

# Weather-Based Prediction of Wind Turbine Energy Output

## Project Documentation

### 1. Introduction

#### **Project Title:**

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

#### **Team Members:**

INDU PETLA (ML & Backend)

Team Members (Frontend, Data Analysis, Deployment)

### 2. Project Overview

#### **Purpose:**

To analyze historical weather and wind turbine generation data using Exploratory Data Analysis (EDA) and Machine Learning techniques in order to accurately predict wind turbine energy output and support renewable energy planning.

#### **Features:**

- Wind energy output prediction (kW/MW)
- Weather parameter analysis
- Data visualization dashboards
- ML-based forecasting model
- Web-based prediction interface
- Model performance metrics display

# 3. Architecture

## Frontend:

HTML, CSS, JavaScript for user input and energy prediction result visualization.

## Backend:

Flask-based Python server handling API requests, preprocessing, and prediction logic.

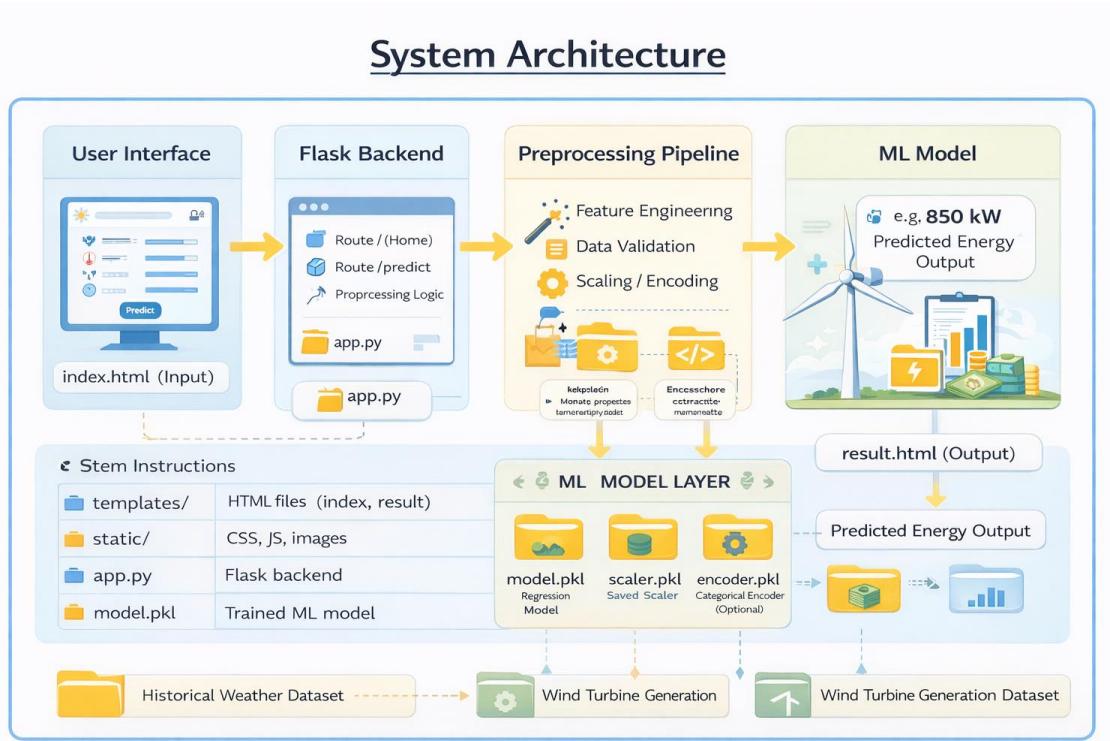
## Model Layer:

Trained regression model (Random Forest / XGBoost / Linear Regression) with saved scaler and preprocessing artifacts.

## Data Layer:

Historical weather dataset + turbine energy output dataset.

## System Architecture Diagram



## 4. Setup Instructions

### Prerequisites:

- Python 3.x
- Flask
- Pandas
- NumPy
- Scikit-learn
- Anaconda (optional)

### Installation Steps:

```
# Create virtual environment
python -m venv .venv
.venv\Scripts\activate

# Install dependencies
pip install flask pandas numpy scikit-learn

# Run application
python app.py
```

## 5. Folder Structure

templates/	→ HTML files (index, result)
static/	→ CSS, JS, images
app.py	→ Flask backend
model.pkl	→ Trained ML model
scaler.pkl	→ Saved preprocessing scaler
dataset.csv	→ Weather & turbine data

## 6. Running the Application

Run the following command:

```
python app.py
```

Open in browser:

<http://localhost:5000>

## 7. API Documentation

### **POST /predict**

#### **Description:**

Accepts weather parameters and returns predicted wind turbine energy output.

#### **Input Parameters:**

- Wind Speed
- Temperature
- Humidity
- Atmospheric Pressure

#### **Output:**

- Predicted Energy Output (kW/MW)
- Performance insight message

## 8. Authentication

Authentication is not implemented in the current version.

### **Future Scope:**

Role-based access control for Admin, Operator, and Grid Manager.

## **9. User Interface**

The UI provides:

- Weather parameter input form
- Energy prediction display
- Graphical output visualization
- Clean and responsive layout

## **10. Testing**

Model evaluated using:

- $R^2$  Score
- MAE (Mean Absolute Error)
- RMSE (Root Mean Square Error)
- Cross-validation

System tested for:

- Input validation
- Prediction response time
- UI responsiveness

## **11. Screenshots / Demo**

- Home page (Weather input form)
- Prediction result page
- Visualization dashboard

(Screenshots can be inserted here in final report)

## 12. Known Issues

- Model performance depends on dataset quality
- Real-time weather data not integrated yet
- Limited to selected dataset regions

## 13. Future Enhancements

- Real-time weather API integration
- IoT-based turbine sensor integration
- Cloud deployment (AWS / GCP / Azure)
- Multi-day and seasonal forecasting
- Advanced dashboard analytics for grid operators