Literature Review: Green Computing For Environmental Sustainability

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ABSTRACT

This research aims to provide an overview of Green IT to improve performance and social responsibility towards the environment. As technology develops, it will have an impact on the natural resources environment. If we do not limit the use of this technology, it will have a significant impact on natural resources. Green Computing is the right step to reduce CO2 emissions effectively. The research method was carried out by conducting literature studies from several journals (national and international) and taking the essence of the research. The type of data in this research uses secondary data, where data is obtained through electronic databases such as Google Scholar, Garuda (Digital Reference Guard), Sinta and from websites with high credibility on the internet that are appropriate to the topic being studied. The research results prove that the application of green computing can streamline and save electrical energy usage, reduce negative impacts on the environment and can extend the life of IT products.

1. Introduction

Technological developments make it easier for people to carry out their daily activities (Maritsa et al, 2021) and help the sustainability of companies or organizations (Puspitasari, 2018). On the one hand, technology advances and supports human life, but on the other hand it also threatens it (Hariyanto, 2019). If we look at it further and in relation to environmental sustainability, more and more computing devices are being used so that electrical power consumption will also increase from year to year. This increase in electrical power consumption is what every element of society needs to pay attention to if computing is not done wisely. Society expects companies to make profits and behave in an ethical, socially responsible, and environmentally friendly manner.

The concept of environmentally friendly activities in daily activities is known as the Go Green/Green Life campaign. This is a form of awareness for every element of society to care about its environment (Haryanto et al, 2021). The rise of environmental issues, especially global warming, has become a central theme today, including for Information Technology business people (Puspitasari, 2018).

One embodiment among many environmentally friendly programs that focuses on the production and utilization of Information Technology devices and infrastructure is Green Computing (Haryanto et al, 2021). Green computing aims to apply and utilize technology for a cleaner and more environmentally friendly planet. Green computing is essentially the study and application of

effectively using computing resources. This is a paradigm towards cost-effective and environmentally friendly energy use practices (Jnr et al, 2018).

The concept of Green Computing was introduced by U.S. in 1992. The Environmental Protection Agency (EPA) has a program called Energy Star to encourage and reward the use of energy-efficient monitors, temperature control equipment, and other technology. A scientific field known as "green computing" investigates, creates, and promotes methods to improve energy efficiency and decrease waste throughout the entire life cycle of computing equipment, from initial manufacture through delivery, use, maintenance, recycling, and disposal in a practical, cost-effective manner. The term Green Computing emerged with the Energy Star boom, specifically referring to how we can be efficient in energy consumption when using computing products. The basis of the movement is the need for economic viability (survival), social responsibility (social responsibility) and environmental impact (environmental influence) (Hariyanto, 2019).

Green IT (or Green IT) is another name for green computing. Green IT is the study and practice of creating computers, servers, and related equipment, such as monitors, printers, data storage devices, and network communications devices, in a way that has little (or no) impact on the environment. In its implementation, Green IT by a company can help the company reduce the cost of spending resources on Information Technology (IT) infrastructure, improve performance and use of its systems in accordance with the process of preservation and social responsibility towards the environment (Murugesan, 2008).

To combat the environmental impacts of technology use, green computing often employs comprehensive and effective holistic strategies. Important elements of the Green Computing strategy are as follows: 1) Green Use: reducing energy use while protecting the environment on PCs and other information system equipment, 2) Green Disposal: renewing and reusing obsolete computers, as well as recycling useless computers and electrical equipment. used, 3) Green Design: designing environmentally friendly materials and energy-saving hardware, for example servers, computers, data centers and cooling equipment. This can be achieved by utilizing innovative methods and environmentally friendly materials, and 4) Green Strategies and Policies: effective plans and policies provide value and concentrate on short-term and long-term profits. This is an important part of green IT and is in line with the Company's strategy and practices (Pracasitaram et al, 2019). The aim of this research is to provide an overview of Green IT to improve performance and social responsibility towards the environment.

2. Method

This research uses which employs the literature review methodology, are books and other written works. This research also uses a qualitative approach with a descriptive analytical research method that collects and recapitulates data that is not only recorded in the form of numbers but is explained clearly and in depth about organizational problems and needs (Zulkarnaen et al., 2020: 229). The function of the descriptive approach is to describe or provide an overview of the subject under study using sample and population data as they are, without doing analysis or drawing generalizable inferences (Zulkarnaen et al., 2018: 55). The descriptive analysis approach offers concise, unbiased, organized, critical, and analytical explanations and information regarding the examination of the significance of adopting green computing.

The type of data in this research uses secondary data, where data is obtained through electronic databases such as Google Scholar, Garuda (Digital Reference Guard), Sinta and from websites with high credibility on the internet that are appropriate to the topic being studied. The qualitative approach is predicated on gathering the necessary data in the beginning, followed by categorization and description.

3. Results and Discussion

Table 1. Article Identity

No	Journal Identity	
1	Title	“Review on Sustainable Green Internet of Things and Its Application”
	Writer	Dr. Abul Bashar
	Journal	IRO Journal on Sustainable Wireless Systems

	Year	2019
	Volume and Pages	Volume 1, issue 4, pages 256-264
	Access Date	15-09-2023
	ISSN	2582-3167 (online)
	Link	https://doi.org/10.36548/jsws.2019.4.006
	Conclusion	There are billions of devices in the Internet of Things, ranging in size from huge to small. Rapid technological development is fueling a huge rise in IoT-connected gadgets, which in turn raises energy usage. Researchers have suggested a variety of methods to lower the energy consumption of internet-of-things components. The overview in this article highlights a number of research that have been carried out to show prospective techniques for reducing IoT and linked device power consumption, as well as applications that make use of environmentally friendly IoT. This review will raise awareness for the creation of more intelligent internet of things applications.
2	Title	"Green Cloud Computing Solution for Operational Cost Efficiency and Environmental Impact Reduction"
	Writer	Dr. V. Bindhu, Mr. C. Vijesh joe
	Journal	Journal of ISMAC
	Year	2019
	Volume and Pages	Volume 01, issue 2, pages 120-128
	Access Date	15-09-2023
	ISSN	2582-1369 (online)
	Link	https://doi.org/10.36548/jismac.2019.2.005
	Conclusion	The application of green computing technology is necessary so that cloud computing can advance sustainably. The green cloud computing approach discussed in this article optimizes the environment while addressing operating costs and environmental impacts. Future work should consider more optimal elements such as virtualization, leasing, and consolidation. The entire life cycle of the virtualization process must be improved. Tenant privacy and security concerns must be addressed. Other important issues that need to be addressed include managing server downtime, combining virtual machines with intelligent support systems, and calculating threshold values depending on various factors.
3	Title	"Green Computing: Emerging Issues in IT"
	Writer	Ms. Amritpal Kaur, Ms. Saravjit Kaur
	Journal	International Journal of Trend in Scientific Research and Development (IJTSRD)
	Year	2019
	Volume and Pages	Volume 3, issue 5, pages 438-440
	Access Date	15-09-2023
	ISSN	2456 – 6470
	Link	https://doi.org/10.31142/ijtsrd25311
	Conclusion	Future computing will be greatly influenced by green computing. The continued and effective growth of information and communications technology (ICT) requires that new computer technologies, architectures, and applications meet green computing standards. Every problem in research and development has the potential to be solved with efficient computing in the future. To better understand it and plan future studies, we will analyze this issue further. The current barriers to achieving environmentally friendly computing are enormous and have an impact on computer performance. Apart from that, what needs to be considered is the efforts of the government and non-government organizations (NGOs). Government regulations pressure businesses to use less energy and be

		environmentally friendly. The focus of all these initiatives currently is on energy conservation and reducing e-waste, but efficiency and e-waste management will be key components of green computing in the future. Future work in the field of green computing will be based on academic research as there is still much to be done in this emerging field. Progress in this area is needed, especially in academics.
4	Title	"Green Computing to Reduce the Harmful Impact of Technology on the Earth"
	Writer	Mrs. S. Kayathri, Mrs. S. Girija, Ms. S. Meena
	Journal	International Journal of Applied Engineering Research
	Year	2018
	Volume and Pages	Volume 13, issue 11, pages 9965-9968
	Access Date	15-09-2023
	ISSN	0973-4562
	Link	https://www.researchgate.net/publication/334544583_Green_Computing_to_Reduce_the_Harmful_Impact_of_Technology_on_the_Earth
	Conclusion	For our civilization, environmentally friendly computing is very important. Electricity is now a major concern, but green computing can solve it. The time has come to use reusable computing resources efficiently. The focus of computing has shifted from complex algorithms to efficient energy use, reduced processing, and alternative energy sources. Capitalists now have new opportunities to utilize computer materials and e-waste thanks to environmentally friendly computing.
5	Title	"Contribution of Green Computing Towards It For Providing Sustainable Environment"
	Writer	Aabidah Nazir, Roshan Birjais, Insha Majeed
	Journal	International Journal of Advanced Research in Computer Science
	Year	2018
	Volume and Pages	Volume 9, issue 2, pages 222-227
	Access Date	15-09-2023
	ISSN	0976-5697
	Link	http://dx.doi.org/10.26483/ijarcs.v9i2.5658
	Conclusion	This essay discusses the necessity for green computing, approaches to green IT, and numerous measures done to ensure the success of green IT. While IT is essential for maintaining nature, it also adds to its overall deterioration. In this article, the major emphasis is placed on lowering carbon dioxide emissions and electricity consumption, which can help the IT sector become more environmentally friendly. Having a sustainable business is vital for small enterprises as well as for average people. We have made an effort to show how environmental sustainability and green IT are related. A overview of the literature on green IT's contribution to environmental sustainability is also included. More inventive designs and detailed measurement identification may be added to this effort to assist transition IT from non-green to green. In order to lessen the risks associated with the IT sectors and make the environment more eco-friendly and sustainably managed, the suggested model may also be improved by adding new aspects impacting the environment.
6	Title	"Green Computing Policies and Regulations: A Necessity?"
	Writer	Wilson Nwankwo, Akinola S. Olayinka and Kingsley E. Ukhurebor
	Journal	International Journal of Scientific & Technology Research
	Year	2020
	Volume and Pages	Volume 9, issue 1, pages 4378-4383
	Access Date	15-09-2023

ISSN	2277-8616
Link	https://www.researchgate.net/publication/338753749_Green_Computing_Policies_And_Regulations_A_Necessity
Conclusion	In the interest of sustainability and progress, this essay explores the extent to which the current environmental protection regulations cover the ideas and methods of green computing. The results demonstrated that while environmental protection regulations and laws exist, there are no definite specialized tools to identify, quantify, and regulate the environmental threat associated with electronic dumping and data center activities in Nigeria. The study comes to the conclusion that the inherent gaps in the laws are a result of the possibility that the growth of technology was not taken into account when the mentioned laws and regulations were drafted and passed. The paper makes the assumption that large data center deployment will continue to rise in Nigeria, particularly in industrial cities like Lagos, and that electronic waste generation and greenhouse gas emissions will result from the operation of such facilities. This assumption is made in light of the fact that owners of such facilities rarely replace them over time, even when their manufacturers deem them unfit for use. Reviewing the policies is advised, as well as carefully outlining the offense and green computing or environmental computing practices.

Benefits and Implications of Green Computing

Environmentally friendly technology has the potential to improve our ecosystem and improve the quality of life, reducing negative impacts on human health and the surrounding environment. More and more researchers are concentrating on applying green technology principles to the internet of things. The aim of green technology and its use in IoT is to reduce its disadvantages and increase its benefits. Desktop virtualization, reducing consumables and encouraging recycling and reuse are other tried-and-true methods of integrating eco-friendly technology into the internet of things. IoT applications that use environmentally friendly technology to increase sustainability. The application of green technology is very useful in various fields such as agriculture, smart city development, supply chains (Bashar, 2019).

Reduce carbon footprint, improve environmental friendliness, and optimize operating expenses in a green cloud computing environment by utilizing data mining and model-based engineering techniques. To reduce environmental impacts, this is done by optimizing resources in such a way that atmospheric pollution can be reduced to the maximum extent possible, thereby maintaining a green environment. For operational efficiency, this is done by increasing server utilization and reducing idle time. Cloud computing environments can use the auto-scaling functionality. With the help of this function, server utilization may be increased and idle time decreased. As a result, there are less CO2 emissions and a more ecologically friendly computing environment since power usage is decreased (Bindhu & Joe, 2019).

Nowadays infrastructure is a major issue in the IT environment and the reasons for this change are due to increasing computing requirements, energy costs and global warming. This shift is a major challenge for the IT industry. Therefore, research is currently concentrated on data center space, system cooling, and power utilization. On the one hand is the computing power that is important for business and on the other hand is the motivational drive, challenges of environmentally friendly systems and infrastructure (Kaur&Kaur, 2019).

Information and communications technology (ICT) rules, procedures, and personal computing practices are all included in the term "green IT." While optimizing the economic effectiveness of IT, its Integrated Systems, LAN, and data hub, citizens who employ sustainable or green computing practices strive to reduce greenhouse gas and e-waste. The use of systems in ways that conserve the environment, energy, and money is made clear (Kayathri et al, 2018).

Green computing not only reduces problems such as pollution, generating e-waste, maximizing greenhouse gases, but also provides additional benefits such as reducing energy consumption and thereby saving energy, being environmentally responsible and environmentally friendly, reducing the harmful impact of computing and its resources , facilitating energy-saving computing and

increasing productivity, enforcing the concept of recycling thereby reducing e-waste. Green computing has also attracted the attention of the business and industrial world on the grounds that the idea of green computing can reduce computing costs and can also extend the life of IT products because green computing is about using computers and related resources in an environmentally friendly environment in a responsible manner. answer (Nazir et al, 2018).

The need for optimistic and sincere planning that can stabilize human desires compared to the carrying capacity of the environment is something that is of concern to the government. These concerns have given rise to a number of laws, policies and environmental management approaches. These policies and management approaches have the following main objectives: 1) integration of environmental concerns into the main economic decision-making processes, 2) creation of environmental restoration costs into the main development schemes, 3) administration of economic tools for the management of natural resources, 4) implementation environmentally friendly technology in major development projects, and 5) mandatory use of Environmental Impact Analysis (AMDAL) for major development projects (Nwankwo et al, 2020).

The combination of new database technologies designed specifically for analyzing large amounts of data and resource-efficient open source software can help organizations save money and become more environmentally friendly. Organizations may do this by cutting back on their three primary areas: data footprint, deployment resources, and ongoing administration and maintenance.

The issue of reducing the environmental effect of fossil fuel emissions and global warming have moved to the top of the global public policy agenda. As a result, organizations and customers are beginning to adopt green goods that provide low-carbon solutions that not only enable them to cut their global greenhouse gas emissions, but also do it with more cost-effective and efficient energy use.

Green Computing Challenge

The number of sensors utilized and the volume of information provided present problems for developing an environmentally friendly IoT that is sustainable. Because IoT devices utilize a limited amount of energy and the communication method uses additional power, it is currently difficult to deploy environmentally friendly technologies in IoT. The acceptance and usage of software and hardware that reduce energy use, as well as the creation, collaboration, and interoperability of technologies to recognize and verify privacy and security, are additional concerns connected to the development of a green IoT. The involvement of computational techniques and continuous advances in communication methodologies are also important issues influencing the implementation of Green-IOT (Bashar, 2019).

Green computing currently has several challenges including: 1) equipment power density/power capacity and cooling, 2) increasing energy requirements for Data Centers and increasing energy costs, 3) controlling the increasing need for heat dissipating equipment, 4) increasing total consumption IT equipment power, 5) equipment life cycle management – Cradle to Grave, and 6) electronic waste disposal (Kaur&Kaur, 2019).

Environmentally Friendly Technology Products

Technology is something that cannot be separated from human life. The technology is driven by energy. Electrical energy is the energy most widely used today. As we know, the majority of electricity generation in Indonesia comes from fossils (petroleum and coal). However, the results of burning these materials are not perfect and produce carbon dioxide gas (CO2) which can cause a greenhouse effect which results in damage to the ozone layer. Electronic devices that support human activities without realizing it produce heat which has a big impact on global warming.

Currently, several IT products have experienced significant developments in supporting green or environmentally friendly technology. One motherboard vendor, ASUS, uses a technology called EPU (Energy Processing Unit). GIGABYTE also released a similar technology called DES (Dynamic Energy Saver). These two technologies function to save electricity consumption. With this technology, motherboards produced by both manufacturers can save electrical energy without sacrificing performance.

Apart from that, MSI also released a new product called Low Cost PC which apart from using little energy, is also small in size. With dimensions of 300x65x240mm, this PC only uses less than

60 watts of energy. Even though its size is small, its capabilities are almost the same as a PC in general.

Figure 1. Example of an Environmentally Friendly Laptop: Acer Aspire Vero

The Acer Aspire Vero laptop is an environmentally sustainable product, reducing CO2 emissions by 21%1. Easily upgraded, recycled and adapted to our planet's needs. Aspire Vero is made from Post-Consumed Recycled (PCR) plastic, used plastic that is recycled and reused as an effort to reduce global waste. The keyboard keys use PCR to reduce the carbon footprint.

Figure 2. Example of an Environmentally Friendly Monitor: Acer Vero BR277

Acer Vero BR277 is an FHD monitor made with 50% PCR plastic and has environmentally friendly certification from ENERGY STAR®, TCO and EPEAT. This monitor packaging is 100% recyclable.

4. Conclusion

The advancement of information technology facilitates activity acceleration and very quick progress. The development of information technology is also accompanied by negative impacts on the environment. Apart from that, the use of fossil energy also has the potential to increase the threat of global warming. A simple solution to prevent these energy problems is to save and be energy efficient. Maximum energy savings will be realized if you understand the concept of energy management and get the support and participation of all parties, namely by implementing green computing.

Green computing is the study and application of resource-conserving computer usage. The application of green computing can streamline and save electrical energy usage and reduce negative impacts on the environment.

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