

Green Computing: Sustainable IT Practices for a Greener Future

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Submitted to:

Dr. Khandoker Mahmudur Rahman

Professor

School of Business & Economics

United International University (UIU)

Submitted by:

Md. Faiyaz Samiuddin

ID: 111 201 238

Major: Supply Chain Management

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School of Business & Economics

United International University

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Letter of Transmittal

March 10, 2025

Dr. Khandoker Mahmudur Rahman

Professor

School of Business & Economics

United International University (UIU)

Madani Avenue Dhaka-1212

Subject: Submission of Green Computing Project Report.

Dear Sir,

I, Md. Faiyaz Samiuddin, bearing ID number 111 201 238, am pleased to submit the enclosed project report titled “**Green Computing: Sustainable IT Practices for a Greener Future**”. This report provides an in-depth analysis of energy-efficient computing solutions, sustainable IT infrastructure, and strategies for reducing the environmental impact of technology.

The study explores key areas such as green data centers, e-waste management, and renewable energy-powered computing, presenting recommendations that can contribute to a more sustainable digital ecosystem. This report highlights the significance of adopting eco-friendly practices in the IT industry, aligning with global sustainability goals.

I appreciate the opportunity to conduct this report and sincerely hope that the findings and conclusion presented in this report will be valuable for further discussions and implementations in green computing initiatives.

I trust that the contents of this report will prove enlightening and informative. It is my earnest hope that you will accept my submission, and I eagerly await your response.

Thank you for your time and consideration.

Sincerely Yours,

Md. Faiyaz Samiuddin

111 201 238

Certificate of Similarity Index

This is to declare that the document as hereby submitted, has been subject to similarity check against relevant databases and published works, including articles, books, reports, internship and project reports. The similarity index for this document will be subject to the institutional requirement as of date, and the author hereby declares that this is an original write-up of the author, however, due to the usage of secondary information, some interpretation and reference has been provided in due course. In addition, no part of this report can be copied, reproduced or referenced without prior written permission or due referencing in current or future scholarly work.

Declaration of the Student

I hereby declare that the research and findings presented in this project report, titled "*Green Computing: Sustainable IT Practices for a Greener Future*," are my original work and have been conducted under the supervision of **Dr. Khandoker Mahmudur Rahman, Professor, School of Business & Economics, United International University.**

I affirm that all statements, analyses, and conclusions in this report are based on my independent research and inquiry. Any references, data, or theoretical frameworks used in this study have been properly cited and acknowledged in accordance with academic integrity standards.

Furthermore, I confirm that this project report has not been submitted to any other institution, either in Bangladesh or abroad, for the purpose of obtaining a degree, diploma, or certification. I have strictly adhered to the guidelines and regulations set forth by United International University in preparing this work.

By submitting this report, I take full responsibility for its content and ensure that it upholds the highest standards of academic honesty.

Acknowledgment

I begin by expressing my gratitude to Allah (SWT), the divine being, for bestowing upon me the opportunity to complete my academic endeavors within the stipulated timeframe and with favorable outcomes.

I wish to convey my heartfelt appreciation to my academic supervisor, Dr. Khandoker Mahmudur Rahman, who serves as a professor at the School of Business and Economics, United International University. The invaluable guidance and unwavering support provided by my supervisor played a pivotal role in the successful culmination of my project. I consider myself exceptionally fortunate to have had the privilege of collaborating with him in conducting this study.

I also extend my thanks to my family for their unwavering support throughout my journey in pursuing a Bachelor of Business Administration (BBA) degree.

Then at last I shall be grateful to those people who read this report and who shall get benefit from this report at present and in future.

Abstract

Green computing is all about green technology, where we can use technology in a sustainable way. It encompasses practices like energy management, utilizing recyclable materials, virtualization, and particular employee procedures and habits. In light of growing worldwide energy demands and environmental concerns, this abstract explores the evolution and critical significance of green computing. Day by day our toxic trait to technology is increasing and environment become polluted every way it's possible. To minimize this pollution green, it or green computing can be the best option for tech users. The environment suffers as a result of the extensive use of computers and associated IT products. Because its components are non-biodegradable, personal computers have a detrimental effect on the environment. Inadequate disposal techniques for computers and their components as well as defects in manufacturing procedures can lead to environmental contamination. Computer manufacturing involves the use of toxic materials, which can have negative environmental implications when properly disposed of. Therefore, we must increase our knowledge of this issue to safeguard our environment and lessen the negative effects of computers. To improve sustainable practices in the technology sector and make sure that technical breakthroughs favorably impact global environmental conservation efforts, this report finishes by emphasizing the importance of ongoing research and industry collaboration.

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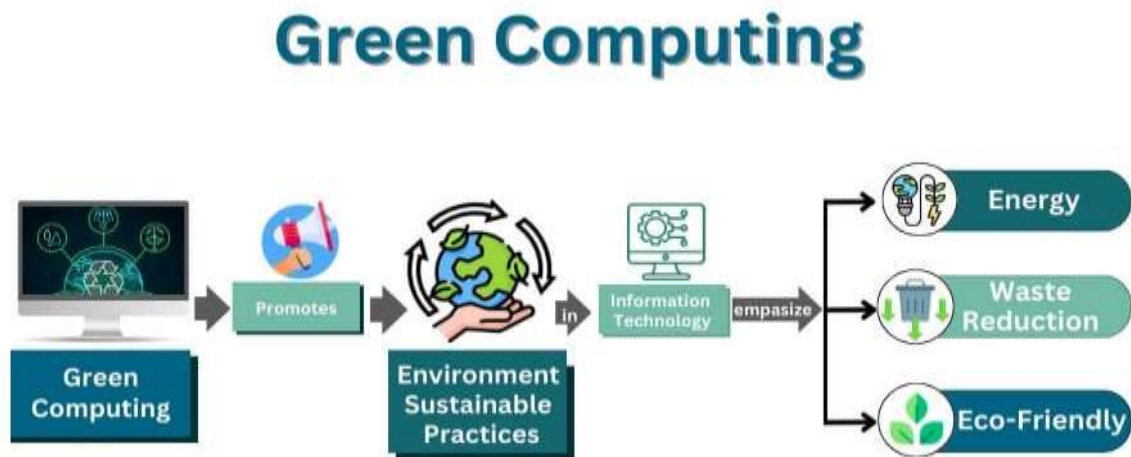
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CHAPTER I: INTRODUCTION

1.1 Background of the study

“Green computing”, also known as environmentally sustainable computing, refers to the development, production, use and disposal of computers and associated systems with as little negative environmental impact as possible. The goal of green computing is to reduce the use of toxic materials, improve energy efficiency over the product’s life and promote the recycling or biodegradation of defective goods and industrial waste. It encompasses a wide range of strategies and practices, all geared towards promoting sustainability and eco-responsibility within the IT sector.

Toxins and environmental contamination can be avoided by properly disposing of and recycling electronic trash or “e-waste.” The development of efficient e-waste management systems, which involve the conscientious collecting, disassembly, and recycling of electronic gadgets is encouraged by green computing.



1. Figure 1.1: Green Computing

Figure-1: Green Computing (Kumar, n.d.)

The IT industry can greatly lower its carbon footprint and help create a more sustainable future by adopting these ideas and putting green computing techniques into effect. In addition to

supporting the environment, this improves the company's standing as an ethical and environmentally conscientious business. (Kumar, n.d.)

1.2 Data Collection:

The report lists the several ways that data is gathered for the research of green computing. To lay the groundwork for this topic, it contains a literature review that gathers data from earlier studies, books, and articles of different authors from Google Scholars. Real-world perspectives on green computing activities can be gained from case studies of significant corporations such as Google, Microsoft, Amazon, and Meta's portfolio. The effects of green computing on corporate responsibility, environmental sustainability, and energy efficiency are examined in surveys and publications through websites and Wikipedia. Data from organizations and the government, such as rules and laws, also aid in comprehending the difficulties of adoption and its potential. Finally, the study's conclusions are supported by statistical data, such as estimates of carbon footprint and energy use.

1.3 Methodology:

The methodology used in this report on green computing follows a qualitative approach, focusing on descriptive and exploratory analysis. It consists of a thorough literature analysis that looks at the development of green computing across time, significant technology advancements, and contemporary business practices. Research papers, industry reports, and case studies of well-known tech firms like Google, Microsoft, Amazon, and Meta are among the secondary data sources used in this report. To find important trends, obstacles, and opportunities for sustainable IT practices in the future, the study also uses thematic analysis. Numerous qualitative elements are examined, including the function of corporate endeavors, policy ramifications, and environmental effect evaluations. Through an analysis of regulatory, financial, and infrastructure hurdles, the study draws attention to implementation challenges, especially in developing nations like Bangladesh. examples of success. To demonstrate best practices and offer comparative insights, case studies of effective green computing implementations are employed. Future directions for sustainable IT solutions are also covered in the report, including the use of cloud computing, AI, and IoT. All things considered, the qualitative method aids in comprehending the wider ramifications of green computing in resolving environmental issues and encouraging sustainability in the technology industry.

CHAPTER II: REVIEW OF THE LITERATURE

2.1 Green Computing Evaluation:

Green technology has its origins in early industry initiatives to reduce environmental damage. Initiatives that established the foundation for contemporary sustainability practices were sparked by the Industrial Revolution, which was essential in highlighting the need for alternate energy sources. (enfuse, 2025)

Green computing has developed in tandem with efforts to lessen the impact of information technology on the environment. Energy efficiency improvements, environmentally friendly IOT procedures, and sustainable hardware are important turning points in this path:

- 1970s-1980s: Early Awareness: At first, worries about how computing will affect the environment surfaced, with an emphasis on energy use and the disposal of electronic waste. (Kumar, n.d.)
- 1992: EPA Energy Star Program Launch: In 1992, the **U.S. Environmental Protection Agency (EPA)** introduced the **Energy Star Program**, a groundbreaking initiative aimed at promoting energy efficiency across various industries. The program was designed to identify and certify products that met strict energy-saving criteria, helping consumers and businesses make environmentally responsible choices. Energy Star-labeled products, ranging from computers and appliances to entire buildings, were recognized for their ability to reduce electricity consumption without compromising performance. The initiative played a crucial role in raising awareness about energy conservation and set the foundation for future sustainability efforts. Over the years, the distinctive **blue Energy Star badge** became a trusted symbol for eco-conscious consumers, encouraging widespread adoption of energy-efficient technologies and environmentally friendly practices. (Kumar, n.d.)



2. Figure 2.1: Logo of Energy Star

Figure -2.1: Logo of Energy Star

- 2000s: Rise of Energy-Efficient Hardware: During the early 2000s, hardware manufacturers began focusing on developing energy-efficient components to address growing concerns about the electricity consumption of IT infrastructure. This included innovations such as low-power processors that consumed less energy while maintaining high performance, as well as power supplies that converted electricity more efficiently. As awareness of data center energy consumption increased, companies explored new cooling techniques and improved system architectures to reduce energy waste. Governments and environmental organizations also started paying attention to the impact of high-energy consumption in data centers. The push toward energy efficiency laid the groundwork for further advancements in green computing, shaping future technological innovations in sustainable hardware. (Kumar, n.d.)
- 2005: The Green Grid Formation: In response to increasing energy consumption in IT operations, leading technology companies came together in 2005 to form **The Green Grid**, a global consortium dedicated to improving data center energy efficiency. This organization was created to develop industry-wide standards, best practices, and measurement tools to optimize energy use and reduce environmental impact. Over the years, The Green Grid has introduced key metrics such as Power Usage Effectiveness (PUE), which helps businesses assess and improve the energy efficiency of their data centers. Through collaborative research, education, and advocacy, The Green Grid has played a crucial role in influencing sustainability strategies across the IT sector. (Kumar, n.d.)
- 2007: Climate Savers Computing Initiative: As concerns about the environmental impact of IT infrastructure grew, businesses began actively focusing on sustainability through initiatives like the **Climate Savers Computing Initiative (CSCI)**. This initiative, launched in 2007, aimed to reduce the carbon footprint of computing by promoting the use of energy-efficient hardware and power management techniques.

Companies involved in the initiative committed to manufacturing, purchasing, and using energy-efficient devices that met stringent environmental standards. CSCI also encouraged IT users to adopt responsible computing practices, such as configuring power settings to minimize energy waste. This movement marked a significant step in the shift toward greener computing by promoting energy conservation and resource efficiency in the technology sector. (Kumar, n.d.)

- 2009: Carbon Footprint Awareness: By 2009, organizations across industries recognized the need to track and reduce their **carbon footprint**, especially within the IT sector. Businesses started evaluating their energy consumption and considering the entire lifecycle of computing products—from manufacturing and usage to disposal. This led to the adoption of eco-friendly technologies, such as energy-efficient servers, advanced cooling systems, and virtualization solutions, which optimized resource utilization while reducing emissions. Companies also implemented sustainability programs aimed at reducing electronic waste, recycling IT equipment, and embracing renewable energy sources. These efforts not only helped minimize environmental impact but also paved the way for more sustainable business models that prioritized energy efficiency and responsible resource management. (Kumar, n.d.)
- 2011: EPA Data Center Energy Efficiency Program: Recognizing the rapid increase in data center energy consumption, the **U.S. Environmental Protection Agency (EPA)** launched the **Data Center Energy Efficiency Program** in 2011. This initiative was designed to provide businesses with tools, guidelines, and best practices to optimize the energy efficiency of their data centers. The program focused on areas such as efficient server usage, improved cooling methods, and better facility design to reduce overall power consumption. The EPA also encouraged organizations to participate in voluntary programs, such as ENERGY STAR certification for data centers, which helped recognize and promote businesses that met high energy efficiency standards. This initiative reinforced the importance of sustainability in IT operations and influenced industry-wide policies on energy management. (Kumar, n.d.)
- 2010s: Cloud Computing and Virtualization: Throughout the 2010s, the rapid growth of **cloud computing** and **server virtualization** significantly improved IT resource efficiency while reducing energy consumption. Traditional data centers, which relied on large numbers of underutilized physical servers, were gradually replaced by virtualized environments that allowed multiple applications to run on fewer machines.

This shift reduced the need for excessive hardware, lowering power consumption and cooling requirements. Cloud computing also enabled businesses to scale their IT infrastructure dynamically, ensuring that energy was used only when needed. Leading technology companies, including Amazon Web Services, Microsoft, and Google, invested heavily in green data centers that ran on renewable energy, further advancing the sustainability movement in the industry. (Kumar, n.d.)

- 2014: Greenpeace Clicking Clean Report: In 2014, Greenpeace released its influential **Clicking Clean Report**, a comprehensive analysis of how major internet companies were impacting the environment. The report assessed tech giants like Apple, Google, Facebook, and Amazon, evaluating their energy policies, reliance on fossil fuels, and adoption of renewable energy sources. It called attention to companies that were leading the shift toward sustainability and those that lagged. The report played a crucial role in increasing corporate transparency regarding environmental responsibility, urging businesses to improve their sustainability strategies. As a result, many large technology firms set ambitious renewable energy targets and pledged to transition toward carbon-neutral operations in the coming years. (Kumar, n.d.)
- 2020: Sustainable Goals and Circular Economy: By 2020, sustainability became a **core priority** for businesses, with many companies committing to ambitious environmental goals. Major corporations pledged to run entirely on **renewable energy**, achieve **carbon neutrality**, and integrate the **circular economy** into their business models. The circular economy approach aimed to minimize waste by promoting recycling, reusing materials, and designing products with sustainability in mind. Companies also began adopting **carbon offset programs**, investing in reforestation and clean energy projects to counterbalance their emissions. As customers and investors increasingly valued corporate responsibility, businesses that failed to meet sustainability standards faced pressure to improve their environmental practices. (Kumar, n.d.)
- In progress: Global Initiatives and Regulations: Today, governments and international organizations are continuously developing **new regulations and policies** to promote eco-friendly computing and reduce electronic waste. Efforts include stricter e-waste disposal laws, incentives for companies that adopt green computing technologies, and carbon taxation to encourage energy-efficient practices. Organizations such as the United Nations and the European Union are working on initiatives to ensure sustainable IT development, focusing on **responsible sourcing of materials, ethical supply**

chains, and improved recycling programs. The growing emphasis on sustainability is reshaping the technology sector, pushing businesses to innovate in ways that reduce environmental impact while maintaining high-performance computing solutions. (Kumar, n.d.)

Green computing has significant potential to positively impact the environment. (Salama, 2020).The information and communication technology (ICT) sector is a major contributor to global greenhouse gas emissions, responsible for between 1.8% and 3.9% of the total. (Amanda McGrath, 2024).Furthermore, the energy demands of data centers are substantial, accounting for 3% of the world's total annual energy consumption, a figure that has doubled in the past decade.

2.2 Importance of Green Computing:

Green computing is crucial for decreasing the negative effects of the expanding IT sector on the environment, addressing e-waste, lowering carbon footprint, and providing several advantages, such as cost savings and environmental protection. It is now required rather than optional. Here are a few significant key points of green computing:

- **Reduction Of Energy Consumption:** Green computing improves hardware and software to cut down on carbon emissions, energy use, and operating expenses, all of which are critical for mitigating climate change.(Paul et al., 2023)
- **Environmental Protection:** Green computing attempts to lessen the environmental impact of technology by developing and operating computers in an efficient manner, which will drastically cut down on carbon emissions and other dangerous pollutants.(S. Singh, 2016)
- **Cost saving:** Green computing techniques can improve corporate social responsibility (CSR) profiles while drastically lowering operating costs, optimizing resources, and consuming less energy.(Paul et al., 2023)
- **Regulatory compliance:** Green Computing helps firms comply, stay out of trouble, and earn operational legitimacy when governments and regulatory bodies implement policies to reduce carbon emissions and promote sustainability.(S. Singh, 2016)
- **Minimization of Electronic Waste:** Green computing emphasizes responsible recycling and disposal of electronic devices and encourages effective design and

disposal techniques to limit electronic waste, minimizing health risks and environmental degradation.(Paul et al., 2023)

- **Long-Term Sustainability:** A key tactic for the IT sector's long-term sustainability is green computing, which ensures that technological advancements don't negatively impact the environment.(S. Singh, 2016)

Businesses and individuals may help create a more sustainable digital future by adopting green computing practices, which balance environmental responsibility and technical advancement.

2.3 Advantages of Green Computing:

Implementing green IT practices provides a win-win scenario for businesses and the planet. The advantages of green computing extend beyond environmental responsibility to include economic and social gains. Here is below:

- The primary advantage of green computing is that it lowers energy consumption by using carbon dioxide-controlling green computing techniques.(M. Singh & Sidhu, 2016)
- Companies can position themselves as environmentally conscious, improve their brand image, and obtain a competitive advantage in the market by implementing green computing techniques. (A roadmap to establishing a green computing strategy for your business, 2020)
- Companies who adhere to government environmental rules and manufacture environmental rules and manufacture items in accordance with stringent environmental standards experience reduced energy costs and even significant tax savings.(Karp, 2008)
- People are motivated to minimize, reuse, and recycle by sustainable computing. (What is Green computing?[Scope,advantages& disadvantages], n.d.)
- Green computing fosters innovation and efficiency by encouraging sustainable practices, optimizes software, and energy-efficient hardware, which results in more affordable goods and more efficient processes. (A roadmap to establishing a green computing strategy for your business, 2020)

- It results in a significant decrease in the amount of heat generated by computer equipment. (What is Green computing?[Scope,advanteges& disadvantages], n.d.)
- Implementing green IT can enhance a person's or an organization's reputation. (What is Green computing?[Scope,advanteges& disadvantages], n.d.)
- By extending the lives of hardware, decreasing electronic waste, and increasing business operations efficiency, green computing enables postponed hardware replacement and cost savings. (Leger, 2024)
- By fostering a sustainable workplace, green computing practices can boost employee engagement and satisfaction, as employees increasingly seek out environmentally responsible employers. (Leger, 2024)

As the world becomes more digital, adopting green computing is not merely a choice; it is essential for a profitable and sustainable future.

2.4 Limitations of Green Computing:

Notwithstanding the importance of green computing, a number of issues must be resolved before its full potential can be achieved. Here are some not worthy limitations:

- **Capital Expenditure:** Despite the long-term cost-effectiveness of green computing, many businesses steer clear of it because of the high initial expenditures, time commitment, and research needed to deploy it. (Roomi, 2020)
- **Green Computer: efficient but limited:** Some green computers might be seen as underpowered because they prioritize energy efficiency over raw performance. They often use low-power processors and components to reduce environmental impact. While this makes them great for basic tasks, they may struggle with demanding applications like gaming and video editing.(M. Singh & Sidhu, 2016)
- **Privacy Leak:** Green computing Systems pose security risks as devices are frequently replaced by employees, so companies need to take appropriate measures to protect themselves from hacker attacks. (Roomi, 2020)
- **Cyber Skills:** Utilizing green IT infrastructure require knowledgeable IT specialists, and when you do, they typically want exorbitant compensation. Without them, there may be outages and other technical issues with your systems. (Roomi, 2020)

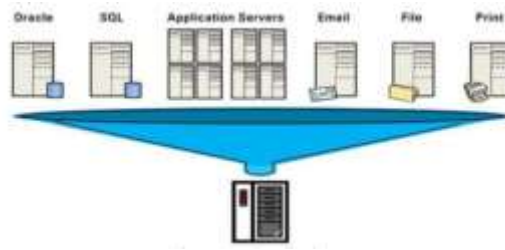
- **Adjustment:** The achievement of green computing depends on the team members of the IT sector. If one member does not adjust these new changes, then all practices of green computing will be wasted. (Roomi, 2020)
- **System Support:** Every day, the technology is advancing rapidly. Everyone should be updated with the time. But Companies are always in a dilemma that it would be safe or not to switch to green computing. They are not left behind with others. (Roomi, 2020)
- **Complex Supply Chains:** The complexity of global IT hardware supply chains makes it difficult for organizations to fully understand the environmental impact of the materials they use. Establishing a truly sustainable supply chain is a significant challenge.
- **Lack of Standardization:** Organizations struggle to compare the environmental impact of various technologies and practices because there are no standardized green computing guidelines. This lack of consistency can slow down the adoption of green IT.

Therefore, considering the limitations, green computing should be practiced and research on these facts so that all the challenges may be overcome and become user-friendly.

2.5 Future Prospects:

In long term of green computing looks like promising, with the combination of room for improvement and modern thoughts. As innovation gets superior, we'll have indeed more ways to create it less destructive to the environment. Modern patterns like AI, cloud computing and IOT will bring both challenges and chances for greener technology. If we continuously keep researching, developing and working together, we can really make green computing tech off and create perfect sustainable tech world. We'll probably see even more focus saving energy, using resources wisely, and recycling hardware. Here are some approaches for this:

- **Use virtualization and cloud computing:** Virtualization lowers cooling and power consumption by combining physical systems into virtual ones on a single system. In desktop, server and storage settings, it improves energy efficiency and cost - effectiveness. (Mohiddin & Babu, 2015)



3. Figure 2.2: Virtualization

Figure-2.2: Virtualization(Mohiddin & Babu, 2015)

Research on green cloud computing seeks to maximize resource utilization, lower carbon emissions, create energy-conscious algorithms, investigate novel cooling solutions and advance sustainability.(Paul et al., 2023)



4. Figure 2.3: Cloud Computing

Figure-2.3: Cloud Computing (What is cloud computing? An overview of the cloud, n.d.)

- **Life cycle assessment:** Future research should examine the entire lifecycle of green computing platforms, from initial design and manufacturing, and disposal. This research should promote a circular economy model and ensure proper handling of electronic waste.(Paul et al., 2023)
- **Power Management:** Effective power management for computing devices involves using Energy Star certified equipment, leveraging software-based energy settings and customizing PCs with power-saving modes. These practices lead to longer battery life, lower operation costs, and improved system stability, ultimately saving money and minimizing environmental impact.(Mohiddin & Babu, 2015)

- **Employee Awareness and Training:** Raising awareness of green computing is essential, especially among employees and IT professionals. Future efforts should include training programs that teach users about the importance of energy management and sustainable IT practices, which can significantly reduce energy waste. (Mohiddin & Babu, 2015)
- **E-Waste Management:** Develop and implement robust e-waste management plans, including recycling programs and responsible disposal methods, to minimize the negative environmental impact of electronic waste. (Kumar, n.d.)
- **5G Technology:** 5G, with its faster speeds and lower latency, facilitates the development of smart cities, connected devices and seamless communication, contributing to improved energy efficiency in IT systems. (Kumar, n.d.)
- **Global Collaboration:** Governments, organizations, and international bodies are working together to tackle global environmental challenges in the IT sector. This collaboration includes sharing resources, exchanging best practices, and jointly addressing sustainability issues in the industry.

Green computing's future is promising due to technological advancements, increased awareness, and cooperative efforts. Transitioning to energy efficiency, intelligent resource usage, and a circular economy can reduce environmental impact.

CHAPTER III: IMPLEMENTATION OF GREEN COMPUTING

Green computing is essential for saving money and lessening the impact on the environment. We can make technology cleaner and more sustainable by implementing green practices like below:

1. **Blackle:** Blackle is Google Programmable Search Engine-powered internet search engine. To save energy, Tony Heap of Heap Media Australia designed it to display search results on a black backdrop with grayish-white lettering. According to Blackle, more than 10.07 MWh of electrical energy had been saved as of July 2023. (Wikipedia , n.d.)
2. **Fit-PC:** Fit-PC is a line of small, fan less, and energy efficient CompuLab, an Israeli company, reliable, and easy to use. Its considered to be green computing project. (Wikipedia , n.d.)
3. **Zonbu Computer:** Zobu is a Linux-powered, compact, fan less and environmentally friendly computer. It was intended to be a more ecologically friendly substitute for conventional personal computers. (Wikipedia , n.d.)
4. **SunRay Thin:** A stateless thin client computer (together with related software) designed for business settings is called the SunRay. A smart card reader is one of its features, and a flat panel display was built into some models. [10]
5. **The Asus Eee PC:** A member of ASUS Eee product family, the ASUS Eee PC is a line of netbook computers manufactured by ASUS. It has a solid-state drive (SSD) for increased durability and speed, a Linux-based operating system and is well-known for being light weight and reasonably priced. (Wikipedia , n.d.)

Apart from these implementations many renowned companies applied green computing in their regular works life.

3.1 Green Computing at Google:

Since its establishment in 1998, Google has offset all of its emissions, making it **Carbon neutral since 2007**. But by **2030**, the corporation wants to run totally on carbon-free energy,

setting even greater goals. In addition to its activities, Google is working with governments and legislators to advance **clean energy solutions** globally.

Google has concentrated on optimizing the energy and resources utilization of its data centers to maximize their efficiency. Because of this, its data centers now run at twice the energy efficiency of a normal data center, thereby lowering their power usage and environmental effect.

Google is dedicated to maximizing environmental benefits through strategic sustainability initiatives. One such effort involves partnering with Crowther Lab to launch science-driven reforestation projects worldwide, helping restore ecosystems and combat climate change. By leveraging advanced data and ecological research, these projects ensure effective carbon sequestration and biodiversity conservation. Additionally, Google's commitment to energy-efficient infrastructure significantly reduces its carbon footprint. Even small actions, such as using Gmail, contribute to this mission, as Google's optimized data centers help minimize environmental impact by up to 98% compared to conventional alternatives. Through these initiatives, Google not only advances global reforestation efforts but also promotes sustainable digital practices. By integrating cutting-edge technology with environmental responsibility, the company continues to set a benchmark for eco-friendly innovation. These efforts align with Google's broader vision of a greener, more sustainable future while inspiring individuals and organizations to adopt environmentally conscious practices. (Google Goes Green, n.d.)

Google created a platform called the **Environmental Insights Explorers (EIE)** that offers more than 3,000 cities useful information to assist lower carbon emissions. Through sophisticated data analysis and modeling, EIE provides building and transportation emissions estimates and mitigation techniques, enabling researchers, city planners and decision makers to effectively address climate change.

Google implements reuse, refurbishing, and recycling strategies in its data centers to minimize waste and enhance sustainability. By extending the life cycle of its hardware, the company reduces electronic waste and conserves valuable resources. In 2016, 36% of its servers were remanufactured using older parts, demonstrating its commitment to resource efficiency. Additionally, over 2.1 million components were resold and repurposed, reducing the need for new manufacturing. This approach not only lowers environmental impact but also supports a circular economy by maximizing the utility of existing materials. By refurbishing equipment

and reselling usable parts, Google cuts down on waste disposal and lowers its carbon footprint. The company's sustainable practices help reduce dependence on raw materials while promoting innovation in recycling. These initiatives align with Google's broader environmental goals and set an example for the tech industry. Through responsible resource management, the company continues to advance eco-friendly operations while maintaining efficiency and performance in its data centers. (A more sustainable future through information and innovation., 2024)

Google committed in 2019 to use recycled materials in all of its products by 2022. Pixel phones, accessories, Pixel books, and Google home speakers are all part of this today. In addition to its software products such as Google Cloud and Gmail, companies may promote sustainability into their operations, Google also offers a collection of best practices. (Google Goes Green, n.d.)

3.2 Green Computing at Amazon:

Amazon Web Services (AWS) is dedicated to leveraging innovation to create a more sustainable and efficient global infrastructure. As part of its commitment to environmental responsibility, AWS continuously enhances energy efficiency across its operations while expanding data centers to meet the increasing demand for AI and cloud computing. The company aligns its efforts with Amazon's broader goal of achieving net-zero carbon emissions by 2040, investing in renewable energy projects and advanced cooling technologies to reduce its carbon footprint. AWS also integrates cutting-edge security measures to ensure data protection as it scales its operations sustainably. By optimizing power consumption, utilizing energy-efficient hardware, and supporting carbon-free energy sources, AWS aims to minimize environmental impact while maintaining high-performance cloud services. These sustainability initiatives not only contribute to a greener digital future but also set a benchmark for the technology industry. Through continuous innovation and responsible resource management, AWS demonstrates its commitment to balancing rapid growth with long-term environmental stewardship. (AWS Sustainability, n.d.)

AWS provides a range of services designed to help businesses minimize their energy footprint by optimizing computing resources and improving efficiency. Through virtualization, AWS enables multiple workloads to run on fewer physical servers, reducing overall energy

consumption. Additionally, optimized compute resources ensure that businesses use only the necessary capacity, avoiding wasteful energy usage. AWS also integrates machine learning-driven efficiency improvements, allowing companies to analyze and adjust their operations for maximum sustainability. A prime example of this is **Amazon EC2**, which offers dynamic scaling of cloud resources based on real-time demand. By automatically adjusting capacity, businesses can avoid excessive energy use while maintaining performance. This approach not only lowers operational costs but also contributes to a more sustainable IT infrastructure. By leveraging AWS services, organizations can significantly reduce their carbon footprint, enhance energy efficiency, and support broader environmental goals. As AWS continues to innovate, it plays a crucial role in promoting greener cloud computing solutions for businesses worldwide. (Customer Carbon Footprint Tool, n.d.)

Despite challenges in adopting a circular economy, prioritizing better design, extended product lifespan, and improved resource recovery remains a key strategy for reducing waste and enhancing efficiency. By focusing on sustainable product development, companies can create hardware and infrastructure that last longer, minimizing the need for frequent replacements. Extending the operational life of equipment through refurbishing, remanufacturing, and repurposing further reduces environmental impact. Additionally, improving resource recovery ensures that valuable materials from retired products are recycled and reintegrated into production, decreasing reliance on virgin resources. This approach not only cuts down on e-waste but also supports a more resilient and sustainable supply chain. By integrating circular economy principles into business operations, organizations can significantly lower their carbon footprint while maintaining high performance and innovation. Overcoming existing challenges requires collaboration, investment in advanced recycling technologies, and a commitment to sustainable practices. Ultimately, embracing a circular economy helps drive long-term environmental and economic benefits. (AWS Sustainability, n.d.)

3.3 Green Computing at Microsoft:

Microsoft is at the forefront of developing sustainable IT solutions, integrating environmental responsibility into its long-term strategy. In early 2020, the company made a bold commitment to powering its cloud data centers entirely with **renewable energy by 2025** and achieving **carbon-negative status by 2030**. This means Microsoft aims to remove more carbon from the

atmosphere than it emits, setting a new standard for corporate sustainability. By investing in clean energy sources, carbon capture technologies, and energy-efficient infrastructure, the company is working to minimize its environmental footprint while maintaining high-performance cloud services. (Varier, n.d.)

Microsoft has expanded its carbon tax to include **Scope 3 emissions**, which come from its supply chain and other indirect sources. By acknowledging these emissions, the company is taking a comprehensive approach to its environmental footprint. To tackle these emissions, Microsoft has forged partnerships with suppliers and is integrating advanced technologies, such as **low-carbon fuels** and carbon capture solutions, to further reduce its overall emissions. (Brad Smith, 2022)

These strategies not only showcase Microsoft's leadership in sustainability but also inspire its partners and customers to adopt similar practices, promoting a collective effort toward a low-carbon future. By setting ambitious goals like becoming carbon-negative by 2030 and transitioning data centers to renewable energy, Microsoft is setting a powerful example for others to follow. The company's initiatives encourage businesses across various industries to integrate environmental responsibility into their operations, driving widespread adoption of sustainable practices. Moreover, Microsoft's efforts support the development of cutting-edge sustainable technologies, from renewable energy solutions to carbon capture innovations, ultimately benefiting the entire tech industry. Through these actions, Microsoft is helping to accelerate the global shift toward a more sustainable and environmentally conscious future, positioning itself as a leader in both technology and corporate social responsibility. (Our Microsoft sustainability journey, 2020)

Beyond its operations, Microsoft's sustainability initiatives influence its customers, partners, and the broader tech industry, encouraging collective action toward a greener future. Its cloud solutions also help businesses reduce emissions by optimizing workloads, enhancing energy efficiency, and leveraging AI-driven sustainability tools. By leading by example, Microsoft demonstrates that innovation and sustainability can go hand in hand, inspiring industries worldwide to adopt more responsible environmental practices. (Varier, n.d.)

3.4 Green Computing at Meta:

Meta has made remarkable progress in its green computing and sustainability efforts. Aiming for **net-zero carbon emissions**, the company has been investing heavily in renewable energy to power its global operations. By the end of 2020, Meta achieved a significant milestone by transitioning to **100% renewable energy** for its operations worldwide, marking a major achievement in its sustainability journey. In 2019, Meta succeeded in reducing its **operational greenhouse gas emissions by 59%** compared to 2017 levels, showcasing the effectiveness of its sustainability initiatives. This reduction not only highlights Meta's commitment to cutting down on its environmental impact but also helped the company secure a position as the **top corporate buyer of renewable energy** in the U.S. and the **second-largest globally**. By taking these bold actions, Meta not only contributes to a greener future but also sets a powerful example for other tech companies to follow, driving the global transition toward more sustainable energy practices. (Our Progress Addressing Challenges and Innovating Responsibly, 2021)

Meta has successfully achieved **carbon neutrality** and transitioned to running all of its operations entirely on **renewable energy**. This marks a major milestone in the company's sustainability journey, reflecting its commitment to reducing its environmental impact. Looking to the future, Meta is setting even more ambitious goals, aiming to reach **net-zero emissions by 2030**. This forward-looking target aligns with the company's continued dedication to sustainability and its broader efforts to tackle climate change. Through investments in energy efficiency, innovative technologies, and green practices across its operations, Meta is positioning itself as a leader in corporate sustainability and inspiring others in the tech industry to follow suit. (Our Path to Net Zero, 2023)

Meta's sustainability efforts go beyond energy and carbon reduction and also include a strong focus on **water usage**. The company has made significant investments in projects aimed at replenishing millions of gallons of water annually, helping to conserve and restore critical water resources. For example, Meta has partnered in **water restoration projects in Oregon and New Mexico**, focusing on restoring natural water systems and ensuring the long-term sustainability of local ecosystems. These initiatives are part of Meta's broader commitment to environmental responsibility, as the company seeks to not only reduce its carbon footprint but also contribute to water conservation and restoration efforts. By addressing both energy and water usage, Meta

is fostering a more sustainable approach to resource management, setting an example for other organizations to adopt comprehensive environmental stewardship practices. (A Closer Look at Facebook's Commitment to Sustainability, 2020)

To further minimize its environmental footprint, Meta has adopted **AI-driven cooling technologies** in its data centers, which significantly improve energy efficiency and reduce cooling-related energy consumption. Additionally, Meta has reduced water usage in its data centers by **80%**, contributing to better water conservation. The company also encourages efficient and environmentally friendly **hardware design**, ensuring that its products have a minimal environmental impact throughout their life cycle. Through these innovative strategies, Meta not only aims to reduce its own carbon footprint but also sets a benchmark for the tech industry, encouraging others to follow suit in the pursuit of a greener future. (Our Path to Net Zero, 2023)

Global leaders are actively promoting sustainable hardware, adopting renewable energy, improving data center efficiency, and advancing green computing to reduce their environmental impact. These initiatives not only highlight the harmony between technological innovation and environmental responsibility but also drive economic growth, strengthen brand reputation, and contribute to a sustainable digital future.

CHAPTER IV: IMPLEMENTATION CHALLENGES FOR BANGLADESH

I. Technological challenges:

When it comes to implementing green technology, Bangladesh has technical obstacles such a lack of inexpensive and accessible green solutions as well as an insufficiency of water and electricity. Green technology is not widely available in a developing country like Bangladesh. (Wikipedia , n.d.)

II. Investment Limitations:

Bangladesh's green computing investment restrictions are caused by some factors, including low demand, a lack of entrepreneur activity, difficulties implementing policies, poor international funding performance, risk-return variations and a lack of capacity building. Resolving these problems is essential to creating a more secure environment for green computing investment in the nation.(Khan, Khan, Uddin, Azim, & Islam, 2017)

III. Internet Infrastructure:

Although the advancements, Bangladesh still faces Challenges related to inadequate infrastructure, including unstable internet connectivity and an unreliable power supply, which may limit the effectiveness of IT operations. There is still a noticeable digital divide between different socioeconomic groups as well as between urban and rural areas. Furthermore, the successful delivery of digital and online services is hampered by the continuing rate of digital illiteracy, especially among older generations. (Kabir, 2024)

IV. HR Issues:

A shortage of qualified workers, poor training initiatives, and a shortage of sustainability-focused corporate policies cause HR issues with green computing implementation in Bangladesh. (Microsoft Being, n.d.) It can be challenging to draw in and keep personnel with expertise in green technology, many companies lack formal retention plans and rewards. Inadequate leadership development, an aging workforce, and a diverse workforce limit sustainable adoption. (Mehrin A. Mahbub, 2024)

V. Security Issues:

Implanting green computing in Bangladesh comes with security risks, including vulnerabilities to cyberattacks and data protection concerns. Organizations Frequently ignore the security risks of emerging green technology as they transition to energy-efficient systems. The risk of leaks is further increased by inadequate infrastructure, such as outdated software and insufficient encryption. (Anju, 2017)

Bangladesh's green computing industry faces obstacles such exorbitant prices, a shortage of qualified personnel, inadequate equipment, and security threats. Improved policies, training, and cooperation are needed to overcome problems. Bangladesh has the potential to embrace green computing, which would increase productivity while lessening its impact on the environment.

CHAPTER V: FINDINGS OF THE STUDY

1) Significance of Green Computing:

- Green computing is important for decreasing e-waste, cutting carbon emissions, and lessening the impact on the environment.
- It increases energy efficiency, lowers costs, and encourages corporate social responsibility (CSR).

2) Challenges in Implementation:

- **Technical Challenges:** Bangladesh has problems such as restricted access to sustainable IT solutions, inadequate water and electricity supplies, and a dearth of reasonably priced green technologies.
- **Investment Barriers:** Investment in green computing is limited because of low demand, little international financing, and poorly implemented policies.
- **HR Challenges:** There are insufficient training programs, a lack of green HR policies for sustainability, and a paucity of qualified personnel.
- **Internet and Infrastructure Limitations:** Unreliable power supplies, erratic internet connectivity, and a digital gap between urban and rural areas are all problems facing the nation.
- **Security Infrastructure:** Outdated security architecture, data breaches, and cyber-attacks might all affect green computing systems.

3) Corporate Initiatives in Green Computing:

- In the areas of carbon neutrality, energy-efficient data centers, and sustainable IT operations, Google, Microsoft, Amazon (AWS), and Meta have made notable progress.
- By 2030, Google wants all of its energy to be carbon-free, and Microsoft and Meta want to have zero net emissions by the same year.

4) Future Prospects of Green Computing:

- A focus on sustainable supply chains, virtualization, and e-waste management.
- Increased emphasis on IoT, cloud computing, and AI to improve energy efficiency

CHAPTER VI: CONCLUSION

The importance of green computing in reducing the negative effects of technology on the environment is emphasized in this paper. It emphasizes the necessity of sustainable IT practices at every stage of a technical product's lifecycle, from creation and usage to disposal. To solve global environmental issues, including e-waste management, the report promotes cooperation between countries, organizations, and international agencies. Looking ahead, it emphasizes the bright future of green computing, which will result in a circular economy, more intelligent resource management, and more efficient energy consumption due to technology improvements and rising awareness. The report acknowledges advancements but calls for further development via innovation, research, and the use of environmentally friendly methods. Lastly, it emphasizes how crucial it is to educate staff members and IT specialists on green computing techniques to promote a sustainable culture both inside and outside of businesses.

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