



Maximising Green Computing in Utilising ICT to Support the Performance of the Academic Community: An Analysis

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The rapid development of information technology makes ICT (Information Communication Technology) a prima donna in streamlining every business process in almost all institutions. However, a few uses of ICT actually pollute the work area because of a lack of concern in choosing and using the ICT equipment appropriately and correctly. Users only look at the function of the process speed by ignoring the functional and integration aspects of the technological device. For this reason, it is necessary to apply a green computing technology so that the use of ICT equipment becomes more effective and efficient, especially in supporting performance, in this case for the academic community. In the process of collecting data and information, the approach used in this research is the study of literature on green computing and the use of ICT sourced from national and international articles and journals, and supported by sources from text books, e-books, magazines and newspapers. The purpose of this study is to see how effective and efficient the use of ICT devices is in supporting the performance of the academic community and its impact on the environment. The results of this study are in the form of an analysis of the application of green computing technology in the work environment of the academic community, which is expected to encourage changes in governance in the use of ICT devices or equipment to be more efficient so as to reduce greenhouse gas emissions such as carbon dioxide (CO₂).

Key words: *analysis, green computing, ICT, performance*



1. Introduction

Technology is equated to humans who continue to grow from infancy to adulthood. The rapid development of the information technology has brought tremendous benefits for the progress of human civilization. Communication activities that previously demanded such complex equipment, now, have been replaced by automatic machines (Pandey et al., 2017). The working system of technology tools has transformed human muscle power with amazing magnification and acceleration (Novita, 2014). Likewise, the discovery of new formulations in the field of computer science, is as if it was able to shift the position of the ability of the human brain in various fields of science and human activity. The progress of information and communication technology that we have achieved has really been recognised and felt to provide a lot of convenience and comfort for the lives of humanity (Yadav et al., 2014).

The development of technology is considered as a solution of existing problems. As we know that in the modern era as it is today, the role of information technology in everyday life is certainly very influential. This is inseparable from our activities which are often supported by information technology itself which is able to answer work demands that are faster, easier, cheaper and save time (Kurniawan et al., 2013).

We take an example of what we see in the Universitas Terbuka Headquarters (UT) which is also not free from the touch of the development and use of this technology. In the current era of globalisation, the use of office technology is needed. Especially for professional workers, in this case they always use office equipment to help complete their jobs. The use of office equipment cannot also be done unsystematically; special skills and willingness to increase knowledge and skills in operating office equipment as work aids are needed.

The rapid development of office technology has several impacts; negative or positive impacts are something we cannot refuse. The more rapid development of science and technology and office equipment (machines) that are used are more sophisticated; this can affect job efficiency. Therefore, with this development we should be able to use and utilise the office equipment well, precisely, and quickly, hence that in the use of this office equipment we have optimal skills and use them according to their respective functions. From the description above, we can know that the role of office technology in the process of data and information at present is work efficiency that involves productivity (Lakshmi et al., 2012). This will happen if we always follow and use modern technological engineering devices, such as computer equipment and the like. Therefore, before using office equipment, we must first know how to operate it (Ramadhan et al., 2016).

University as an educational service provider in carrying out its operations cannot be separated from the use of information technology both in services to students such as KRS, DNU, KTPU, correspondence, student memos, announcements and academic info as well



as other supporting services such as internal and external operational administration. With so many data and information exchange transactions every day, both print and digital data, it is necessary to consider using this green computing technology to support operational activities to be more effective and efficient and to reduce and optimise the use of resources such as electricity, paper usage, computer optimisation, information technology devices that are not used and others.

Based on these phenomena, it is necessary to explain how to utilise appropriate green computing technology in the educational institution environment with the aim of creating an environmentally friendly work environment, also optimising existing work to be more effective and efficient and as a campaign that the application of this technology can be implemented starting from the world of education and becomes the basis of learning for students in applying environmentally friendly technologies in the workplace and in everyday life (Hariyanti & Wirapraja, 2017).

2. Green Computing

Green computing is an effort to provide education to the public regarding the use of ICT equipment that aims to improve resource efficiency in order to reduce the environmental impact of its use. This educational effort can be done with practice and policy (EMA Kaseya, 2008). In general, green computing can be interpreted as an action and program to minimise the adverse effects of the use of technology on environmental sustainability.

The emergence of the term green computing related to the manufacture and use of computer devices with the use of carbon in small amounts. The aim is to reduce the use of hazardous materials such as cadmium, mercury and other toxic substances (Soomro & Sarwar, 2012). In addition to reducing the use of hazardous materials, it is also to maximise energy efficiency over the life of the product. Another goal of green computing is managing power and energy efficiency, environmentally friendly hardware and software options and recycling components increasing product usage (Singh & Sidhu, 2016).

Applying green computing means offering solutions to preserve the environment and its resources. The form of the application is in the form of designing, making, using and disposing of the computer and its resources efficiently with the aim of minimising its negative impact on the environment, even if needed the impact does not appear at all (Singh & Sidhu, 2016).

2.1. The History and Development of Green Computing

The emergence of green computing was marked when the United States Environmental Protection Agency launched the Energy Star Program in 1992. The program was

demonstrated to the public by labelling computers and other devices with the "Energy Star" label. Basically, this program is designed to promote and introduce energy efficiency on monitors, climate control equipment and other technologies, with the initial technique being to raise sleep mode among electronic device users (Singh & Sidhu, 2016). Besides in the United States, in the same year, the TCO Development organisation in Sweden launched the TCO certification program. This program has an impact on reducing the use of CRT monitors, because they promote low magnetic and electrical emissions from the CRT-based screens. After the promotion, the program will be continued by including the criteria for energy consumption, ergonomics and the use of hazardous materials in construction (Wikipedia, 2019).



Figure 1. Energy Star Logo

Many government agencies have adopted standards and policies that encourage the implementation of green computing. In 2006, the Energy Star Program was revised to add more stringent efficiency requirements to ICT equipment. In 2008, a recycling program for outdated computers and electronic equipment that was often used both in the office and at home was formed (Wikipedia, 2019).

Many industries have also implemented green computing as a form of their concern for the environment, including (Wikipedia, 2019):

1. Climate Savers Computing Initiative (CSCI) is an effort to reduce PC power consumption in active and inactive states. CSCI provides an environmentally friendly product catalogue from its member organisations, and information to reduce PC power consumption. It started on 2007-06-12. This name comes from the Climate Savers program from the World Wildlife Fund, which was launched in 1999. WWF is also a member of the Computational Initiative
2. Green Electronics Council offers the Electronic Product Environmental Assessment Tool (EPEAT) to assist in purchasing "greener" computing systems. The board evaluates computing equipment on 51 criteria - 23 required and 28 optional - that measure the efficiency and sustainability attributes of a product. Products are rated

Gold, Silver, or Bronze, depending on how many optional criteria they fulfil. On 2007-01-24, President George W. Bush issued Executive Order 13423, which required all United States Federal agents to use EPEAT when purchasing a computer system.

3. Green Grid is a global consortium dedicated to advancing energy efficiency in the data centre and business computing ecosystem. The company was founded in February 2007 by several major companies in the industry - AMD, APC, Dell, HP, IBM, Intel, Microsoft, Rackable Systems, SprayCool (bought in 2010 by Parker), Sun Microsystems, and VMware. Green Grid has grown to hundreds of members, including end users and government organisations, all focused on improving the efficiency of data centre infrastructure (DCIE).
4. The Green500 list assesses supercomputers with energy efficiency (megaflops / watt), encouraging a focus on efficiency rather than absolute performance.
5. Green Comm Challenge is an organisation that promotes the development of energy conservation technologies and practices in the field of ICT.
6. The Energy Specifications of the Transaction Processing Performance Council (TPC) adds to the existing TPC benchmarks by enabling the optional publication of energy metrics in addition to performance results.
7. SPEC Power is the first industry standard benchmark to measure power consumption in relation to performance for server class computers. Other benchmarks that measure energy efficiency include SPECweb, SPECvirt, and VMmark.

2.2. Concepts and Supporting Elements of Green Computing

The concept of green computing itself has a working system that controls the performance and utilisation of resources in electronic and computer software. This control can be done through software, hardware, embedded systems, or manually by humans themselves, as a shared awareness to realise environmentally friendly technology, another working concept is how to utilise computer hardware and software better, more efficiently and more usefully, so that it can save resources and be more environmentally friendly (Saha, 2018).

There are 4 (four) main approaches that can be applied to increase social awareness and the promotion of green computing (Pazowski, 2015):

- a. *Green use*, taking environmentally friendly measures by minimising the consumption of electrical energy on other ICT computer equipment.
- b. *Green disposal*, recycling old and unused computers so they don't become waste.

- c. *Green design*, designing computer devices with other energy-efficient ICT devices such as printers, servers, air conditioners, and other digital devices.
- d. *Green manufacturing*, minimising waste in the process of making computer devices to reduce the impact on environmental pollution.

This approach includes several fields, efforts and actions in the use of computers and efficient computing. It is expected from these efforts and actions to find a way to achieve sustainability.

3. Green Computing Implementation

In implementing green computing, ICT in order to achieve a "green", there are at least three general categories that must be met and that (Singh & Sidhu, 2016):

- a) reducing carbon footprint to increase efficiency
- b) reducing the use of electronic goods
- c) changing lifestyles with a low impact on the environment

3.1. Green Computing Policy

The implementation of green computing in Indonesia gets centralised direction which is sourced from several ministerial regulations as well as government and other stakeholder regulations related to saving national energy. Some of these regulations are:

1. Law of the Republic of Indonesia No. 32 of 2009 concerning Environmental Protection and Management Chapter IV concerning the labelling of the level of energy efficiency of producers and importers of energy utilisation equipment.
2. Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia No. 13 of 2012 Chapter II concerning the implementation of savings in electricity usage.
3. Government Regulation of the Republic of Indonesia, namely PP No. 70 of 2009 concerning Energy Conservation Chapter II concerning the responsibilities of the government, local governments, entrepreneurs and the community in implementing energy conservation.
4. Decree of the Director General of Electricity and Energy utilization No. 238- 12/47 / 600.5 / 2003 dated October 6, 2003 concerning the procedures for affixing energy-saving sign labels.

5. Decree of the Head of the National Standardisation Agency Number: 10 / KEP / BSN / 2003 dated March 31, 2003 concerning the Indonesian National Standard (SNI) 04-6958-2003 concerning the label of the level of energy saving in the use of electricity for household and the like.
6. Law Number 30 of 2007 concerning Energy Part Five Article 8 concerning energy management activities that are environmentally friendly.
7. Government Regulation of the Republic of Indonesia number 79 of 2014 concerning National Energy Policy Part Two paragraph 1 concerning Energy Conservation, Energy Resource Conservation and Energy Diversification Article 17 paragraph 7 concerning guidance and application of energy conservation policies.

Many educational institutions in Indonesia have implemented policies that have been made by the government. Some of the examples are:

1. Universitas Terbuka Headquarter (UT) which is located in South Tangerang. The use of air conditioners in every room in the UT head office has been centrally set where to turn on and turn off automatically at the time of entry and return hours of office. The temperature of the air conditioner is adjusted to the temperature of the room. Besides, supporting devices such as copiers and printers have a standby mode with low consumption of electrical technology. Monitors that are used while working are monitors labelled Energy Star. In addition to the employees being asked to reduce the printing of email attachments, they are recommended to store attachments in their respective cloud on their Microsoft account. Not only that, employees are also reminded to print or photocopy if only needed and use blank pages for printing documents that are not too important such as letters that are still in draft form.
2. In Universitas Negeri Semarang, the classrooms do not use air conditioning because there are already many trees around the campus area that can make cool air around. That way, the production of carbon emissions can be reduced and energy savings also increased. In addition, attendance at Unnes for students and employees is done online, as well as the academic system which has been supported by the SIKADU (Integrated Academic Information System) application.
3. Universitas Brawijaya in the Faculty of Engineering changes the AC specifications with the capacity according to the needs of each room. The lighting system was also implemented with the use of TL LED lamps with 16W power and LEDs with fluorescent with 4W power.

4. Universitas Kristen Petra has an MVAC control system in the form of an energy audit Air Conditioning system in buildings W and P with the installation of the Smart Card Access Control Unit and access via fingerprint that serves to limit and control the use of artificial lighting in classrooms, offices and meeting rooms.
5. Universitas Multimedia Nusantara, controls the heat and sunlight that enters the room and also minimises the use of air conditioning. Some of the ways include controlling heat using a double skin façade, which in the end was able to reduce electricity consumption by 47%.
6. Universitas Udayana makes SOP guidelines in regulating usage schedules and replacing TL lamps with LHE lamps.

3.2. Green Computing Implementation and IT Utilisation

Some things that can be done to support green computing on computer devices include:

1. Buying a product with an energy star label, as already explained that the device labelled Energy Star is made based on the idea for less energy consumption and when not in use the device has been programmed into low power mode.
2. Shutting down the computer when not in use, because computers and devices consume a lot of energy and ultimately produce more CO₂ emissions.
3. Putting sleep mode or hibernate on the computer when not used for a short time, because in these two conditions the computer consumes less power.
4. Not using a screensaver because in this condition the electrical energy is still used even if the computer is not used.
5. Adjusting the PC power plan, thereby saving a lot of electrical energy. Because if the computer consumes more electricity, it will endanger the environment.
6. Recycling old devices with recycling techniques in specialised laboratories and things like this have been widely applied in several companies.
7. Using of LCD monitor screens, because it is more energy efficient than CRTs.

4. Maximising Green Computing in the Utilisation of IT to Support the Performance of the Academic Community

In its implementation there are many aspects related to green computing; this research focuses on the utilisation of hardware and infrastructure development needed by organisations to achieve cost and power savings, where the use of computing technology at this time is considered detrimental to the environment. With the use of green computing which is still considered a new technology, the aim is to design better computer system governance, both in terms of processing and of course must be able to make efficiencies in the energy consumption that already exist today. Because of the greater power consumption, it also directly has an impact on increasing greenhouse gas emissions such as carbon dioxide (Yadav et al., 2014).

In addition, this research was conducted to overcome the problems faced, such as excessive use of air conditioners in work spaces and meeting rooms, systems that emit carbon dioxide, thus making air circulation unfavourable and impacting employee health. All these problems can be solved by having a well-ventilated laboratory where there is a good supply of fresh air circulation (Novita, 2014).

Green computing elements include sustainability, environmentally friendly, efficient use of energy and resources and reducing useless work. The application of green computing can be done on data centres, workstations, work environments and on oneself.

The amount of energy needed in the data centre comes from the cooling machine, causing the data centre to become one of the biggest contributors to carbon dioxide emission pollution which is more than 70 million tons. Meanwhile, to clean up the pollution requires two billion trees (Kompas.com, 2015). In addition, data centres require large costs for maintenance and operations. The things that can be done to implement green computing in the data centre in the form of (Saha, 2018):

- a. Delivering energy-efficient server technology by controlling the temperature of the data centre.
- b. Virtualisation technology by consolidating and reducing the number of servers in physical form; how to create a virtual machine to be placed on multiple physical hosts, using shared storage and networking.
- c. Blade server technology, consisting of enclosure chassis components, server bays, fans and power supplies, interconnect devices, management modules and blade casings. With so less rack space requirements, simple cabling and lower power consumption.

- d. Data centre efficiency metrics are needed to measure, determine and validate data centre efficiency. One of them is by dividing the power that goes into the data centre with the power used to run the computer infrastructure in it. This can be done by utilising the PUE (Power Usage Effectiveness) metric.

PC at work station is the biggest contributor in absorbing energy in offices. Green computing actions can be done by (Saha, 2018):

- a. Power management technology found in the BIOS. Through ACPI (Advanced Configuration and Power Interface), this will cut at least 25% of energy consumption.
- b. The client group only uses 50% of energy consumption.
- c. Replacing it with a laptop, because its energy consumption is smaller, 5x more efficient than a desktop computer.

In the work environment, what can be done is to "replace" the work environment itself with teleconference, virtual office and teleworker. Skype and several other instant messaging applications are some that can help this happen. By implementing that, many savings can be obtained such as maintenance costs, operational costs and energy costs. It also saves work space and transportation costs.

As for oneself, many things that can be done to support the green computing movement are carried out well. Some things have already been done, but there are still a few small activities that might still be overlooked while being able to maximise green computing actions, for example:

- a) Minimising the use of fax, now there is an email for document circulation.
- b) Using recycled paper (reuse and recycle paper) to print documents that are not too important, such as a draft letter.
- c) Instead of buying a new computer, use an old computer but the system and device that have been upgraded, such as adding RAM to devices with a capacity of under 2 GB. This will reduce electronic waste.
- d) Recycling unused hardware in this case in accordance with the 3R concept (Reduce, Recycle, and Reuse) with the aim of reducing the impact of electronic waste disposal, for example by utilising used computers that are not used as grid computing.
- e) For certain documents, reducing font size and spaces and do double-sided printing (back and forth)
- f) Using an inkjet printer rather than a LaserJet printer
- g) Turning off the power and computers when returning home, because when the computer is off but if the socket is still installed, it still consumes electricity even though it is small.

- h) Enabling leaders and staff to digitally transmit files for example via e-mail, virtual group discussions or mailing lists, where this also indirectly trains leaders and staff in utilising technology properly and wisely.
- i) Utilising cloud servers that are intended for file sharing. For example, each subunit or study program has a cloud to store important files, no need to print documents. If at any time you need the file, the staff can easily get it.
- j) Trying to start implementing renewable energy resources for example by utilising solar panels or renewable fuels such as biogas as a substitute for electricity during the day to divert electricity consumption for example for lights and air conditioners.
- k) Turning off the AC in certain rooms when the room is no longer in use, such as meeting rooms and prayer rooms.

In addition, to maximise the application of green computing related to students, a number of lecture activities have also been carried out online, such as registration through the website and learning, both using the MOOCs or Moodle platforms. Continuing the example of the previous application of green computing, online registration and learning is also applied to UT with the concept of distance learning. For example, registration no longer fills in the form but can be done on the page www.sia.ut.ac.id and UT provides learning assistance for students by facilitating them in an online tutorial (tuton) that can be accessed on the page [http://www.elearning .ut.ac.id](http://www.elearning.ut.ac.id). With learning like this, UT has helped minimise the use of paper and excessive electricity consumption. Not only UT, there are still several campuses in Indonesia that implement e-learning as support for the green computing movement, including:

1. Universitas Gajah Mada with its e-LISA (eLearning System for Academic Community)
2. Institut Teknologi Bandung by providing studio e-learning facilities for students
3. Universitas Indonesia, applies online learning with a system where students can take one or several courses online and can obtain certificates / transcripts if they have met the evaluation of learning outcomes and declared to pass the relevant online course.
4. Institut Teknologi Sepuluh November, uses the name ITS Share as an e-learning recording platform which is short for Sharable & Reusable eLearning ITS.
5. Universitas Bina Nusantara, held an online lecture program called BOL, short for Binus Online Learning.

In the presentation of the Minister of Research Technology and Higher Education on the commemoration of National Education Day at the UI Campus, there are already 15-20 campuses in Indonesia that implement distance learning or e-learning. At least by implementing this e-learning, academicians have participated in protecting the earth with the green computing movement.



5. Conclusion and Suggestion

1. Green computing technology is the best solution for educational institutions to reduce waste of ICT devices and equipment that are no longer used.
2. The utilisation of green computing technology can be started from educational institutions as a facility to instil awareness for the academic community to create an environment free of waste and pollution both in the workplace and in the environment.
3. The wise use of technology, not only establishes a pollution-free environment, but it is also in order to make efficiency in the management process of educational institutions.
4. There are still many activities that must be carried out by institutions to maximise and support the green computing move.
5. The challenges in implementing green computing are indeed heavy, whether in terms of cost or device structure, but with increasing research in science and technology, these challenges are expected to be overcome.

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