

## Advancements in Artificial Intelligence for Renewable Energy Systems over the Past Decades

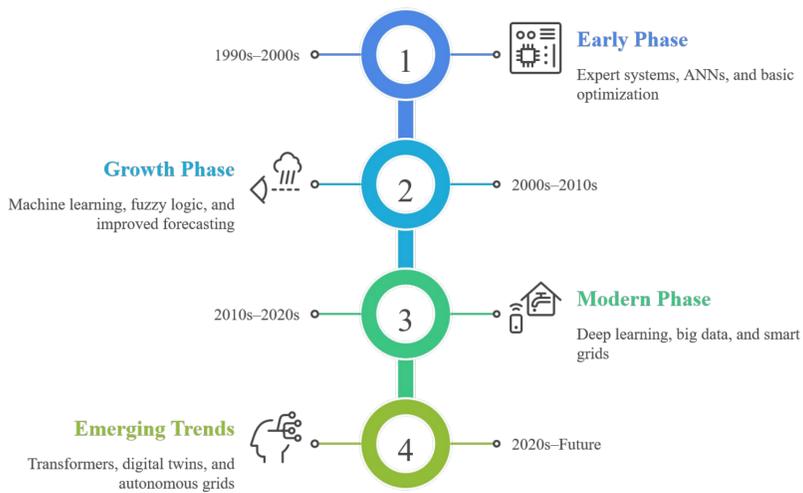
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### INTRODUCTION

The integration of artificial intelligence into the energy infrastructure of renewable energy sources has been making significant steps during the last several decades that are being led by the need to have sustainable and clean energy solutions in the global arena. The advanced data-processing and smart decision-making of AI have been used at both ends of the renewable technology spectrum: wind turbines, solar photovoltaic arrays, energy storage, and hybrid power structure, hence improving efficiency, reliability, and optimisation of operation. Such technological innovations relate to such critical issues as the natural variability of the renewable generation, the growing complexity of the systems, and the complexity of the grid integration; these challenges are met by enhancing the precision of the forecasting, developing control mechanisms, and enhancing energy-management procedures. Additionally, the development of AI approaches to problem solving has expanded their use in the rationalization of resource allocation and the integration of renewables in large-scale terms in the quest to achieve carbon-neutral goals, inclusive of explainable AI and reinforcement learning approaches. However, there are still important problems, such as data quality, model interpretability, cybersecurity, and scalability, which require ongoing research and innovation. Overall, the AI and renewable energy systems are working together to create a smarter, stronger, and more sustainable future.

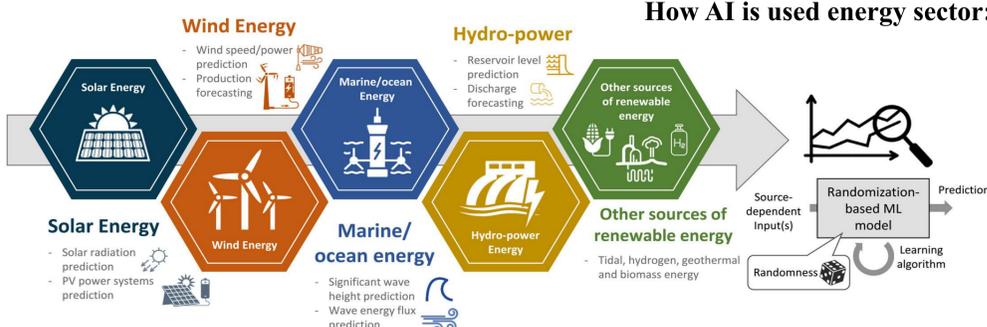
### Evolution of AI in Renewable Energy



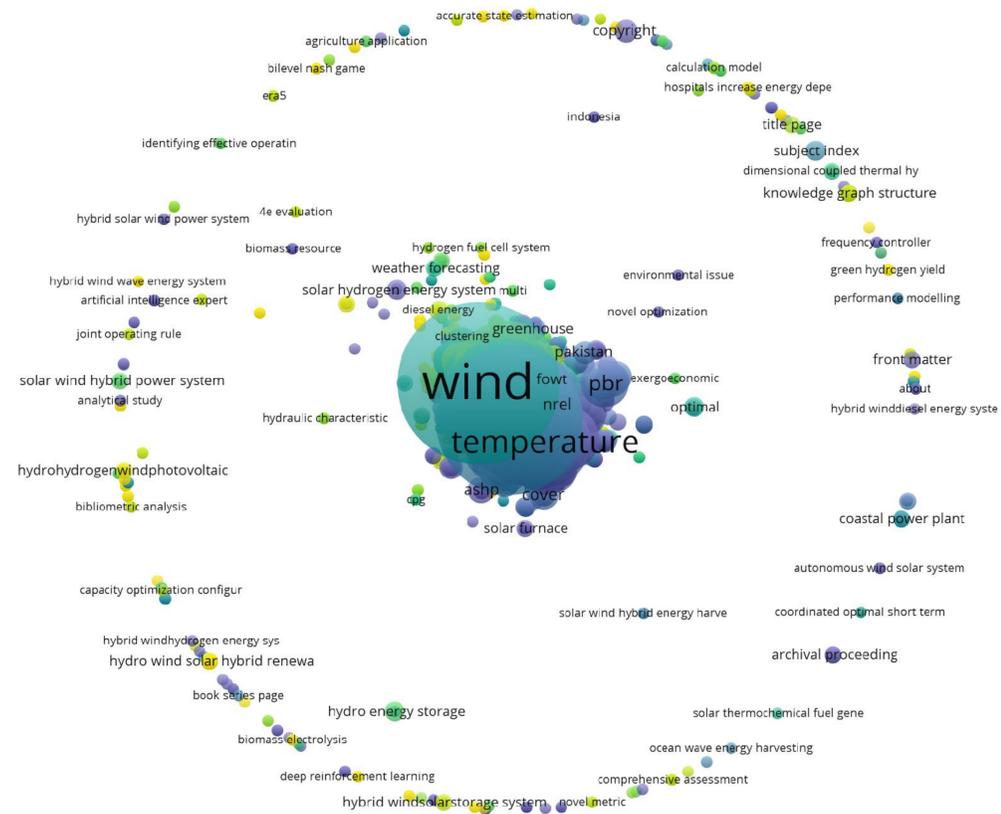
### AI Techniques Used in Renewable Energy Systems

Category	Techniques	Renewable Energy Applications
Machine Learning	Regression, SVM, Random Forest	Energy forecasting (e.g., solar irradiance via SVM), load prediction
Deep Learning	CNN, RNN, LSTM, Transformers	Time-series prediction (e.g., wind power with LSTM), PV output optimization
Optimization Algorithms	GA, PSO, ACO	Grid integration, resource allocation in hybrid systems
Advanced Systems	Fuzzy Logic & Expert Systems, Multi-Agent & Hybrid AI	Fault detection, real-time control in multi-source renewables

### How AI is used energy sector:

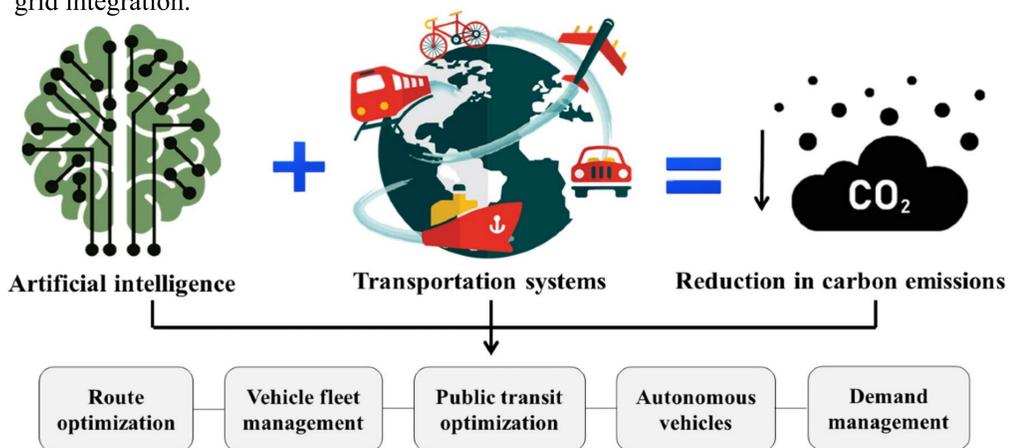


### AI Applications in Renewable Energy



### Role of AI in Climate Change Mitigation

AI has significantly enhanced renewable energy systems by improving efficiency, reliability, and operational optimization across various technologies such as wind, solar, energy storage, and hybrid systems. AI techniques like machine learning, neural networks, and optimization algorithms have been widely applied to address challenges, including variability in renewable generation, forecasting accuracy, system control, and grid integration.



### CONCLUSION

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