

Achieving Sustainable Integration of Renewable Energy via Smart Grids and Artificial Intelligence

Aouragh Karim
(aouragh.karim@yahoo.com)
Independent Researcher

INTRODUCTION & AIM

The increasing demand for clean and sustainable energy has accelerated the adoption of renewable energy sources such as solar and wind power. These resources help reduce greenhouse gas emissions and dependence on fossil fuels. However, their intermittent nature creates challenges for maintaining grid stability and ensuring a reliable electricity supply. Smart grids have emerged as an effective solution by integrating advanced communication, monitoring, and control technologies. This study investigates the integration of renewable energy sources into smart grids using intelligent control strategies and predictive models to improve energy efficiency, reliability, and environmental sustainability.

METHOD

A smart energy storage system was integrated to store excess energy and supply electricity during peak demand periods or unexpected power shortages. The performance of the proposed system was evaluated using indicators such as energy losses, voltage stability, frequency regulation, and carbon emissions. The obtained results were compared with those of a conventional power grid.

RESULTS & DISCUSSION

The simulation results showed significant improvements in grid performance. Energy losses were reduced by up to 15% compared with traditional systems, indicating more efficient energy utilization. The intelligent control strategies also enhanced voltage and frequency stability, especially during peak demand and fluctuations in renewable energy generation. Furthermore, the integration of energy storage systems improved the reliability of power supply and reduced the impact of renewable energy intermittency.

Environmental analysis revealed that the proposed system reduced carbon emissions by approximately 12% due to the increased use of renewable energy and reduced dependence on fossil fuels. The artificial intelligence models achieved accurate predictions of renewable energy output, supporting better planning and operational decision-making. These findings demonstrate the effectiveness of combining renewable energy, smart grids, and intelligent technologies.

CONCLUSION

The study confirms that integrating renewable energy sources into smart grids can significantly improve efficiency, reliability, and sustainability. Intelligent control systems, predictive models, and energy storage technologies contribute to reducing energy losses, enhancing grid stability, and lowering carbon emissions. The proposed approach provides a practical solution for managing renewable energy variability while supporting sustainable energy development.

Future Work

Future research should focus on implementing the proposed system in large-scale power networks and exploring advanced energy storage technologies and artificial intelligence techniques to further improve forecasting accuracy, grid reliability, and overall system performance.