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Optimizing Renewable Energy Integration: LiDAR-Based Solar Forecasting and Smart Energy Management for Grid Stability

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Extended Abstract

As the demand for renewable energy surges, a critical challenge emerges: the dependence of wind and solar power on atmospheric conditions, leading to supply fluctuations—exceeding demand at times and falling short at others[1]. Addressing this issue requires an effective strategy for balancing supply and demand, with a core focus on optimizing power generation forecasting and control to enhance scheduling and load management. This research leverages LiDAR-based remote sensing technology[2] to assess and predict solar irradiance by analyzing cloud coverage, drift patterns, optical thickness, and occurrence frequency. Unlike traditional passive irradiance measurements[3], this approach enables automated, intelligent, and networked monitoring, facilitating smart control of photovoltaic systems. As a result, it enhances peak shaving and valley filling, improving renewable energy utilization efficiency. Building on LiDAR forecasting and IoT-driven solar energy management, this research aims to develop an integrated energy system that optimizes production, storage, and conversion. By merging high-precision LiDAR predictions with real-time IoT control, the system achieves enhanced responsiveness to environmental fluctuations. The goal is to enhance Power Conversion System (PCS) strategies in island mode while integrating energy storage and hydrogen production technology. This ensures efficient, stable operation during grid interruptions, addressing future localized energy needs. The research will deliver both theoretical foundations and practical insights for next-generation green energy systems, advancing sustainability and carbon neutrality.

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