

Optimization in Renewable Energy Systems for Sustainable Smart Cities Using Quantum Algorithms

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Abstract:

The transition to renewable energy is essential for building sustainable smart cities, yet optimizing such complex systems remains a major challenge. This study proposes a novel framework that leverages quantum algorithms to optimize the integration, distribution, and management of renewable energy resources. By modeling large-scale energy systems—encompassing solar, wind, and bioenergy sources—quantum-inspired algorithms such as Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE) are utilized to solve high-dimensional, non-convex optimization problems with greater efficiency than classical methods. Combined with IoT-based monitoring and real-time data analytics, the framework supports predictive load balancing, energy demand forecasting, and system resilience under dynamic urban conditions. Experimental simulations demonstrate the potential of quantum computing to significantly improve operational performance, scalability, and sustainability in smart city energy infrastructures.

Keywords:

Renewable energy, quantum algorithms, smart cities, energy optimization, sustainability, IoT.

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