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

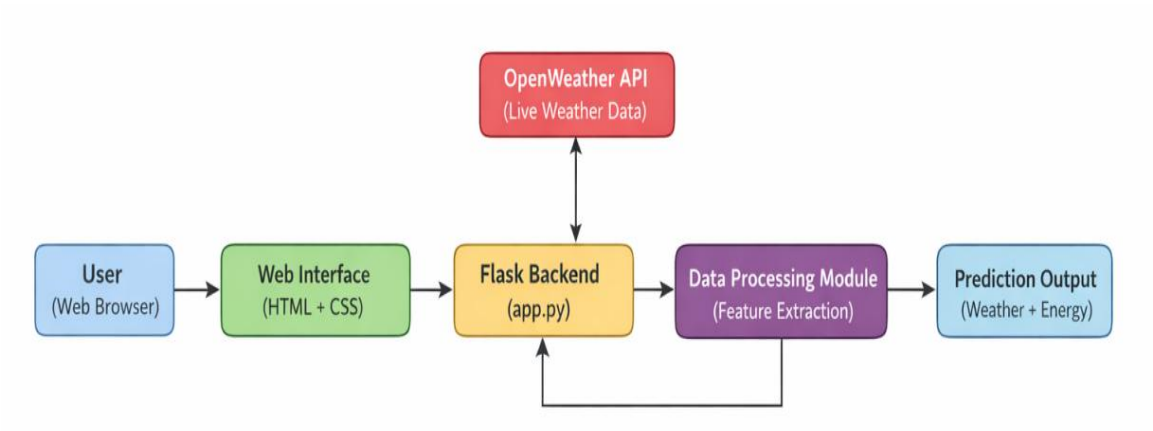
1. Introduction

Wind energy is one of the fastest-growing renewable energy sources worldwide.
This project focuses on predicting wind turbine energy output using weather parameters such as wind speed, temperature, humidity, and pressure. Accurate prediction helps optimize renewable energy management and grid stability.

2. Project Overview

Wind energy is one of the fastest-growing renewable energy sources worldwide. However, wind turbine power generation is highly dependent on weather conditions such as wind speed, temperature, humidity, and atmospheric pressure. Accurate prediction of wind energy output is essential for efficient energy management, grid stability, and operational planning.

This project focuses on developing a machine learning–based system that predicts wind turbine energy output using real-time weather data. By leveraging regression algorithms and data visualization techniques, the system aims to assist renewable energy providers in optimizing energy production and improving forecasting accuracy.

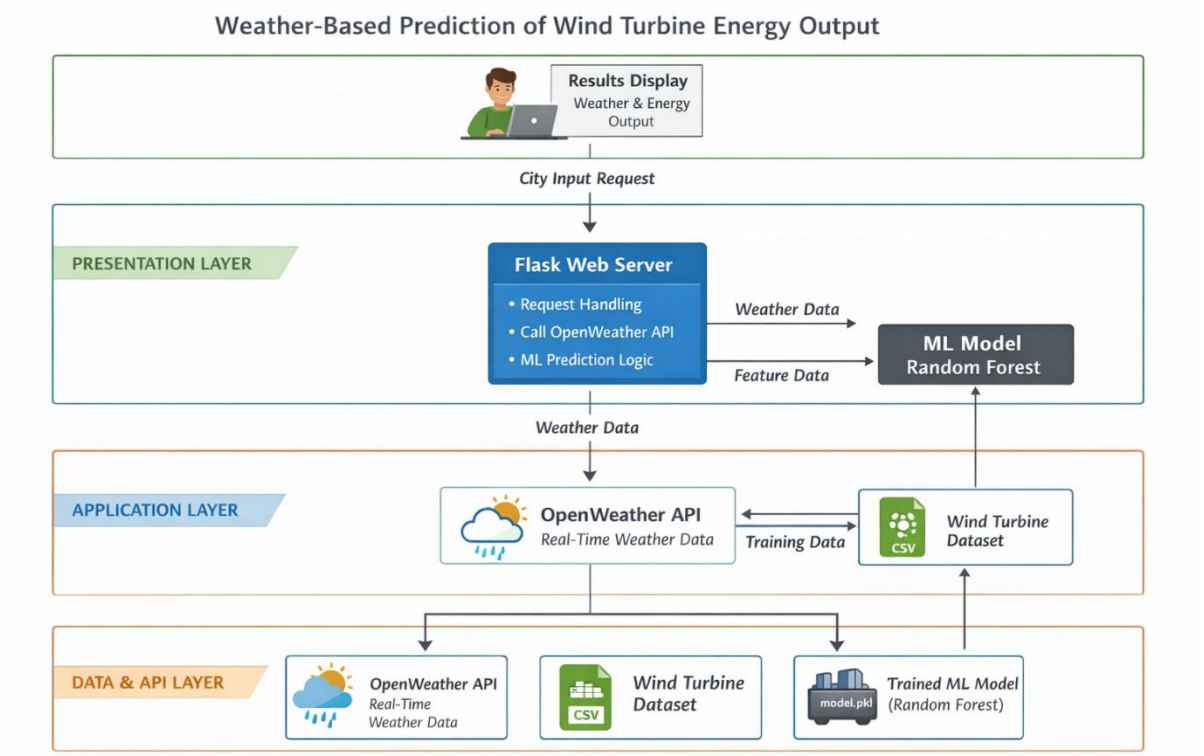


3. Objectives

The objectives of this project are:

- To collect and analyze weather and wind turbine datasets.
- To preprocess and clean the dataset for better model performance.
- To develop a machine learning regression model for energy prediction.
- To evaluate model performance using standard regression metrics.
- To build a web-based interface for real-time weather-based energy prediction.

4. Architecture



Frontend: HTML, CSS (Flask Templates)
Backend: Python Flask
Machine Learning: Scikit-learn Regression Model
API: OpenWeather API
Development: Google Colab & VS Code

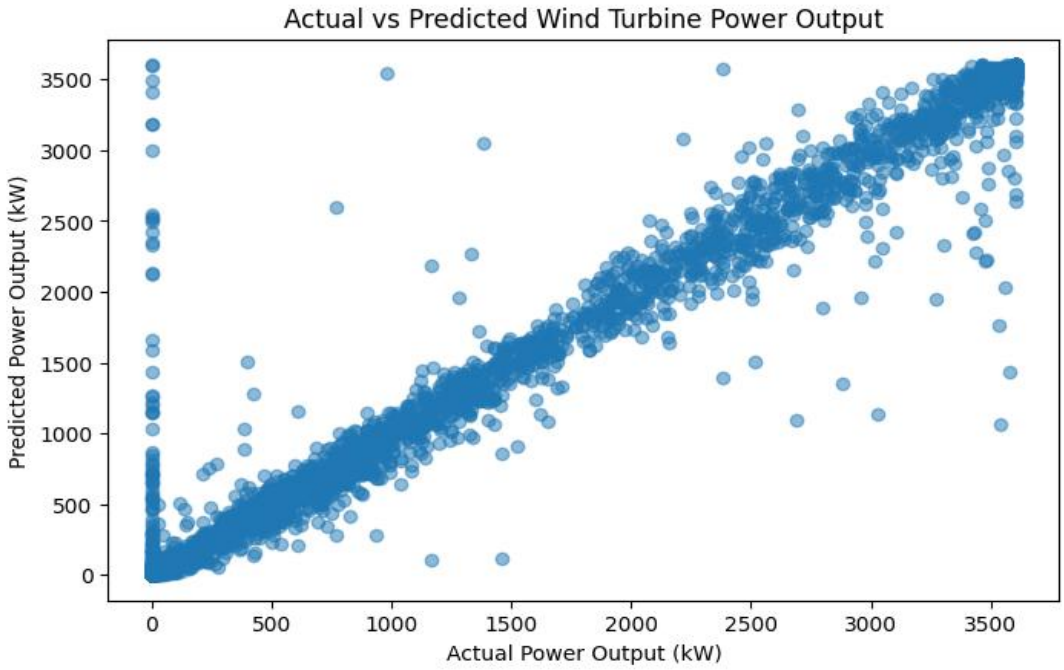
5. Data Preprocessing

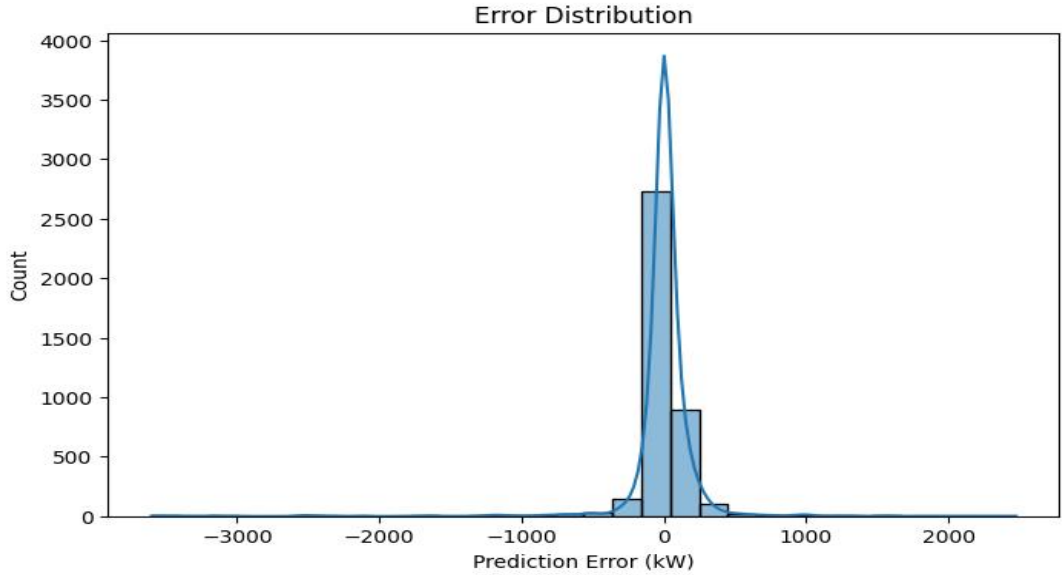
Preprocessing steps included:

- Handling missing values
- Data normalization

• Train-test split (80:20)
• Data visualization using bar, line, and pie charts

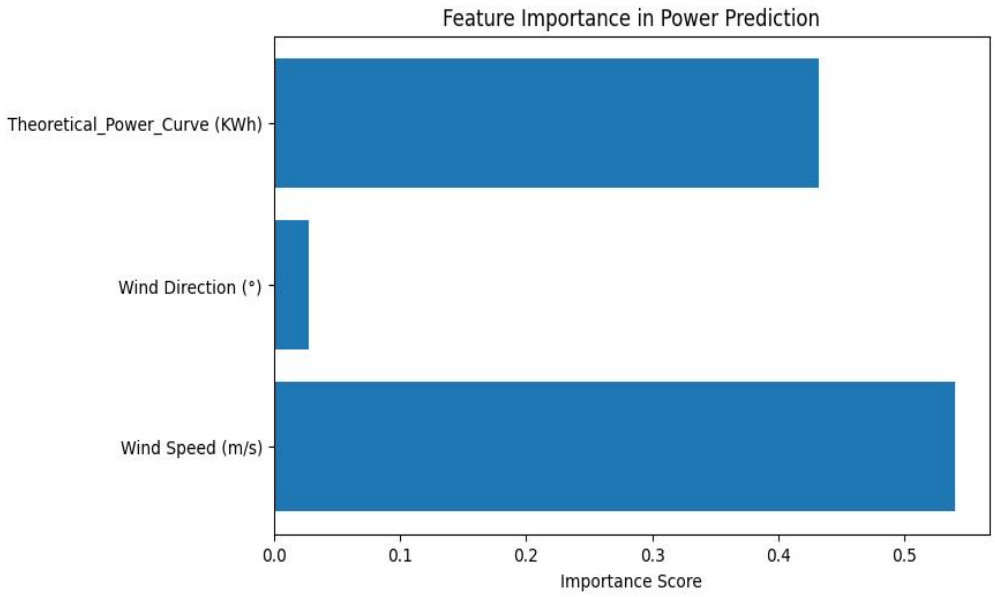
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42
)
```





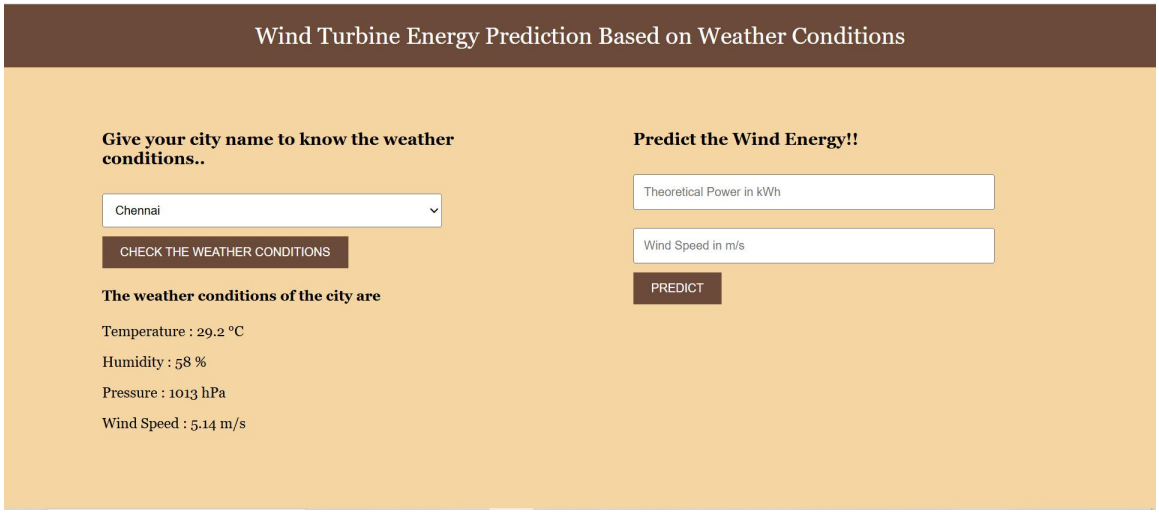
6. Model Development

Model trained using weather features:
Wind Speed, Temperature, Humidity, Pressure.
Performance evaluated using regression metrics.



7. Web Application Features

- Enter city name
- Fetch real-time weather data
- Predict wind turbine energy output
- Display results on UI



8. Testing & Validation

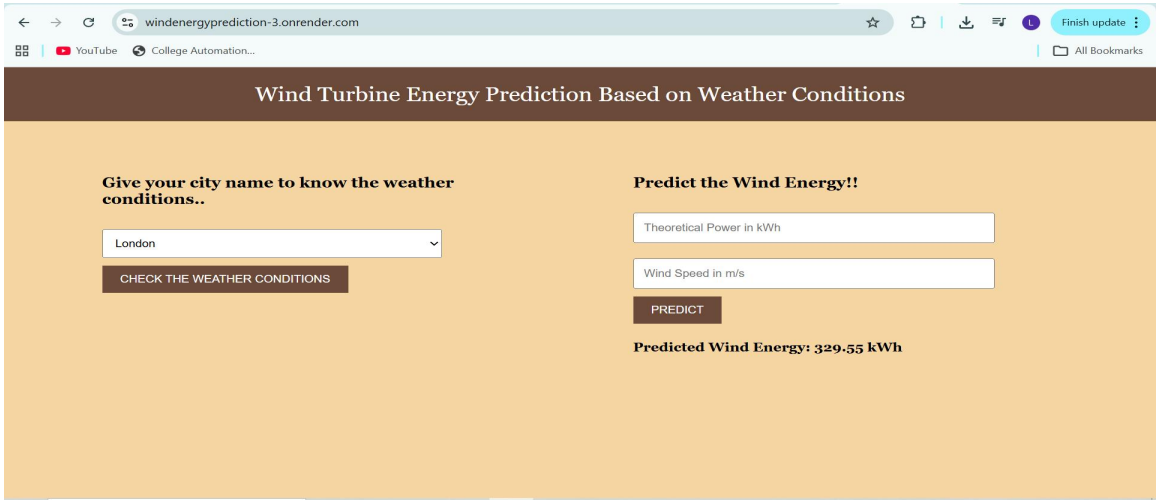
Model validated using train-test split.
User Acceptance Testing performed for web application functionality.

9. Advantages

- Improves renewable energy forecasting
- Supports sustainable power planning
- Scalable and cloud-deployable solution

10. Conclusion

The system successfully predicts wind turbine energy output using machine learning and real-time weather integration.



11. Future Enhancements

- Integration with IoT sensors
- Deep learning model implementation
- Cloud deployment
- Advanced dashboard analytics

12. Project Deployment

Project files github repository link as follows:
https://github.com/LakshmiJahnaviBommareddy/WindEnergyPrediction

App demo link:
https://drive.google.com/file/d/1AZAE9DdpRkwVERlWUYbunOp8_3DvUwjQ/view?usp=drive_link