20 PCs that are stored. Not only PC but also other electronic equipment, such as printers, LCDs, dispensers and air conditioners.
5. The final stage of the survey on electronic waste collectors will sort again the parts up to the smallest, from the outer frame to the wires and the copper or gold content. From some parts they will sell it in kilograms, such as copper. Not yet known how the next process of the collectors for the remaining products.

*2) E-Waste Management Improvement Opportunity*

One of the systems already drafted by the Ministry of Environment of the Republic of Indonesia is Extended Producer Responsibility (EPR) [27]. EPR concept requested that producer responsible to monitor the distribution of product and handling of their waste, manage their e-waste, responsible to produce of environmental friendly product. From the survey, it has not been found a campus that adopts the concept of EPR. Higher education as consumer can bring their e-waste to the collection facility, where Collector will make the cooperation with producer and Local Government to facilitate the collection facility especially for the location. In addition, the collector also developed the incentive mechanism for the take back scheme mechanism. But the big challenge in implementing this EPR system is that we need to coordinate with local governments to disclosure the e-waste management system and to build programs on how to encourage community willing to collect their e-waste. We need to support coordination among electronic producer, refurbishment / Recondition Company and local government on how to build collection point.

## V. CONCLUSION

This research activity concludes that in Indonesia there were still higher educations that did not have official policy about green computing or its sub aspect. Generally it is because the Higher Education has not considered Green computing as a campus problem, some Higher education implements ad hoc policies that were fixed at any time by authorized officials for certain cases, others were due to the related policy documents still in the process of drafting.

When viewed from the willingness of higher education to commit long-term through the curriculum and Strategic Plan, some sources assume that the green computing need not be included in the curriculum, but possible in the campus strategic plan. Comparative test results also showed that there was a significant relationship between the number of students and lecturers with the willingness of the campus to include the topic of green computing in the curriculum. Lecturer readiness was needed if Higher education wanted to include the topic in the curriculum. However, the comparative test results against the variable Strategic Plan did not find any significant relationship with any variable. More research is needed on the extent to which Higher education can incorporate green computing topics in the curriculum or in their strategic plans.

With regard to e-waste management, higher education in Indonesia has implemented electronic waste management by sorting out products that can still be used. However, the management pattern has not involved the EPR concept recommended by the Government. Constraints faced in the implementation of the concept of EPR is the need to encourage community willing to collect their e-waste, and coordination among electronic producers, refurbishment / recondition company and local government on how to build collection points.

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