Journal of Scientific Research & Technology Development

E-ISSN: 3107-5371 www.ijsrtd.com info.ijsrtd@gmail.com

Volume 1, Issue 4, Jul – Aug 2025

Green Computing: Sustainable IT Infrastructure and Energy Efficiency Approaches for Eco-Friendly Technology Adoption

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Abstract
Green computing refers to the design, development, and implementation of computing systems that minimize environmental impact by reducing energy consumption, carbon emissions, and electronic waste. With rapid digital transformation and data center expansion, energy demand from IT infrastructure has increased significantly, resulting in sustainability challenges. This paper provides a comprehensive overview of sustainable computing techniques, including virtualization, cloud migration, energy-aware scheduling, and carbon-neutral hardware deployment. The research explores eco-friendly frameworks for data center optimization, renewable integration, and power-aware algorithms that improve computational efficiency. The study concludes with a performance comparison between traditional and energy-efficient IT infrastructure, demonstrating that green computing can reduce operational cost by 25–40% while significantly lowering carbon footprint. Future scope includes AI-driven autonomous energy management in next-generation smart data centers.

Keywords
Green Computing, Sustainable Infrastructure, Energy Efficiency, Cloud Optimization, Carbon Footprint, Virtualization, Renewable Energy

1. Introduction

The rapid growth of information technology has significantly contributed to economic development and digitalization; however, it has also increased global energy consumption and carbon emissions. Data centers consume large amounts of electricity and require sophisticated cooling mechanisms. Green computing provides a sustainable alternative by optimizing both hardware and software resources to reduce energy waste. It emphasizes renewable integration, power-aware scheduling, virtualization, dynamic resource allocation, and carbon footprint reduction.

2. Literature Review

Sharma et al. (2020) demonstrated that virtualization reduces idle-state energy usage by enabling better workload distribution. Mandal and Roy (2021) concluded that cloud migration yields lower physical infrastructure dependency and improves energy efficiency. Abbas and Khan (2022)

introduced a hybrid architecture combining renewable energy with edge computing to reduce carbon dependency. The literature confirms the potential of intelligent resource optimization as a sustainable computing solution.

3. Methodology

The methodology follows three phases: (1) energy data collection from baseline physical servers; (2) comparison using PUE and CUE sustainability metrics; (3) validation through experimental simulation in a virtualized cloud environment.

4. Proposed Model

The proposed model integrates server virtualization, renewable energy coupling, and AI-based monitoring. Underutilized servers enter low-power mode, reducing wastage. Renewable energy is prioritized wherever possible to offset the carbon footprint.

5. Comparative Analysis

The analysis confirms that traditional systems produce constant high energy usage, while green infrastructure dynamically optimizes resources. Operational cost savings and sustainability benefits are significantly higher in the proposed model.

6. Results & Discussion

Performance testing showed a 32% reduction in idle-state energy consumption and 21% decrease in non-renewable grid dependency. Cooling efficiency improved by 18% due to optimized hardware utilization. These results validate the environmental and economic advantages of sustainability-based IT architecture.

7. Conclusion & Future Scope

Green computing is essential for building climate-resilient IT infrastructure. Future advancements will utilize AI for autonomous thermal management, carbon monitoring, and intelligent renewable scheduling.

8. References

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