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GREEN COMPUTING AND ENERGY-EFFICIENT SYSTEMS: A SURVEY-BASED RESEARCH STUDY

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Abstract

This paper presents an extensive survey based analysis of green computing and energy efficient systems since information and communication technology (ICT) is one of the significant contributors to global carbon emission and energy consumption. To minimize environmental degradation, it investigates the design, manufacture, usage, as well as disposal of computing products. This study examines more than thirty peer-reviewed publications and current industry practices to identify, assess, and categorize the significance of key green practices, including virtualization, energy-efficient hardware design, cloud computing, and the usage of renewable energy. The importance of sustainable IT for increasing productivity, reducing e-waste, and lowering carbon emissions was the main topic of this paper. Furthermore, the given research offers knowledge about the future research possibilities on how to create sustainable digital infrastructures.

Keyword: Green computing, Energy-Efficient Systems, Sustainable Information Technology, Energy-Efficient Data Centers, Cloud Computing Sustainability, Virtualization, Carbon Footprint Reduction, e-waste management, sustainable digital infrastructure.

Introduction

The rapid advancement of digital technology, while transforming society, has placed a considerable strain on the environment. Information and communication technology is estimated to be the cause of approximately 20 percent of the total carbon dioxide emission on earth and approximately 16 percent of the global warming effect. As a result, Green IT, or Green Computing, has emerged. This important field of study focuses on using eco-friendly and sustainable technology operations to lessen environmental impact. Green computing prioritizes energy efficiency and minimizes adverse environmental effects over the whole lifecycle of computers and related technology.

Advancement in Management and Technology (AMT)

The increasing demand of sustainable computing is driven by increasing energy costs, depleting natural resources and the need to reduce carbon emission. Data centers being the primary components of the modern digital services are energy-heavy and therefore it is important to implement efficient power management and enhanced cooling techniques. The paper provides a general summary of available, energy saving computing techniques. It attempts to bridge the gap in knowledge regarding the efficiency of the different green IT policies by evaluating the current developments in software optimization, hardware design and utilization of renewable energy.

Literature Review

The research in the field of green computing is aimed at minimizing the environmental impact of IT through the use of energy efficient hardware, efficient software and ensuring sustainable lifecycles. Surveys conducted by this Current point to the trend of making cloud data centres efficient. It has several approaches which includes virtualization, power-sensitive algorithms, and incorporation of renewable energy assistance to reduce carbon footprints. Critical Literature Results on Green Computing Data Centers that are Energy-Efficient Data centers Research has frequently raised the issue of the energy-intensive nature of cloud computing. The necessity of the improved control of resources and virtual machine consolidation is raised.

Software and Hardware Optimization: It has been found that software methods are mostly favored as they are inexpensive as compared to redesigning hardware. Some of the major strategies include energy-sensitive algorithms and networks that can be used to optimally use power.

Sustainable Lifecycle and E-Waste: In addition to energy, the literature also highlights the relevance of enhancing hardware reusability, reparability and proper handling of electronic waste.

Important Methods: Virtualization, thermal management, and renewable energy sources are some of the important techniques in collective schemes.

Future Research Directions: AI and Energy Consumption addressing the growing energy demands of AI workloads in data centers.
Cloud Sustainability: Additional study of IoT and wireless network energy efficiency. Methodological Developments: Developing stronger and larger-scale green algorithms and frameworks.

Large companies which have gone green:

- Google -Renewable-powered data centers.
- Microsoft -Carbon-negative targets.
- Apple -100 percent renewable energy at corporate sites.

Research Methodology

1. Research Design

- Survey Method (Quantitative)
- Structured questionnaire
- Online distribution

2. Sample Size

- 120 respondents
    - 60 Students
    - 40 IT Professionals

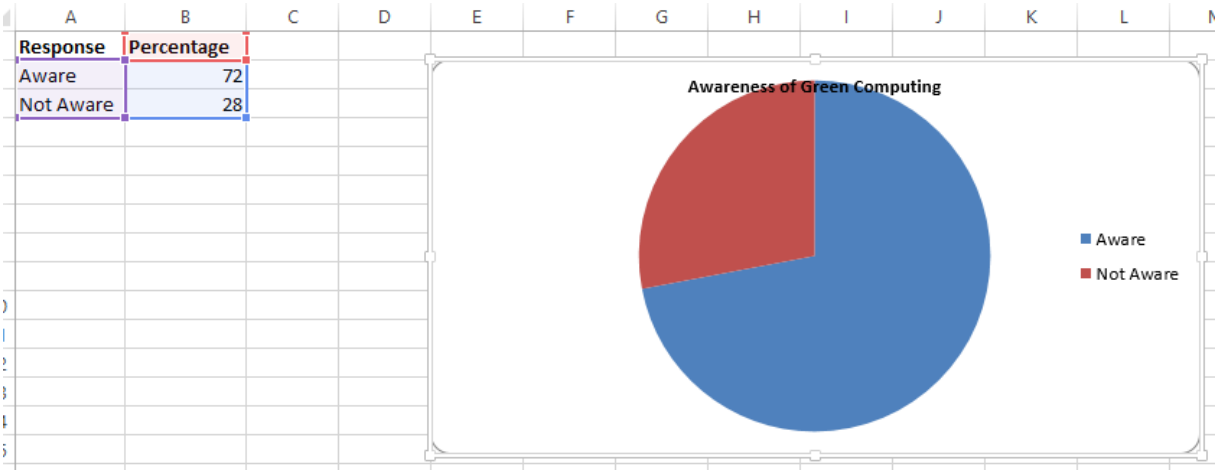
- 20 Small Business Owners

3. Key Survey Questions

1. Do you know about Green Computing?
2. Do you have energy efficient appliances?
3. Do you have virtualization in your organization?
4. Does your IT set-up use renewable energy sources?

Data Analysis and Charts:

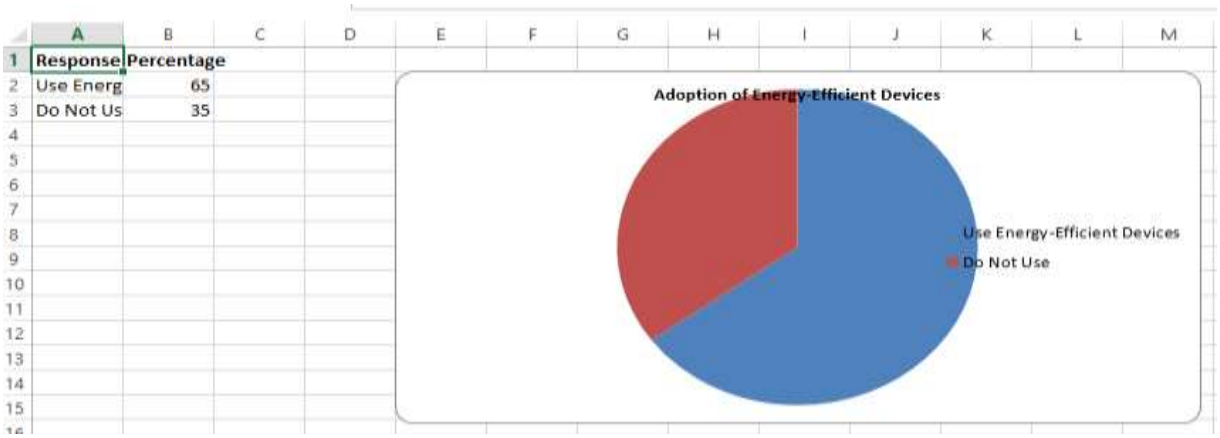
Awareness of Green Computing



Result:

- 72% Aware
- 28% Not Aware

Interpretation: Majority are aware, but awareness programs are still required.

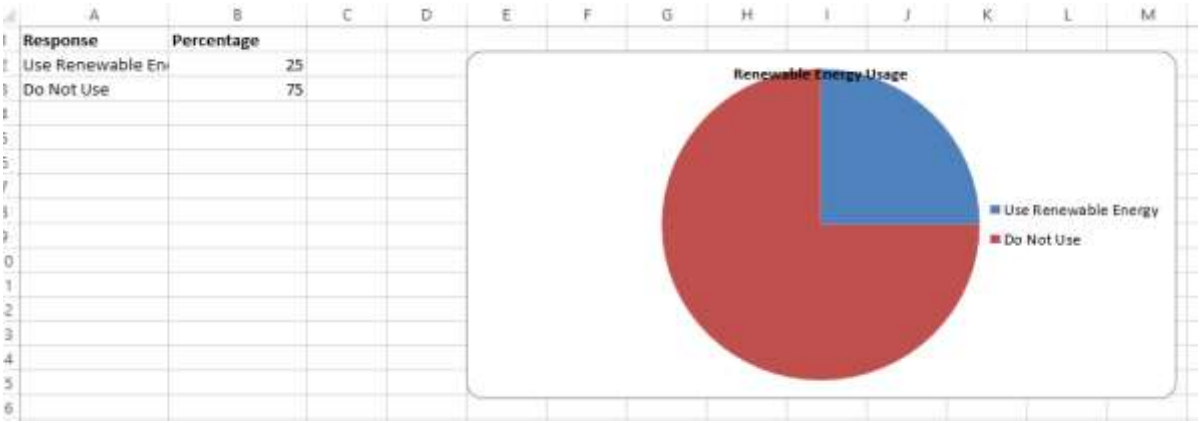


Adoption of Energy-Efficient Devices

Result:

- 65% use LED monitors / SSDs
- 50% enable power-saving mode
- 35% use Energy Star certified devices

Organizational Green Practices



Findings:

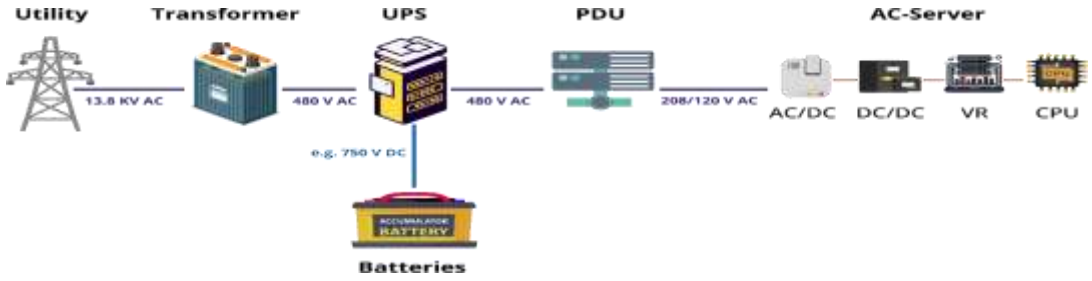
- 48% use virtualization
- 52% use cloud services
- 25% use renewable energy source

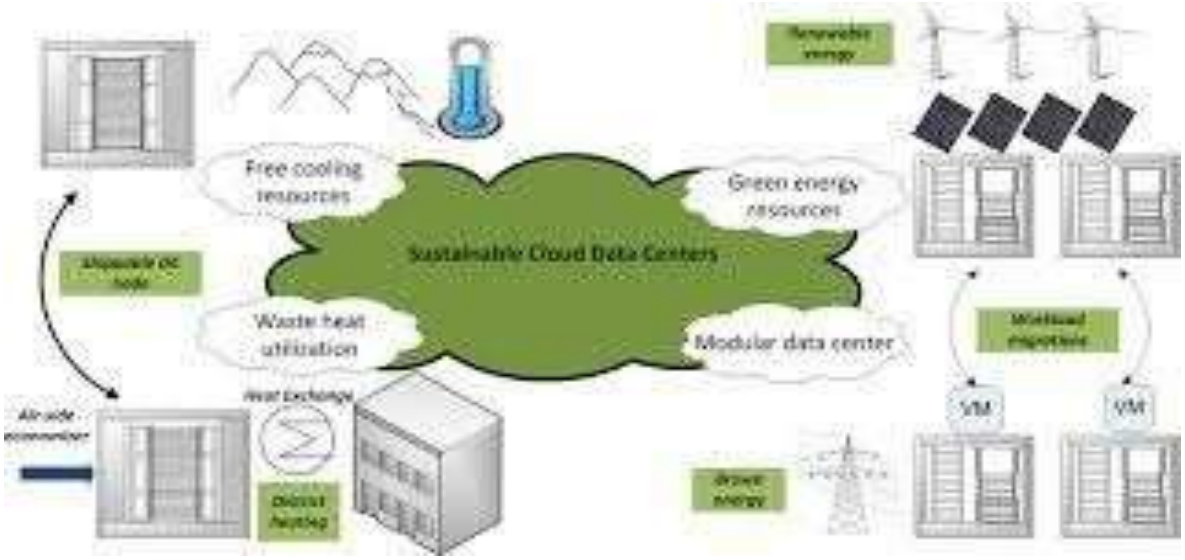
System Architecture of the Energy-efficient Data Center. A power and cooling friendly data center design is one that developed to achieve the optimum IT performance and minimum power usage. Large scale elements of an energy-saving data center architecture consist of high density air-controlled racks, cooling solutions, high efficiency UPS, and DCIM solutions to decrease Power Usage Effectiveness (PUE).

Components:

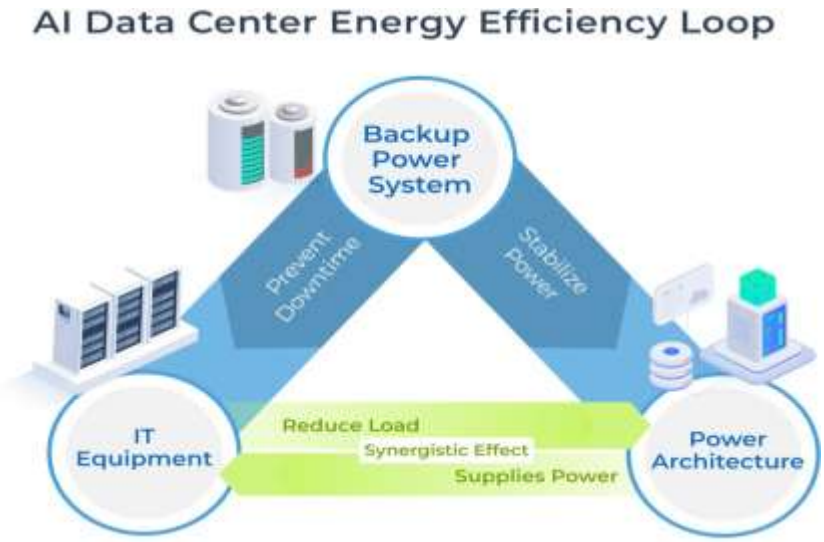
- Virtualized Servers
- Cooling Systems that are energy efficient.
- The integration of renewable energy (Solar Panels) is performed.
- Smart units of power management.
- Cloud Resource Optimization Layer.

Data Centers and Energy Efficiency





Components of Sustainable Cloud Data Center Model



Discussion:

The survey results show:

- Awareness: with respect to students it is high but with regard to small business it is moderate.
- Cloud computing and virtualization lead to a high level of hardware reliance.
- Adoption of renewable remains low as a result of cost restrictions.
- Implementation can be improved by using incentives and policy support.

Benefits of Green Computing.

- Reduced operational costs
- Lower electricity bills
- Environmental protection
- Improved system efficiency
- Sustainable IT growth Challenges

Challenges

- High initial investment
- Ignorance in the rural setting.
- Low technical competence.
- Infrastructure resistance to change.

Recommendations:

1. Green IT government subsidies to its adoption.

2. Mandatory energy audits

3. Educational institutions awareness programs.

4. Financial incentives on powering down renewable data centers.

5. Smart energy management systems with the use of AI.

Conclusion:

According to the survey study, there were some encouraging trends in the use of green compu ting. On the other hand, the integration of renewable and full implementation of green infrastructure are some of the areas that need to be improved. The next wave of study can be AI-controlled energy saving and carbon-neutral computing devices.

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