Weather-Based Prediction of Wind Turbine Energy Output: A Next-Generation Approach

1. Core Problem Understanding

Traditional wind energy prediction models struggle with sudden weather changes, non-linear wind behavior,

seasonal variability, and limited real-time adaptation.

2. Key Weather Parameters

Wind Speed, Wind Direction, Air Density, Temperature, Humidity, Atmospheric Pressure, Turbulence Intensity.

3. Data Sources

Weather stations, satellite data, SCADA systems, terrain maps, historical logs.

4. Next-Generation Prediction Ideas

AI-driven models (LSTM, Transformers), Hybrid physical-AI models, Edge computing, Digital twins.

5. Smart System Architecture

Input Layer → Processing Layer → Prediction Layer → Output Layer.

6. Innovative Features

Explainable AI, federated learning, self-calibrating turbines, carbon-aware optimization.

7. Use Cases

Grid optimization, revenue forecasting, predictive maintenance, policy planning.

8. Evaluation Metrics

MAE, RMSE, forecast horizon accuracy, adaptability to extreme weather.

9. Research Gaps

Extreme weather handling, offshore forecasting, low-data regions, climate-aware models.

10. Conclusion

Next-generation weather-based prediction systems enable smarter, adaptive, and reliable wind energy forecasting.