International Journal of Computer Applications Technology and Research
Volume 12–Issue 12, 48 - 71, 2023, ISSN:-2319–8656
DOI:10.7753/IJCATR1212.1009

Green Computing: A Comprehensive Review of Sustainable IT Practices

Mohammed Swaleh

ICTS Department

Technical University of Mombasa

Kenya

Prof. Franklin Wabwoba

Department of Information Technology

Kibabii University, Kenya

Abstract

The objective of the study titled "Sustainable IT Services: Assessing the Impact of Green Computing Practices" is to analyze existing literature on green computing and its effects on sustainable IT services. The aim is to identify crucial concerns and strategic areas that can enhance customer value, business value, and societal value. The paper examines sustainable IT techniques, including power management, virtualization, enhancement of cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure to fulfill sustainability criteria. According to the authors, sustainable IT strategies are expanding the concept of sustainability beyond energy consumption and product considerations. This expansion requires the restructuring of both the IT organization as well as the overall practices in order to fully achieve the strategic advantages of green computing.

In essence, this paper provides a significant reference for institutions who wish to understand and adopt sustainable IT practices, particularly in the realm of green computing.

Keywords: Green Computing, Sustainable IT, ICT sustainability, Sustainable Computing, Green IT, Green ICT, Green Technology

International Journal of Computer Applications Technology and Research
Volume 12–Issue 12, 48 - 71, 2023, ISSN:-2319–8656
DOI:10.7753/IJCATR1212.1009

INTRODUCTION:

1.1 Background of Study

Green computing, sometimes referred to as green IT or ICT sustainability, is the approach to the design, production, utilization, and disposal of computers and other technological devices with the aim of reducing their negative impact on the environment. The primary objectives of green computing are to optimize energy efficiency throughout the lifespan of the product, and enhance the recyclability or biodegradability of obsolete products and waste generated in factories [Gichuki et al., 2018].

Green computing is crucial for all types of systems, ranging from portable devices to extensive data centers. The environmental impact of the IT sector is substantial, representing 5-9% of global electricity consumption and over 2% of total emissions. Hence, in order to maintain competitiveness, data centers and telecommunications must enhance their energy efficiencyand increase their reliance on renewable energy sources[(*Between 10 and 20% of Electricity Consumption From the ICT* Sector in 2030?*, 2018)]].

There are multiple strategies that both corporations and individuals can adopt to enhance sustainability in the field of information technology. These strategies encompass server collocation, adherence to data center best practices, migration to the cloud, and utilization of cutting-edge IT technologies [(*Sustainable IT: Ways IT Can Be More green and why it matters*, 2019)].

Green computing includes the utilization of energy-efficient central processing units (CPUs), servers, peripherals, power systems, and other IT equipment. Additionally, it emphasizes the reduction of resource consumption and the efficient management of electronic waste[(*What Is Green Computing? | Definition From TechTarget*, 2023)].

Another sustainable IT strategy is server virtualization, a method that enables numerous virtual machines to operate on a single physical server. This approach effectively reduces energy

usage and carbon footprint[(Expert Panel, 2023)].

Green computing offers numerous advantages for both the environment and enterprises. According to Zaveria(2023), adopting energy-saving measures can yield several benefits, including cost savings, decreased greenhouse gas emissions, enhanced health and working conditions, and improved brand reputation.

Green computing is an all-encompassing method for implementing sustainable practices in the field of information technology. It entails the use of several tactics and approaches to minimize the environmental consequences of IT operations. Green computing, as defined by TechTarget in 2023, refers to the practice of using computer resources in an environmentally friendly and sustainable manner.

1.2 Problem Statement

Currently, the majority of operations in Kenya have been digitized, resulting in a significant dependence on the ICT hosting systems that support them. Consequently, there has been an acquisition of more hardware to meet the increasing demand for further digitalization of services. Nevertheless, the absence of sustainable technology for the implementation and deployment of ICT in both commercial and governmental organizations has led to ineffective utilization of ICT resources, heightened energy consumption, and various technical difficulties. Due to these issues, institutions increasingly mandate the implementation of an environmentally sustainable IT deployment strategy.

Sustainable IT techniques, including power management, virtualization, enhanced cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure, have the potential to enable intelligent management, facilitate scalability, and promote efficient resource utilization. Institutions can enhance resource allocation efficiency and system scalability by incorporating sustainable IT practices into their service platforms. This can aid in guaranteeing smooth

and continuous operations while simultaneously optimizing the overall efficiency of operations (Koratagere, S. et. al (2023). Hence, it is imperative for Kenyan institutions to adopt sustainable IT practices on their platforms to improve efficiency and adaptability.

The main objective of this project is to implement sustainable IT practices, including power management, virtualization, enhanced cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure, in order to fulfill sustainability criteria in both commercial and governmental organizations in Kenya.

In accordance with the findings of Gichuki et al. (2018), institutions are facing mounting pressure to adopt more sustainable practices in their utilization of information and communication technology (ICT). In order to achieve its Vision 2030 development roadmap, Kenya must use green ICT practices to enhance both its organizational and environmental sustainability. The study aimed to examine the environmental impact of green ICT and assess the efficacy of green ICT management in Kenyan institutions.

A combination of quantitative and qualitative approaches was employed, together with an explanatory study design. The technique of purposive sampling was employed to choose specific elements for investigation, whereas random sampling was utilized to conduct a survey of sixty-seven (67) higher education institutions (HEI) in Kenya. The results suggest that despite the implementation of energy-efficient technology, green ICT is predominantly causing adverse effects on the environment due to inadequate electricity management by HEI. The presence of incomplete replacement and unfulfilled optimization of green ICT solutions is evident, alongside the launch of new products and re-materialization. Positive indicators would include increased consolidation, reduced printing, and proper disposal of equipment in compliance with government rules. Kenyan institutions encounter many challenges including

limited awareness, uncertain investment returns, restricted collaboration, and insufficient finance. The research recommends that institutions focus on establishing a framework to implement green ICT policy (Samoei et al, 2021).

1.3 Study Objectives

1.3.1 To investigate environmentally-friendly IT practices, such as efficient power usage, virtualization, advancements in cooling technology, recycling, proper disposal of electronic waste, and optimizing the IT infrastructure, in order to fulfill sustainability criteria in institutions.

1.3.2 Offer suggestions for Kenyan institutions to implement.

The primary research questions in green computing involve evaluating the challenges and solutions in various IT sectors, such as IoT, data centers, and telecommunications, to achieve energy efficiency, waste reduction, and the use of renewable energy sources [Butt, S. et. al. (2020].

2.0 Literature Review:

2.1 History and Evolution of Green Computing

Green computing, often referred to as Green Technology or Green IT, gained significant attention in 1992 with the introduction of the Energy Star program by the U.S. Environmental Protection Agency. The algorithm successfully detected consumer gadgets that complied with energy efficiency regulations (Merritt, 2022, Shanthi, D., & Shalini, M. (2022)]. Over time, the notion of green computing developed and expanded to include a wider array of actions with the goal of diminishing the ecological consequences of technology. This encompasses the utilization of lower amounts of energy, the mitigation of waste, and the advocacy of sustainability [Salama M (2020)].

2.2 Sustainable IT Practices

Key components of sustainable IT practices encompass the utilization of energy-efficient technology,

virtualization, and cloud computing. Energy-efficient hardware minimizes energy consumption by optimizing device utilization according to user choices [Energy5 (2023)]. Virtualization is the process of combining numerous physical servers or resources into a single virtual environment. This allows for better use of resources and minimizes power consumption, cooling needs, and physical space requirements [Energy5 (2023)]. Cloud computing enables remote access to computing resources, hence removing the requirement for energy-intensive on-site servers. The source cited is a publication titled "Energy5" from the year 2023[*Energy5*. (2023)]

2.3 Environmental Impact of Data Centers

Data centers are widely known for their substantial energy requirements. These facilities require a continuous and uninterrupted supply of electricity to operate the servers, cooling systems, and networking equipment. Data centers are predicted to consume around 3% of the global energy supply, and this percentage is projected to increase due to the continuous expansion of the digital ecosystem[(Utilities One, 2023)]. The energy consumed by these facilities not only exacerbates climate change but also presents financial burdens for businesses[(Utilities One, 2023)].

2.4 Energy-Efficient Solutions for Data Centers

In order to address the environmental issues presented by data centers, it is essential to examine and implement eco-friendly alternatives. The options prioritize the enhancement of energy efficiency, the reduction of carbon emissions, and the utilization of renewable energy sources [Utilities One, 2023].

Integrating energy-efficient cooling solutions can substantially decrease energy usage in data centers. Data centers can achieve carbon neutrality and realize long-term cost savings by using renewable energy sources. Virtualization and load balancing are effective methods for maximizing server utilization, resource allocation, and energy efficiency [Utilities One, 2023].

2.5 Key Studies and Findings Related to Green Computing

According to a study conducted by Microsoft, their cloud services demonstrate remarkable energy efficiency, surpassing on-premise data centers by a significant margin of 93%. The cloud is a very sustainable option for enterprises, with a carbon efficiency that is 98% higher than that of traditional data centers[(Svistun. O (2023)].

According to the International Energy Agency (IEA), data centers account for around 1-1.5% of the overall global electricity usage. The global data centers consumed a total of 220 to 320 Terawatt hours of electricity in 2021, which accounted for approximately 0.9% to 1.3% of the world's total electricity consumption. Roundy (2023) reports a significant rise in data center energy use, ranging from 10% to 60%, since 2015.

To conclude, green computing is not merely a trendy term, but rather an essential component of our technological advancement. The advancements in green computing offer both environmental and long-term economic benefits [Energy5. (2023)]. Organizations can effectively mitigate their environmental impact, attain cost savings, and enhance their financial performance by implementing green computing solutions [Energy5. (2023)].

3.0 METHODOLOGY

This paper thus assesses the Impact of Green Computing Practicestowardsthe Sustainable IT Servicesthrough desktop study. Same is done through literature review of various papers done in different countries. The literature is collected basis their relevance and their age, narrowing the same to papers within 10 years of age and related to the topic of green computing and Kenyan institutions.

At the end of it the paper aims to come up with recommendation for sustainable IT services in Kenya for institutions to adopt.

4.0 DISCUSSION OF FINDINGS

Below are the discussion and findings of the current trends by HEI in embracing green computing.

4.1.Creating Awareness of Green ICT and Green IT Plan

This is a critical trend and approach that should be applied at the HEI. Learning institutions should be the first to train society to confront and adopt environmental challenges and environmentally good practices in their use of ICT.

According to a study conducted by (Thomson et al., 2015), the real degree of Green ICT adoption and readiness throughout South African institutions appears to be very low. According to Asabere et al. (2016), several green ICT practices are carried out on a very small scale in Ghanaian institutes. According to the literature, the level of green ICT adoption and implementation at institutions in developing countries is relatively low when compared to institutions in wealthy countries.

In Kenya, this is a move that Higher Educational Institutes (HEI) have already taken; for example, Green ICT is currently one of the courses taught at HEI (Samoei et al, 2021). This is supported by a study by Kirui, et. al. (2023), which reports that Some initiatives have been made by Kenyan universities to guarantee sustainable development. For example, to apply greening IT strategies in universities, both public and private universities took part in creating the "Kenya Green University Network (KGUN). This

entails planning how to incorporate green computing techniques into the institution's operations. It also entails promoting green computing to students and faculty in order to encourage involvement.

4.2. Green Computing Practices and Technologies

Green computing, or sustainable computing, is the practice of creating and utilizing computer systems that cause little harm to the environment. This encompasses the development of hardware that consumes little energy, the enhancement of software for optimal performance, and the advocacy for proper disposal of electronic devices [Energy5. (2023)]. Below are few essential green computing practices:

4.2.1. **Tracking Base Energy Usage**: Monitoring the energy consumption of your data center or IT infrastructure is the first step towards making it more energy-efficient[Borgini. J, 2023].

4.2.2. **Investing in Energy-Efficient Hardware:** Energy-efficient computer hardware significantly impacts energy consumption and overall sustainability. This includes laptops, servers, or peripherals[(*7 Green Computing Best Practices - InApp*, 2023)].

4.2.3. **Power Management:** Optimal power management can contribute to reducing energy consumption, lowering electricity bills, and mitigating environmental impact[(*Utilities One*, 2023)].

4.2.4. **Investing in Renewable Energy Technologies**: Organizations can consider green energy alternatives such as geothermal cooling, wind power, and hydroelectric power to power their data centers[Borgini. J. 2023].

4.2.5. **Server Virtualization**: This technology allows multiple operating systems and applications to run on a single physical server, creating virtual machines (VMs) that share the server's resources. This can improve data center efficiency

and scalability[(*How Does Server Virtualization Improve Data Center Efficiency and Scalability?* 2023)].

Server virtualization enhances data center efficiency and scalability by dynamically distributing resources to virtual machines (VMs) according to demand, hence minimizing idle capacity and optimizing performance [*How does server virtualization improve data center efficiency and scalability?* (2023)].

The majority of institutions have embraced virtualization. Gichuki et al. (2021) found that system virtualization optimizes hardware use, leading to a decrease in hardware components by an average of over 60%. This minimizes expenses related to power consumption, maintenance, carbon emissions, and wasteful disposal. It also decreases the need for additional floor space and facilitates the rapid expansion of hardware resources.

4.2.6. **Cloud Computing**: Cloud computing offers numerous benefits when it comes to sustainability and eco-friendliness compared with traditional on-site IT infrastructure solutions such as reduced energy consumption, lower carbon emissions, efficient resource utilization, scalability options, among others[Utho, 2023].

In order to achieve sustainable development, it is necessary to mitigate the adverse impacts of information technology. This can be achieved by implementing Green IT. Green IT enhances environmental sustainability through the optimization of energy consumption, reduction of greenhouse gas emissions, utilization of less hazardous materials, and promotion of the reuse and recycling of computing equipment components when reaching their renewal level (Owoche, P., et. al. (2019).

4.3. Environmental Impact of Green Computing

4.3.1. Energy Savings - Implementing green computing practices can greatly minimize energy consumption. This is accomplished by employing more efficient hardware and software, including low-power processors, solid-state storage, cloud computing, and virtualization [Zaveria (2023)].Energy-efficient computers or office equipment have the potential to save energy expenses by up to 65%, depending on how they are used (Owoche, P., et. al. (2019). In addition, the utilization of sleep mode and power management functionalities on computers can effectively conserve energy (*Green Computing and E-Waste - Office of Sustainability - University of Maine, n.d.*). According to Bonuccelli (2022), Microsoft Azure and other major public cloud providers have the potential to reduce emissions by 98% when compared to on-premises datacenters. This reduction in emissions can assist organizations in lowering their carbon footprints and decreasing expenses.

4.3.2. Reduction in E-Waste - Green computing is essential for minimizing electronic waste (e-waste). E-waste encompasses outdated, no longer in use, or discarded electrical devices that include both valuable and dangerous substances, necessitating specific procedures for their management and recycling[Prasant, P, 2020]. Green computing advocates for the reuse and recycling of electronic equipment, thus minimizing the production of e-waste (Bonuccelli, 2022). By maximizing the lifespan of existing devices, the environmental impact of electronics usage can be minimized. In addition, implementing strategies that facilitate the reutilization or recycling of current equipment

can effectively decelerate the production of electronic waste [Bonuccelli, G. (2022)].

4.3.3. Other Positive Outcomes

Green computing can also lead to other positive outcomes. For instance, it can enhance the flexibility and productivity of technology users by enabling teleworking and online collaboration, which can reduce travel costs, traffic congestion, and carbon emissions[*Zaveria* (2023)]. Furthermore, green computing can strengthen the brand and public image of businesses that adopt it by demonstrating their social responsibility and innovation[*Zaveria* (2023)].

In conclusion, the implementation of green computing practices can have a significant positive impact on the environment by saving energy, reducing e-waste, and promoting sustainability. It is a vital shift towards a more eco-conscious and efficient tech landscape[El-shamy, H, 2023].

4.4. Case Studies of Green Computing Initiatives

4.4.1. **Google -** Google, a tech giant, has made significant strides in sustainable computing by optimizing data center operations and investing in renewable energy. Their efforts have not only reduced their carbon footprint but also led to substantial energy savings and cost reduction[El-shamy, H., 2023].

4.4.2. **UPS -** UPS, a global logistics company, has been able to reduce its greenhouse gas emissions significantly by leveraging digital technologies and low carbon integrated materials. This has helped the company to reduce the environmental impact of its transportation activities, which make up the bulk of its greenhouse gas emissions[Dilmegani, C., 2023].

4.4.3. **Shenyang Aircraft Corporation -** a Chinese aircraft manufacturer, successfully carried out a green IT transformation by effectively utilizing internal resources, building confidence with

business divisions, and reinforcing their commitment to the transformation process. The integration of production and research enhanced efficiency, while the establishment of a production network supported the efficient allocation of resources[Zeng, et. al.(2018)].

4.4.4. **Arabian Gulf Oil Company -**The Arabian Gulf Oil Company, a prominent corporation in Libya, undertook a study with the aim of promoting awareness regarding green computing. The organization presented various strategies for implementing green computing, including power management, energy efficiency, online work, email usage, virtualization, and cloud computing. The study sought to establish green computing as an effective tool for management [Benamer, W. H, et. (2021)].

4.4.5. **China Mobile -**China Mobile, a telecommunications company, has harnessed collective IT resources for sustainability. Their green leadership strategy has set them apart from the competition, ultimately improving profits. Having a green image has also provided them with a competitive advantage[Li, Y, 2021].

These case studies demonstrate that green computing initiatives can lead to significant energy savings, cost reductions, and environmental benefits. They also highlight the importance of integrating such initiatives into the tech ecosystem to contribute to a more eco-conscious industry.

4.5.Challenges in Implementing Green Computing

Green computing, also known as green technology, aims to reduce the environmental impact of technology by conserving energy, reducing waste, and promoting long-term sustainability[(*Green Computing - Approaches | Challenges*, 2022)][Kirvan, P. 2023].

However, implementing green computing presents several challenges:

4.5.1. **Balancing User Satisfaction and Environmental Impact**: One of the primary difficulties lies in achieving a harmonious equilibrium between attending to the demands of systems, hardware, and software, while simultaneously prioritizing end-user contentment, complying with regulatory obligations, overseeing infrastructure reorganization, and guaranteeing a favorable return on investment [Green Computing - Approaches | Challenges, 2022)].

4.5.2. **Cost of Transition:** Transitioning to green computing often involves replacing existing technology assets with energy-efficient ones, which can be costly[Kirvan, P. 2023].

4.5.3. **Energy Consumption**: Modern technology is based on a diverse set of hardware, complex systems, and networks, all of which require energy to operate. This energy often comes from nonrenewable resources, such as coal, which have a significant environmental impact[*Green Computing - Approaches | Challenges*, 2022)].

4.5.4. **Resource Use**: Nonrenewable resources, such as precious metals like gold, are used to manufacture technology. The extraction and use of these resources can have a significant environmental impact[*Green Computing - Approaches | Challenges*, 2022)].

4.5.5. **Regulatory Compliance**: Green computing initiatives must comply with various regulatory requirements, which can be complex and challenging to navigate[(Kasam, 2023)].

4.6.Future Trends and Emerging Technologies in Green Computing

Several emerging technologies and trends are shaping the future of green computing:

4.6.1. **Cloud Computing**: Cloud computing is a major trend in

green computing. By hosting services on remote servers, cloud computing can reduce the energy consumption and environmental impact of individual devices[The future of Green IT - Tech Mahindra. (2022)]

4.6.2. **Energy-Efficient Data Centers**: Businesses are increasingly adopting green IT to design energy-efficient data centers. This includes using IT equipment for air conditioning, heating, cooling, and ventilation[(Kasam, 2023)].

4.6.3. **Green Software Development**: The development of green software spans the entire lifecycle of software: development, operation, and disposal (reuse). This includes design and coding options, choice of language, selection of AI models, and software development[(*10 Recommendations for Green Software Development*, 2021)].

4.6.4. **AI and IoT:** The convergence of technologies like AI and the Internet of Things (IoT) is greatly impacting Green Supply Chain Management (GSCM) market[Ahmad, S., et. al. (2023)].

4.7. Potential Areas for Further Research

There are several areas where further research could help advance green computing:

4.7.1. **Environmental Impact Assessment**: Further research is needed to assess the environmental impact of different computing technologies and practices[(*10 Recommendations for Green Software Development*, 2021)].

4.7.2. **Standards and Regulation:** More research could help develop standards and regulations for green computing, which could help guide businesses and other

organizations in their green computing efforts[(*10 Recommendations for Green Software Development*, 2021)].

4.7.3. **Harnessing Software for Environmental Sustainability:** Research could explore how software can be used to promote environmental sustainability, such as by optimizing energy use or reducing waste[(*10 Recommendations for Green Software Development*, 2021)].

4.7.4. **Green Algorithms and Practices in Emerging IT Technologies:** Research could concentrate on developing environmentally friendly algorithms, circuits, structures, and practices in emerging IT technologies of the current decade [Shuja, J. (2017)].

4.7.5. **Implementation of environmentally-friendly technologies at the industrial and organizational level**: The price of energy per unit will experience a substantial increase due to a large decline in global energy resources. Consequently, it is imperative for both public and government sectors to develop and implement cutting-edge strategies and plans for green computing [Shuja, J. (2017)].

5. Conclusion:

Green computing, or sustainable computing, seeks to limit energy usage, decrease electronic waste, and advocate for ecologically responsible practices across the whole IT lifecycle. Adopting green computing practices can result in substantial energy conservation, financial savings, and positive environmental outcomes. However, challenges in implementing green

computing include balancing user satisfaction and environmental impact, the cost of transitioning to energy-efficient technologies, and regulatory compliance[Salama, M. (2020)] [*Green IT Factsheet*. (2023)].

Emerging trends and technologies in green computing include cloud computing, energy-efficient data centers, green software development, AI and IoT, and carbon-aware computing[(Merritt, 2022)] [Jacob M, J. (2015)]. These advancements possess the capacity to fundamentally transform the industry by offering both environmental advantages as well as long-term commercial gains.

Potential areas for further research in green computing include environmental impact assessment, standards and regulation, harnessing software for environmental sustainability, green algorithms and practices in emerging IT technologies, and greening of industrial and organizational level technologies[(Education, 2022)].

In conclusion, green computing is a crucial approach to promote sustainable practices in the Institutions, aiming to reduce energy consumption, minimize e-waste, and protect the environment. By embracing energy-efficient technologies, responsible resource use, and proper disposal of electronic waste, organizations can contribute to a more eco-conscious and efficient tech landscape[Safdie, S, (n.d.].

REFERENCES:

Ahmad, S., Mishra, S., & Sharma, V. (2023). Green Computing for Sustainable Future Technologies and Its Applications. In *Contemporary Studies of Risks in Emerging Technology, Part A* (pp. 241-256). Emerald Publishing Limited.

Beardmore, A. (2020, October 12). *Uncovering the Environmental Impact of Cloud Computing*. Earth.Org. https://earth.org/environmental-impact-of-cloud-computing/

Benamer, W. H., Elberkawi, E. K., Neihum, N. A., Anwiji, A. S., & Youns, M. A. (2021). Green Computing case study: calls for proposing solutions for the Arabian Gulf Oil Company. In E3S Web of Conferences (Vol. 229). EDP Sciences.

Between 10 and 20% of electricity consumption from the ICT* sector in 2030? (2018, August 9). Enerdata. https://www.enerdata.net/publications/executive-briefing/between-10-and-20-electricity-consumption-ict-sector-2030.html

Bonuccelli, G. (2022, February 9). Learn the Environmental and Cost Benefits of Green Cloud Computing. Parallels Remote Application Server Blog - Application Virtualization, Mobility and VDI. https://www.parallels.com/blogs/ras/benefits-green-cloud-computing/

Borgini. J. 8 green computing best practices | TechTarget. (2023). Data Center. https://www.techtarget.com/searchdatacenter/tip/8-green-computing-best-practices

Butt, S., Ahmadi, M., & Razavi, M. (2020, November). Green Computing: Sustainable Design and Technologies. In 2020 5th International Conference on Innovative Technologies in Intelligent Systems and Industrial Applications (CITISIA) (pp. 1-7). IEEE.

Dilmegani, C. Top 10 Sustainability Case Studies & Success Stories in 2023. (2023). AIMultiple. https://research.aimultiple.com/sustainability-case-studies/

Education, I. C. (2022, April 19). What Is Green Computing? - IBM Blog. IBM Blog. https://www.ibm.com/blog/green-computing/

El-shamy, H. Green Computing: Paving the Way for Energy-Efficient IT Solutions. (2023). Green Computing: Paving the Way for Energy-Efficient IT Solutions. https://www.linkedin.com/pulse/green-computing-paving-way-energy-efficient-solutions-hanya-el-shamy

Energy5. (2023.). Energy5. https://energy5.com/green-it-practices-for-energy-efficient-workspaces

Expert Panel. (2023, August 3). Council Post: 20 Sustainable Practices To Help Businesses And Tech Teams 'Go Green.' Forbes. https://www.forbes.com/sites/forbestechcouncil/2023/08/03/20-sustainable-practices-to-help-businesses-and-tech-teams-go-green/

Gichuki, D. K., Nambiro, A. W. and Wabwoba, F. (2018). An Investigation of the Impact of System Virtualization on Green ICT Deployment in Kenyan Public Universities. IJSRSET, 4 (11): 25 – 29, DOI:https://doi.org/10.32628/IJSRSET173810

Green Computing and E-Waste - Office of Sustainability - University of Maine. (n.d.). Green Computing and E-Waste - Office of Sustainability - University of Maine. https://umaine.edu/sustainability/energywise/green-computing-and-e-waste/

Green computing - Approaches | Challenges. (2022, June 1). Green Computing - Approaches | Challenges.

https://adservio.fr/post/green-computing-approaches-challenges

Green IT Factsheet. (2023). Center for Sustainable Systems. https://css.umich.edu/publications/factsheets/built-environment/green-it-factsheet. Center for Sustainable Systems, University of Michigan. 2023. "Green IT Factsheet." Pub. No. CSS09-07.

Harmon, R. R., & Auseklis, N. (2009, August). Sustainable IT services: Assessing the impact of green computing practices. In PICMET'09-2009 Portland International Conference on Management of Engineering & Technology (pp. 1707-1717). IEEE.

How does server virtualization improve data center efficiency and scalability? (2023). Server Virtualization: Benefits, Challenges, and Tips. https://www.linkedin.com/advice/0/how-does-server-virtualization-improve

Jacob M, J. Sr. 2015, Relevance and Impact of Green Computing in IT, International Journal Of Engineering Research & Technology (IJERT) RTPPTDM – 2015 (Volume 3 – Issue 30),

Kasam, A. (2023, July 24). Green Computing: The Future of IT. EnterpriseTalk. https://enterprisetalk.com/featured/green-computing-the-future-of-it/

Kirui, L. K., Nambiro, A. W., & Masinde, E. O. (2023) Green Information Technology (IT) Strategies in Institutions of Higher Learning in Kenya for Sustainability: Challenges and Opportunities.

Kirvan, P. What is green computing? | Definition from TechTarget. (2023, March 1). Data Center. https://www.techtarget.com/searchdatacenter/definition/green-computing

Koratagere, S., Koppal, R. K. C., & Umesh, I. M. (2023). Server virtualization in higher educational institutions: a case study. International Journal of Electrical and Computer Engineering (IJECE), 13(4), 4477-4487.

Li, Y. Doing good while doing well: the case of business IT initiatives. (2021). Doing Good While Doing Well: The Case of Business IT Initiatives. https://knowledge.essec.edu/en/sustainability/doing-good-doing-well-business-it-initiatives.html

Merritt, R. (2022, October 12). What Is Green Computing? NVIDIA Blog. https://blogs.nvidia.com/blog/what-is-green-computing/

Owoche, P., Wabwoba, F., & Wechuli, A. N. (2019). Global Information Technology Infrastructure in Addressing the Problem of Environmental Degradation in Kenya. International Journal of Information Technology Convergence and Services, 9(1), 1-14.

Paul, S. G., Saha, A., Arefin, M. S., Bhuiyan, T., Biswas, A. A., Reza, A. W., ... & Moni, M. A. (2023). A Comprehensive Review of Green Computing: Past, Present, and Future Research. IEEE Access.

Prasant, P. E-Waste Management in Green Computing. (2020). E-Waste Management in Green Computing. https://www.linkedin.com/pulse/e-waste-management-green-computing-paidisetti-prasant-

Pratt, M. K. Cloud computing's real-world environmental impact | TechTarget. (2023). Sustainability and ESG. https://www.techtarget.com/sustainability/feature/Cloud-computings-real-world-environmental-impact

Roundy, J. Assess the environmental impact of data centers | TechTarget. (2023). Data Center. https://www.techtarget.com/searc

hdatacenter/feature/Assess-the-environmental-impact-of-data-centers

Safdie, S. What is Green Computing and What does it Imply? (n.d.). What Is Green Computing and What Does It Imply? https://greenly.earth/en-us/blog/company-guide/what-is-green-computing-and-what-does-it-imply

Salama M (2020), Green Computing, a contribution to save the environment - Lancaster University. Lancaster University. https://www.lancaster.ac.uk/data-science-of-the-natural-environment/blogs/green-computing-a-contribution-to-save-the-environment

Samoei, I., Moturi, C. and Orwa, D. (2021). Green ICT in Institutions of Higher Learning in Kenya. International Journal of Innovative Science and Research Technology. 6(3)

Shanthi, D., & Shalini, M. (2022), Green Cloud Computing–A Review. Stochastic Modeling.

Shuja, J., Ahmad, R. W., Gani, A., Abdalla Ahmed, A. I., Siddiqa, A., Nisar, K., ... & Zomaya, A. Y. (2017). Greening emerging IT technologies: techniques and practices. Journal of Internet Services and Applications, 8(1), 1-11.

Sustainable IT: Ways IT Can Be More Green and Why It Matters. (2019, October 16). BMC Blogs. https://www.bmc.com/blogs/sustainable-it/

Svistun. O, How to Achieve Energy Efficiency and Sustainability in Cloud-Based Solutions. (2023.). How to Achieve Energy Efficiency and Sustainability in Cloud-Based Solutions. https://www.linkedin.com/pulse/how-achieve-energy-efficiency-sustainability-cloud-based

The future of Green IT - Tech Mahindra. (2022).

https://files.techmahindra.com/static/img/pdf/the-future-of-green-it.pdf

The power of green computing. (2023, October 23). MIT Technology Review. https://www.technologyreview.com/2023/10/23/1081969/the-power-of-green-computing/

Utho, 4 Reasons Why Cloud Computing is a Sustainable and Eco-Friendly Choice. (2023). 4 Reasons Why Cloud Computing Is a Sustainable and Eco-Friendly Choice. https://www.linkedin.com/pulse/4-reasons-why-cloud-computing-sustainable-eco-friendly-choice-

Utilities One. (2023). Utilities One. https://utilitiesone.com/the-reliance-on-energy-intensive-data-centers-environmental-concerns

What is green computing? | Definition from TechTarget. (2023, March 1). Data Center. https://www.techtarget.com/searchdatacenter/definition/green-computing

Zaveria. (2023, August 4). Top 5 Advantages of Green Computing. Analytics Insight. https://www.analyticsinsight.net/top-5-advantages-of-green-computing/

Zeng, D., Fu, X., & Ouyang, T. (2018). Implementing Green IT transformation for sustainability: A case study in China. Sustainability, 10(7), 2160.

7 Green Computing Best Practices - InApp. (2023, September 29). InApp - Your Technology Partner for the Long Haul. https://inapp.com/blog/7-green-computing-best-practices/

10 Recommendations for Green Software Development. (2021, November 18). Green Software Foundation. https://greensoftware.foundation/articles/10-recommendations-for-green-software-development