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Green and Sustainable Computing: Efficient Strategies, Best Practices, and Emerging Research Trends

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Abstract: *Green and sustainable computing has evolved from a narrow focus on reducing the energy consumed by computer hardware into a broader discipline concerned with energy efficiency, distributed architectures, artificial intelligence, environmental impact, and lifecycle sustainability. This paper presents a structured review and trend analysis based on the findings reported in a recent large-scale study of 11,119 Scopus-indexed journal articles published between 1960 and 2025. The reviewed study used BERTopic with transformer-based embeddings, UMAP dimensionality reduction, HDBSCAN clustering, and temporal analysis to identify 36 research topics. This paper reorganizes those findings into an IJARSCT-style review format and synthesizes the major research directions, thematic groups, developmental stages, challenges, and future opportunities. The evidence shows that virtualization and hardware-efficiency themes have historically been important, while edge computing, AI-supported systems, neuromorphic architectures, UAV computing, and environmentally aware computation have gained research attention. The review also highlights limitations associated with database coverage, metadata quality, topic interpretation, and the use of relative topic prevalence. The resulting framework can help students and researchers understand the changing landscape of green computing and identify areas for further investigation.*

Keywords: Green Computing, Sustainable Computing, Energy Efficiency, Artificial Intelligence, Edge Computing, BER Topic Green AI.

I. INTRODUCTION

Green computing, also called sustainable computing, is the process of developing and optimizing computer chips, systems, networks, and software to maximize efficiency by using energy efficiently and minimizing negative environmental impact. It emerged in response to concerns about the environmental
effects of information and communication technology (ICT). Its major goals include energy efficiency, reduction of carbon emissions, sustainable infrastructure, and reduction of electronic waste.

Green computing is studied across areas including green data centers, green cloud computing, green IoT, green databases, green data mining and information retrieval, green machine learning, green e-commerce and e-government, green procurement, green agriculture, green education, smart grids, and green transportation systems.Digital technologies are now embedded in communication, public services, education, business, scientific research, and industrial operations. The growth of data-intensive applications, cloud platforms, artificial intelligence, and distributed systems has increased the computational resources required to operate digital infrastructure. As a result, the environmental dimension of computing has become an important research concern.

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Green computing refers to approaches that reduce energy consumption, improve resource utilization, and limit the environmental impact of computing systems. A sustainable perspective extends this idea across the lifecycle of digital technologies, including manufacturing, operation, cooling, replacement, and disposal. Current research therefore covers energy-efficient hardware, resource-aware software, sustainable artificial intelligence, data-center optimization,carbon-aware workload management, and lifecycle assessment.

II. PROBLEM STATEMENT AND RESEARCH GAP

Problem statement: The rapid growth of information and communication technologies (ICT), cloud computing, artificial intelligence (AI), data centre, Internet of Things (IoT) devices, and high-performance computing has significantly increased energy consumption and environmental impact. Computing infrastructure requires substantial electrical power for processing, storage, networking, and cooling, while the manufacturing and disposal of electronic devices contribute to carbon emissions, resource depletion, and electronic waste (e-waste).

Research Gap: Limited integration of sustainability strategies: Existing approaches frequently focus on individual aspects, such as energy-efficient hardware, data centre cooling, or workload scheduling, rather than integrating hardware, software, networking, and lifecycle management into a unified framework.

Research Questions: Which green computing strategies are most effective in reducing energy consumption and carbon emissions?

III. EXISTING SYSTEM

The diagram above illustrates the existing computing system, including users/devices, the application layer, data-centre infrastructure, and output services. It also highlights environmental impacts such as high energy consumption, carbon emissions, cooling requirements, and e-waste generation.

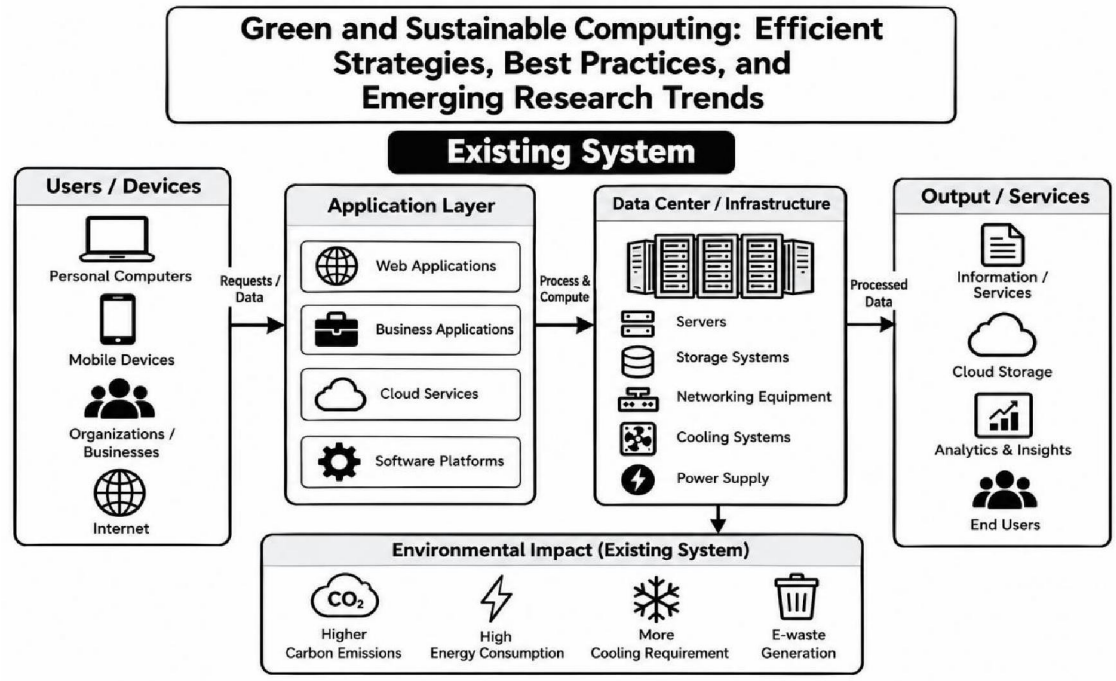

Fig 1: Green And Sustainable Computing: Efficient Strategies, Best Practices, And Emerging Research Trends Existing System.

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Working of existing system:

1. User Input: Users access the system through computers, mobile devices, or other digital devices and send requests
2. Application Layer: Web applications, business applications, cloud services, and software platforms receive and process user requests.
3. Data Centre Processing: Servers execute tasks and process the requested data. Storage systems save data, while networking equipment transfers information.
4. Power and Cooling: The infrastructure requires electricity to operate. Cooling systems remove excess heat generated by servers and other equipment.
5. Output Generation: After processing, the system delivers results such as information, cloud storage, reports, and digital services to users.
6. Environmental Impact: Conventional systems can consume excessive energy, produce carbon emissions, require substantial cooling, and generate e-waste when hardware becomes outdated.

IV. PROPOSED SYSTEM

The proposed system for Green and Sustainable Computing: Efficient Strategies, Best Practices, and Emerging Research Trends uses the CA-MA-DFSA method to improve energy efficiency and optimize computing resources. It focuses on monitoring CPU usage, memory utilization, server workloads, and power consumption. The system dynamically allocates computing resources according to workload requirements and schedules tasks efficiently. It aims to reduce unnecessary energy consumption, minimize idle server time, improve resource utilization, and lower operational costs.

The proposed system also focuses on reducing carbon emissions and electronic waste through sustainable computing practices. By combining resource monitoring, efficient task scheduling, and energy management, the system aims to provide reliable computing performance while reducing environmental impact.

V. PROPOSED CA-MA-DFSA METHOD

Working of Proposed System

Sr. No.	Module	Description
1.	CA – Computing Analysis	Analyses system workload, CPU usage, memory usage, and energy consumption.
2.	MA – Monitoring and Allocation	Monitors resource requirements and allocate resources according to workload.
3.	DFSA – Dynamic and Flexible Scheduling Algorithm	Schedules computing tasks efficiently and prioritizes resource utilization.
4.	Energy Optimization	Reduces unnecessary power consumption by avoiding idle resource usage.
5.	Green Resource Management	Improves the utilization of servers, storage, and other computing resources.
6.	Performance Evaluation	Evaluates energy consumption, processing time, resource utilization, and system performance.
7.	Sustainable Output	Aims to provide computing services with improved energy efficiency and reduced environmental impact.

Table 1: working of proposed system

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VI. RESULTS AND DISCUSSIONS

Green and Sustainable Computing focuses on reducing the environmental impact of computing systems through energy-efficient technologies, resource optimization, and sustainable IT practices. The study highlights the importance of reducing energy consumption, minimizing carbon emissions, managing electronic waste, and improving the efficiency of computing resources.

The results indicate that techniques such as virtualization, cloud computing, energy-efficient hardware, and intelligent power management can contribute to sustainable computing. These approaches help improve resource utilization, reduce unnecessary electricity consumption, and support environmentally responsible technology development.

Fig 2: Environmental Benefits of Green Computing

VII. LIMITATIONS OF THIS REVIEW

This paper is a structured review and synthesis based primarily on the supplied 2026 source study. It does not independently reproduce the original Scopus query or BER Topic experiment. Consequently, the reported topic percentages and trend values should be understood as results of the source study. The review also inherits the source study's limitations, including database coverage, metadata dependence, topic-label interpretation, and the use of relative prevalence rather than direct impact measures.

VIII. CONCLUSION

Green and Sustainable Computing is an important way to protect our environment while using modern technology. The main aim is to save electricity, reduce pollution, and minimize electronic waste. By using energy-efficient computers, cloud computing, renewable energy, and proper e-waste management, we can make technology more environmentally friendly.

Green computing also helps organizations save money and use computer resources more efficiently. New technologies, such as artificial intelligence and smart energy management systems, can further improve energy efficiency in the future. However, some challenges, such as high initial costs and a lack of awareness, still need to be addressed.

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In conclusion, everyone has a role to play in making computing more sustainable. By following simple green computing practices and adopting new technologies, we can reduce environmental damage and create a cleaner, greener, and better future for the next generation.

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