PREDICTING THE ENERGY OUTPUT OF WIND TURBINE BASED ON WEATHER CONDITION

IBM NALAIYA THIRAN

PROJECT REPORT

Submitted By

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SUMAN A	**(611219104110)**
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VISHNUVIGNESH Y	**(611219104118)**

in partial fulfillment for the award of the

degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE AND ENGINEERING

KNOWLEDGE INSTITUTE OF TECHNOLOGY,

SALEM-637504

ANNA UNIVERSITY::CHENNAI 600 025

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BONAFIDE CERTIFICATE

Certified that this project report titled **"PREDICTING THE ENERGY OUTPUT OF WIND TURBINE BASED ON WEATHER CONDITION"** is the bonafide work of "**PRAVEEN KUMAR S (611219104068), SIMON CHRISTOPHER P (611219104097), SUMANA (611219104110), VIGNESH C (611219104115), VISHNUVIGNESH Y (611219104118)** who carried out the project work under my supervision.

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and Engineering,	and Engineering,
Knowledge Institute of Technology,	Knowledge Institute of Technology,
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SPOC	**HEAD OF THE DEPARTMENT**

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At the outset, we express our heartfelt gratitude to **GOD,** who has been our strength to bring this project to light.

At this pleasing moment of having successfully completed our project, we wish to convey our sincere thanks and gratitude to our beloved president **Mr. C. Balakrishnan,** who has provided all the facilities to us.

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CHAPTER - 1

1. INTRODUCTION

1.1 Project Overview

The prediction of wind power plays an important role in maintaining the stability of the entire power grid. Wind power prediction plays a key role in dealing with the challenges of balancing supply and demand in any electricity system, given the uncertainty associated with the wind farm power output. In this paper, a Machine learning approach is proposed for the power prediction of wind turbine based on wind flow. Utilization of wind energy sources provides advantages in terms of being environmentally friendly, and it can be energy source reliable. Accurate wind power forecasting reduces the need for additional balancing energy and reserve power to integrate wind power. For a wind farm that converts wind energy into electricity power, a real-time prediction system of the output power is significant. In this guided project, a prediction system is developed with a method of combining statistical models and physical models. In this system, the inlet condition of the wind farm is forecasted by the auto regressive model. Hence, Building an application to recommend the Power Grid to suggest the best time to utilize the energy from wind farm. We will be using Random forest regression models, one for future Wind speed prediction and another for future wind direction prediction, these predictions would be fed to our Third regression model which would give us the Future Power output. Increasing concern for the environment has led to governments and companies pushing for renewable power generation.

1.2 Purpose

The main purpose of the project is to reduce the coal usage in industries instead by predicting the energy output from the wind turbine based on weather condition (for next 72 hours). Which is more advantage for the industries for upcoming usage of power based on predication, instead burning of coal . In this project we have the feature to predict the temperature,pressure,humanity for the selected cities.The Random forest regression model is used to predict the energy output of the wind turbine. The data that is publicly available for weather stations close to wind farms can be used to give a good prediction of the energy output. If the output can be predicted more accurately, energy suppliers can coordinate the collaborative production of different energy sources more efficiently to avoid costly overproduction.

CHAPTER - 2

LITERATURE SURVEY

2.1 Existing problem

Levels of production of wind energy are hard to predict as they rely on potentially unstable weather conditions present at the wind farm. In particular, wind speed is crucial for energy production based on wind, and it may vary drastically over time.Energy suppliers are interested in accurate predictions, as they can avoid overproduction by coordinating the collaborative production of traditional power plants and weather-dependent energy sources. This will ultimately result in substantial monetary saving.

2.2 References

2.2.1. Artificial Neural Network Model for Wind Mill.

An artificial neural network is a computational model that consists of several processing elements that receive inputs and deliver outputs based on their predefined activation functions. Windmill control can be used with different input data with air pressure and water irradiation variables. The methods are classified and analyzed into four groups according to the application: forecasting and predictions, design optimization, fault detection and diagnosis, and optimal control. The Artificial Neural Network model for Uncertain Variables, can be used to control Windmills with different input data Establishing variable preference weights based on output with the Probability technique. The less air pressure, the greater of wind speed. And the greater of sunlight, the greater of wind speed. The factor that determines the movement of the wind is the difference in pressure in nature. Airflow flows through the pressure over a large area to a small area. The flow of air that blows in nature is a result of the difference in wind temperature gain. So that the difference in temperature causes a difference in pressure, and produces wind flow. Wind potential that can be utilized for wind energy generation is wind potential with a minimum speed of 4.16 m/s. The minimum wind speed (generally 12-14 km/h) to begin turning and generate electricity. strong winds (5060 km/h) to generate at full capacity. winds of less than 90 km/h, beyond that speed, the turbines must be stopped to avoid damage. The use of wind mill plays a role in producing wind power which can be used as a source of electrical energy. The movement of this wind mill is a matter of uncertainty, to determine whether or not the wind mill moves. So that the model used in this study is the Artificial Neural Network model for Uncertain Variables (VTP) which is a selection model using probability techniques, membership degrees, logical OR functions, linear programming and Euclidean distance to reduce the learning process.

2.2.2. Wind Power Prediction Based on Recurrent Neural Network with Long Short-Term Memory Units.

Producing electricity from renewable resources has been widely used in the past 10 Years above to decrease the worldwide difficulty with electrical energy and environmental pollution. For a wind farm that converts the wind power to electrical energy, a big challenge is to predict the wind power exactly despite the instabilities. The climatic conditions present at the site decide the power output of a wind farm. A precise forecast is required to overcome the difficulties initiated by the frequent weather conditions. If the output is forecasted accurately, energy providers can keep away from costly over production. In this paper, an end-to-end web application has been developed to predict and forecast the wind turbine's power generation based on the weather conditions. The prediction model has been developed using Bidirectional Long Short-term Memory which is a unique kind of RNN (Recurrent Network Network). Bidirectional long-short term memory (Bidirectional LSTM) is the process of making any neural network have the sequence information in both directions backwards (future to past) or forward(past to feature).It performs excellent in terms of capturing long-term dependencies along with the time steps and is hence ideal for wind power forecasting. Wind power is one of the most promising renewable energy sources, it is clean, safe and inexhaustible. However, predicting wind signal has always been challenging because the time series data is nonlinear, non-stationary, and disordered. In this paper, we provide a novel predicting framework including a recurrent neural network (RNN) structure model with long short-term memory (LS TM) units and an effective forecasting map adapted to different prediction horizons. We compare our new approach with concurrent methods and show that our new method is more effective in predicting wind power.

2.2.3. PREDICTING POWER OUTPUT BASED ON WEATHER CONDITION ON WIND TURBINES

Wind plant has lower cost of energy compared to other renewable energy source for large scale application. Due to the different geographical patterns, weather, and properties of the wind turbines, a wind turbine may have various performances given different situations. If the total output of a wind power plant can be predicted with high accuracy, more useful information can be provided to the power companies to help in scheduling the power generation Wind speed is affected by a number of factors and situations, operating on varying scales (from micro to macro scales). These include the pressure gradient, Rossby waves and jet streams, wind speed is affected by a number of factors and situations, operating on varying scales (from micro to macro scales). These include the pressure gradient, Rossby waves and jet streams, A very simple and effective means to eliminate leading or lagging power factor errors, reduce voltage raise and fall, enhance equipment operating life and improve system power capacity. The range offers consolidated features in one package without the risk of Vibration, while stabilizing electrical networks by providing harmonic mitigation, power factor correction and load balancing. In a simple alternating current (AC) circuit consisting of a source and a linear load, both the current and voltage are sine curve. If the load is purely resistive, the two quantities reverse their electric field at the same time. At every instant the product of voltage and current is positive or zero, the result being that the direction of energy flow does not reverse. In this case, only active power is transferred Wind direction is reported by the direction from which it originates. For example, a northerly wind blows from the north to the south. Wind direction is usually reported in cardinal directions or in horizontal degrees. Wind direction is measured in degrees clockwise from due north. In general, wind directions are measured in units from 0° to 360°, but can alternatively be expressed from -180° to 180°.

2.2.4. Deep Learning-Based Prediction of Wind Power for Multi turbines Wind Farm

The difficulty of conducting the temporal-size sequence prediction, such as "wind turbine power prediction," is to simultaneously extract the time dependence and spatial features hidden in the data. After data preprocessing, the LSTM-CNN joint prediction model is proposed, which exploits a two-stage modeling strategy. In the first stage, the temporal features are difficult by the LSTM sub-model. In the second stage, the spatial connections between more things from the spatial matrix is determined by the CNN sub-model. LSTM can effectively difficulty the data temporal dependence, has excellent performance in prediction on a same things of time scales, and can be trained by back- cause continue through time algorithm. The CNN has the ability in processing the input in the form of two-dimensional images, and can meet the need to simultaneously predict the power of multiple wind turbines the LSTM-CNN joint modelling is mainly divided into two stages, which are In the first stage, the LSTM captures the temporal correlation in the data that has been preprocessed. Specifically, the processed power data of n wind turbines goes into n LSTM modules and each LSTM model is set to β layer. Each LSTM outputs a value. After series and processing, the corresponding output values of each turbine are put into a two-dimensional matrix Wp according to the location of the wind turbines In the second stage, the CNN is used to extract the spatial correlation stored in the matrix Wp. Starting from the input layer of CNN, the spatial features in the matrix Wp are captured by the convolution kernel to obtain a new feature map. The CNN will gradually extract the spatial information of the spatial power matrix after multiple complex-pooling layer structures and output a one-dimensional vector in the final output layer as the actual output of the model. In this study, Rectified Linear Unit Re LU) is selected as the activation function of the convolutional layer. As an unsaturated nonlinear function that can accelerate the convergence rate during training, Re LU can significantly improve the performance of CNN.

2.3 Problem Statements Definition

Problem Statement (PS)	I am (Customer)	I’m trying to	But	Because	Which makes me feel

PS-1	Electrical board officer	Find next 72 hrs energy output from windmills.	It shows less energy output.	It predicts only 24 hrs	confusion
PS-2	Student	Find the accurate output.	It display the approximate output.	It cannot predict accurate value.	Frustrated
PS-3	Faculty	Access the Wind Turbine website	It has technology immaturity.	It was not updated up to date.	Irate
PS-4	Employee	Fetch the exact information On Energy prediction.	It does not provide sufficient information.	The developer doesn’t built the website to provide sufficient information	Exasperate

PS-5	Power Minister	Use the website to know how it works.	But-There is no tour guide for this website to guide the user those who are immaturity in using technologies.	The developer doesn't add any tour guide for this website that guides the people those who are immaturity in technology.	Mishandle

CHAPTER NO: 3

IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

3.2 Ideation & Brainstorming

1.Brainstorming And Idea Prioritization

2.Brainstorm, Idea Listing and Grouping

3.Idea Prioritization


4
Prioritize
Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.
20 minutes
Create a GUI to predict the energy
Future wind direction prediction
Output in Kilowatt/Hr
Duration
Physical Model
LSTM Models
Recognize weather condition
Wind Speed detection
Finding Humidity
Date and time
Importance
If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?
Feasibility
Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	To predict the energy output of wind turbines.
2.	Idea / Solution description	In this project, a Machine learning approach is proposed for the power prediction of wind turbines based on wind flow and a prediction system is developed with a method of combining statistical models and physical models. In this system, the future prediction of wind farm is forecasted by the autoregressive model.
3.	Novelty / Uniqueness	1. Finding weather conditions using city names can be performed on the same page. so that accurate prediction can be possible. 2. Neat and clear GUI should be developed.
4.	Social Impact / Customer Satisfaction	1. Energy suppliers are interested in accurate predictions, as they can avoid overproduction. 2. Predicting wind energy will reduce the use of nuclear power sources and traditional sources of energy such as coal and oil. 3. These will rapidly decrease the co_2

		emission.
5.	Business Model (Revenue Model)	1. Cost-efficient. 2. Time consumption is very low. 3. Easily portable. 4. Only internet is required. 5. This application is reliable. 6. Easy to use.
6.	Scalability of the Solution	This website can be accessed by everyone who needs information regarding this prediction.

3.4 Problem solution fit

CUSTOMER SEGMENTS(S) Electricity providers, industrialists, the government, and ordinary people	**CUSTOMER LIMITATIONS** 1. Which city energy do they want to predict 2. Internet connection 3. Web browser	**AVAILABLE SOLUTIONS** *(PROS AND CONS)* 1. A website is created which shows the accurate prediction of wind energy 2. Pros – reduce overproduction 3. Cons – web application
PROBLEMS/ PAINS *(ITS FREQUENCY)* 1. Prediction of future wind direction and wind speed 2. No proper platform for wind energy prediction	**PROBLEM ROOT/ CAUSE** 1. Existing solutions do not satisfy the customer's expectation 2. it tends to more customers to invest in windmills.	**BEHAVIOR ITS INTENSITY** Need to study more about wind power forecasting.

<table>
<tr>
<td>TRIGGERS TO ACT
1. Most energy suppliers are satisfied with renewable energy resource
2. It will reduce the emission of co_2.
3. Accurate prediction needed</td>
<td rowspan="2">YOUR SOLUTION
A website is developed with a combination of ML algorithms that predicts wind energy using wind speed and wind direction The website has a user-friendly interface which means anyone can able to access the website and make benefit from it.</td>
<td>CHANNELS OF BEHAVIOR
(ONLINE)
Try to search it on google, YouTube, WhatsApp, and other platforms.</td>
</tr>
<tr>
<td>EMOTIONS
(BEFORE/ AFTER)
Before - Guilty, Frustrated
After – Satisfied, Calm, happy</td>
<td>OFFLINE
Ask field experts, and energy suppliers and refer to books in the library</td>
</tr>
</table>

CHAPTER NO: 4

REQUIREMENT ANALYSIS

4.1 Functional Requirements:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form
FR-2	User Confirmation	Confirmation via Email
FR-3	Essentiality	1. City name 2. Wind speed 3. Wind direction 4. Weather condition
FR-4	Output	Energy Predicated in KWh

4.2 Non-functional Requirements:

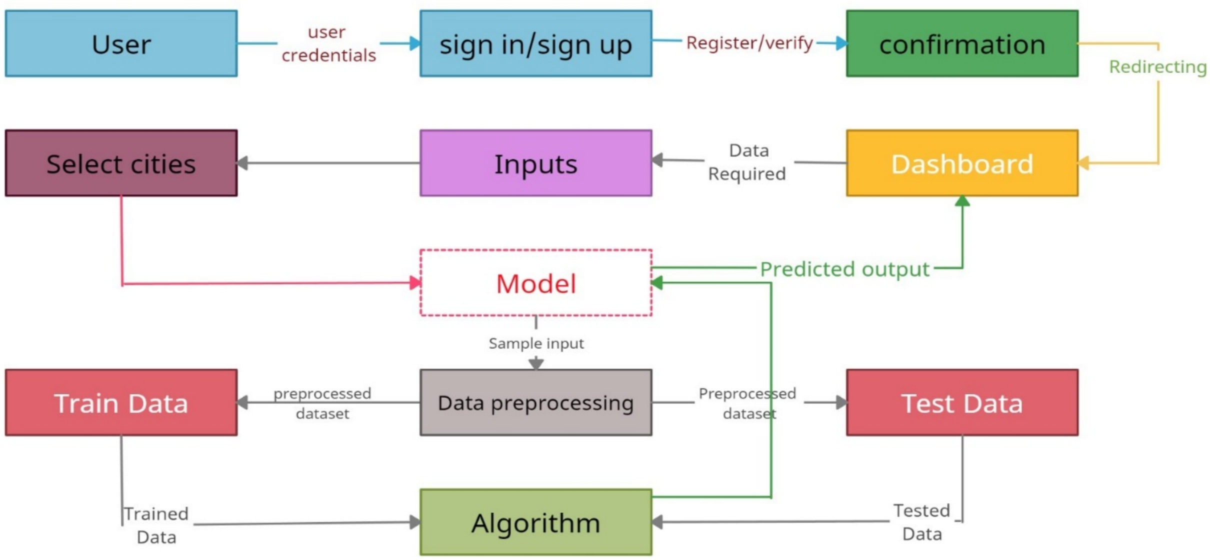
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	1. Easy to learn User friendly 2. Efficient
NFR-2	Security	Privacy - User can have Own accounts to secure their data.
NFR-3	Reliability	Wind Energy is reliable because it is both unlimited and domestic
NFR-4	Performance	Accuracy is high due to combination of multiple ML models to predict the output .

NFR-5	Availability	This is a web based application so we can access in any device that have a web browser with good Internet facility.
NFR-6	Scalability	It can be extended further to provide API which can be used by third party organisations such as Industries, Power suppliers , Governmental ,etc.

CHAPTER NO: 5

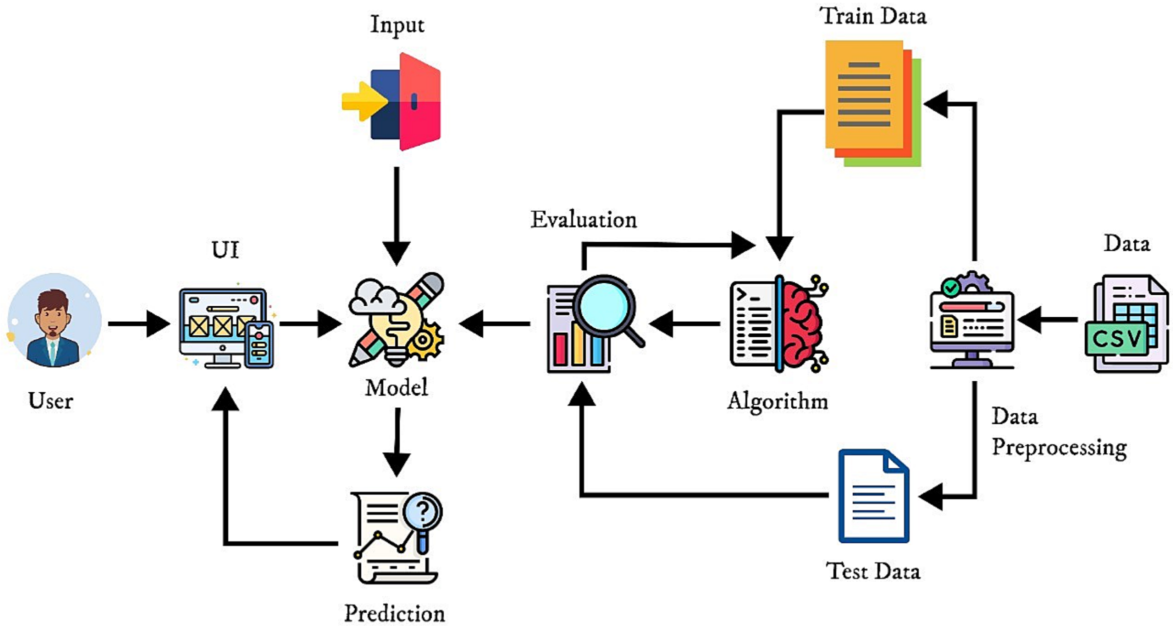
PROJECT DESIGN

5.1 Data Flow Diagrams



5.2 Solution & Technology Architecture

Solution Architecture



Technical Architecture

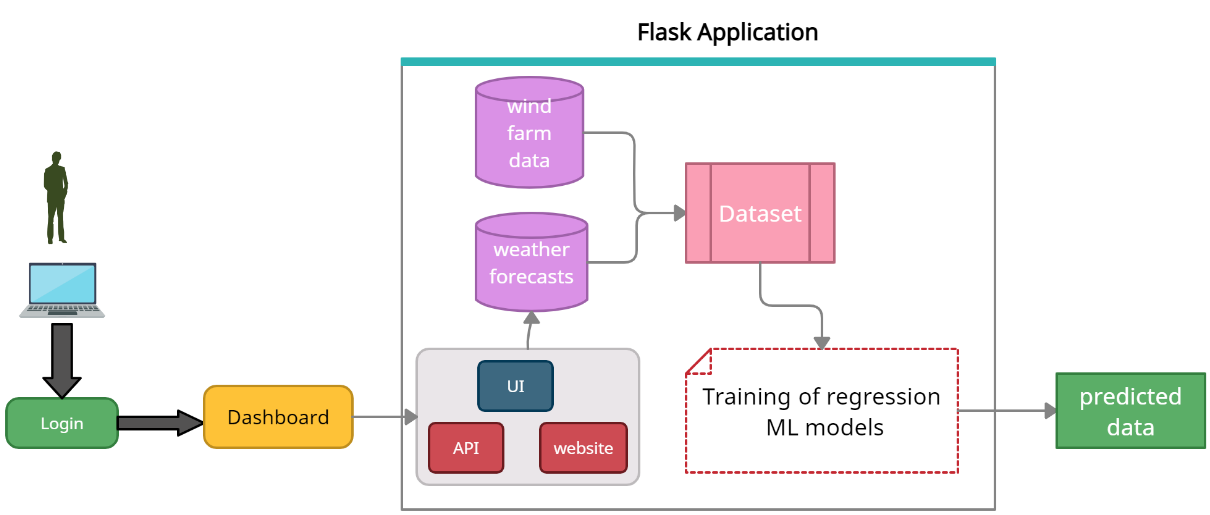


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web UI	HTML, CSS, JavaScript
2.	Application Logic-1	Prediction process	Java / Python
3.	Database	Integer type used to store the collected and examine weather data	MySQL, NoSQL
4.	Cloud Database	Database Service on Cloud	IBM DB2, IBM Cloud DB
5.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem
6.	External API	Used to predict weather	IBM Weather API, etc.
7.	Machine Learning Model	This model is developed to predict the rainfall using ML algorithms	Algorithms like regression, classification, clustering and ML models
8.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: intel i3 with 4GB ram Cloud Server Configuration :IBM cloud service	Local, IBM Cloud Storage Services

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology

1.	Open-Source Frameworks	Backend Framework, CSS, Relational Database	PyJWT, Flask, IBM Cloud DB
2.	Security Implementations	Request authentication using JWT Tokens	SHA-256, Encryptions, SSL Certs
3.	Scalable Architecture	Support for Multiple sample prediction using Excel File	Pandas Numpy
4.	Availability	Availability is increased by distributed servers in Cloud VPS	IBM Cloud Hosting
5.	Performance	The application is expected to perform accurate prediction	Auto regressive models

5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and	I can access my account / dashboard	High	Sprint-1

			confirming my password.			
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation on email & click confirm	High	Sprint-1
	Login	USN-3	As a user, I can log into the application by entering email & password	I can access the dashboard	High	Sprint-1
	Dashboard	USN-4	User can get information about wind energy. He can able to see a button called predict energy by clicking the	I can predict for single sample	High	Sprint-1

			button he can give input.			
Customer (Web user)		USN-5	Once I enter the Dashboard I can give input values by choosing a city	I can predict the energy production of selected city	High	Sprint-1
		USN-6	As a user I can get visual representation of the prediction	I can have single output	High	Sprint-1
		USN-7	As a user I can view the detailed report of my prediction	I can access details of my process and prediction	Medium	Sprint-1
Customer Care Executive	Documentation	USN-8	As a helper I can refer the documentation for support and guidance	I can use user manual for guidance	Medium	Sprint-1,2, 3,4

Administrator	Settings	USN-9	As a developer I can access dashboard’s settings and view the API token	I can view the API token for creating request	Low	Sprint-4
	Feedback	USN-10	As a developer I can able to view user feedbacks	I can customize these web page based on feedback	Medium	Sprint-4

CHAPTER NO: 6

PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Sprint	**Functional Requirement (Epic)**	**User Story Number**	**User Story / Task**	**Story Points**	**Priority**	**Team Members**
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email and password,and confirming my password.	5	High	Simon Christopher P
Sprint-1		USN-2	As a user, I can register for the application through a Mobile number.	3	Low	Vignesh C

Sprint-1		USN-3	As a user, I can register for the application through Gmail	4	Medium	Suman A
Sprint-1	Login	USN-4	As a user, I can log into the application by entering my email & password	5	High	VishnuVignesh Y
Sprint-2	Select City	USN-5	As a user, I should select the city to find the weather details of that city.	5	High	Praveen Kumar S
Sprint-2	Weather Details	USN-6	As a user, I can view the current weather conditions of the selected city.	5	High	Simon Christopher P
Sprint-3	User Input	USN-7	As a user, I should give the theoretical power and wind speed to predict the	5	High	Suman A

			energy output.			
Sprint-4	Energy Output	USN-8	As a user, I can view the predicted energy output of wind Turbines.	5	High	VishnuVignesh Y
Sprint-3	User details	USN-9	As an admin, I should store the details of the user.	6	Medium	Simon Christopher p
Sprint-2	Data Pre-Processing	USN-10	As an admin, I should clean and pre-process data using pandas.	5	High	Suman A
Sprint-2		USN-11	As an admin, I should train and test the dataset using sklearn.	5	High	VishnuVignesh Y

Sprint-3	Model Building	USN-12	As an admin, I should predict the accuracy of data using supervised machine learning.	12	High	Vignesh C
Sprint	**Functional Requirement (Epic)**	**User Story Number**	**User Story / Task**	**Story Points**	**Priority**	**Team Members**
Sprint-4	API	USN-13	As an admin, I should connect the presentation tier, logic tier, and data tier using python flask.	10	High	Vignesh C
Sprint-4	Notification	USN-14	As an admin, I should send the prediction chart via mail	5	Medium	Praveen Kumar S

6.2 Sprint Delivery Schedule

It shows the time taken for each sprint

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	17	8 Days	22 Oct 2022	29 Oct 2022	8	02 Nov 2022
Sprint-2	20	4 Days	31 Oct 2022	03 Nov 2022	8	07 Nov 2022
Sprint-3	23	5 Days	04 Nov 2022	08 Nov 2022	8	11 Nov 2022
Sprint-4	20	4 Days	09 Nov 2022	12 Nov 2022	11	13Nov 2022

Velocity:

Average velocity of sprint-1: AV = 17/8 = 2.125

Average velocity of sprint-2: AV = 15/4 = 5

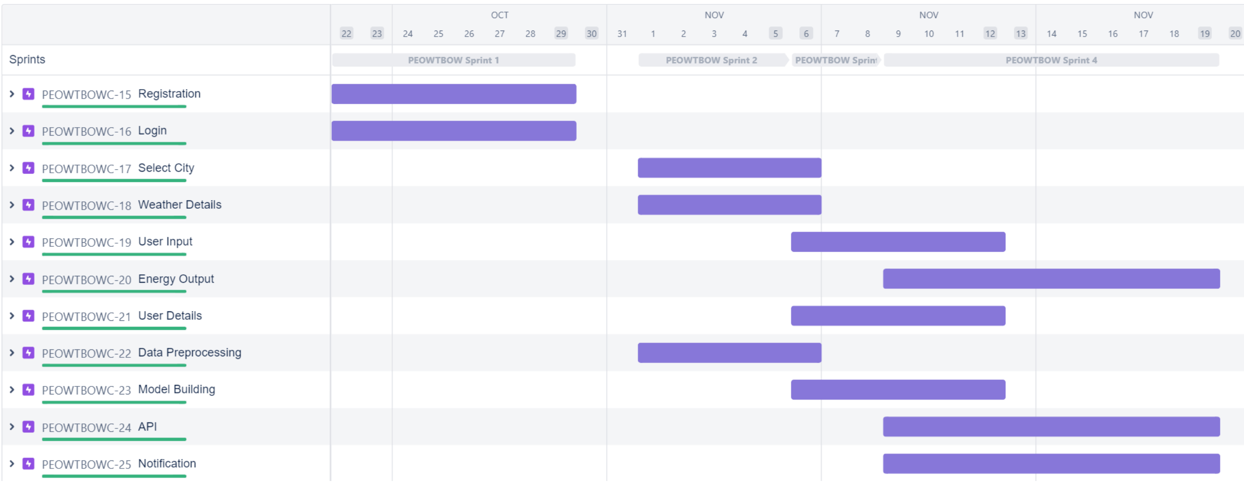
Average velocity of sprint-3: AV = 18/5 = 4.6

Average velocity of sprint-4: AV = 20/4 = 5

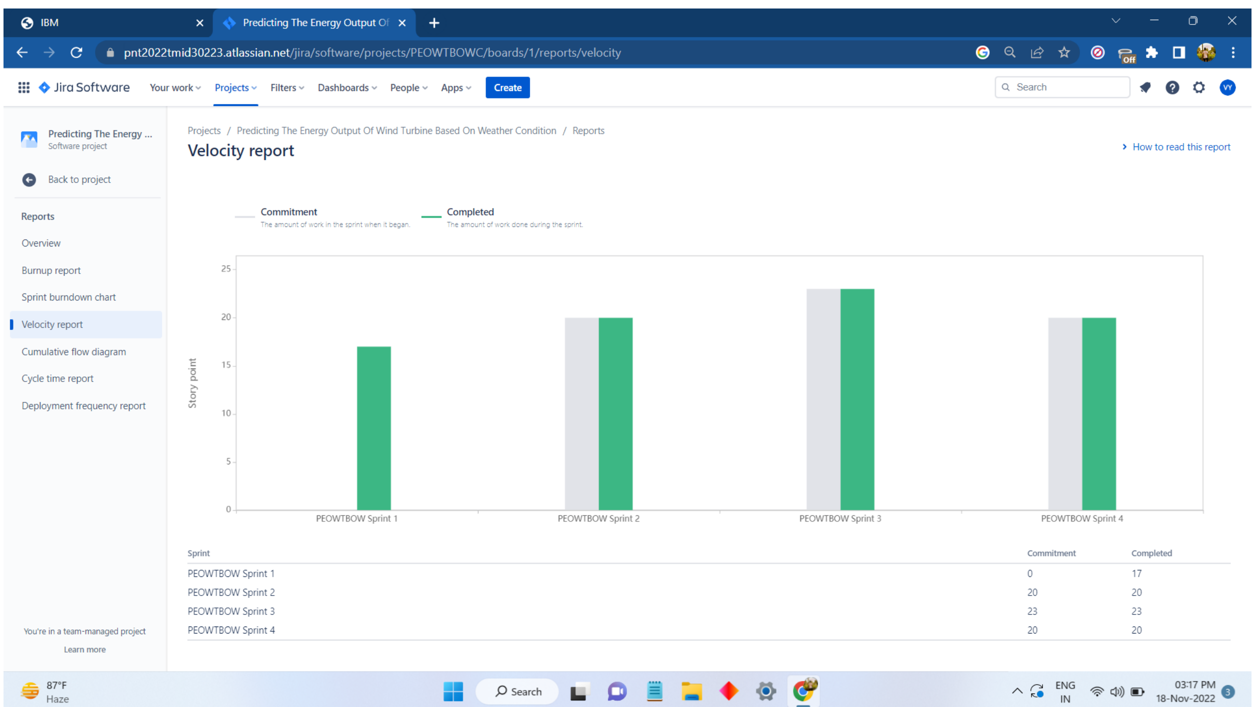
6.3 Reports From JIRA

It shows time taken to completed status of all the issues in the sprint.

Roadmap

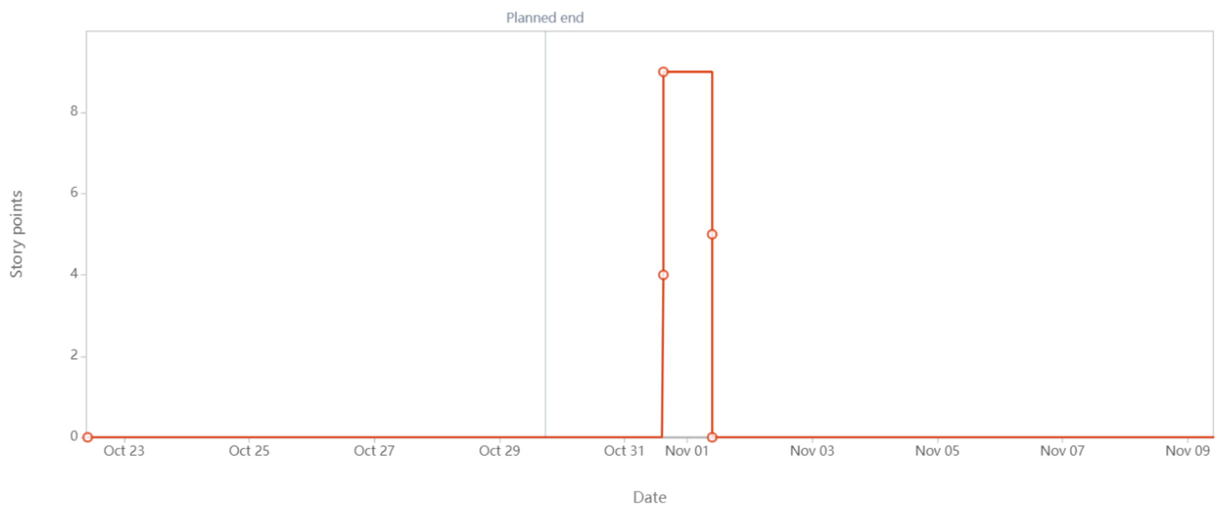


Velocity Report

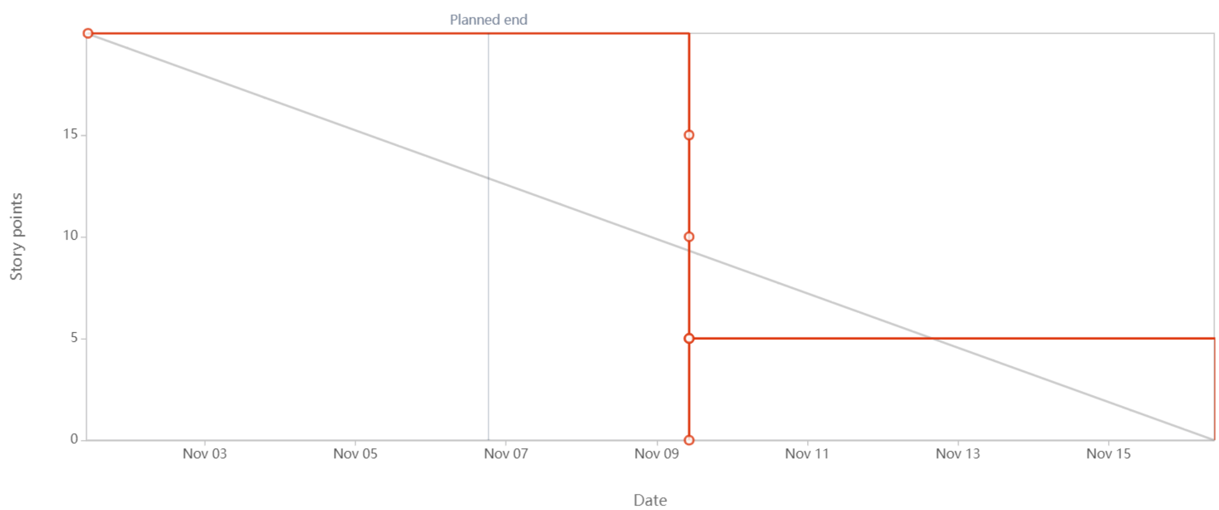


Burndown Chart

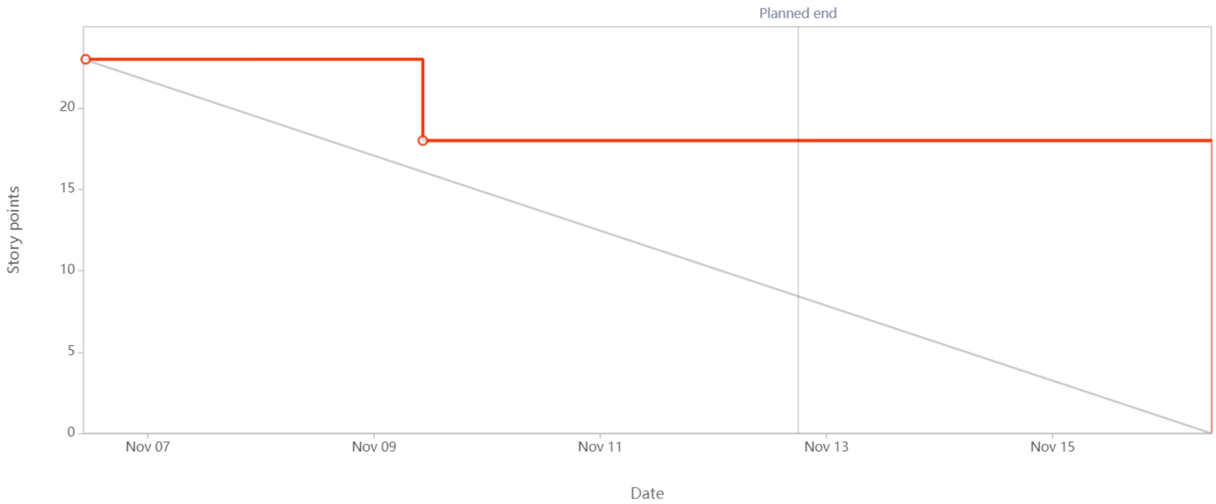
Sprint 1



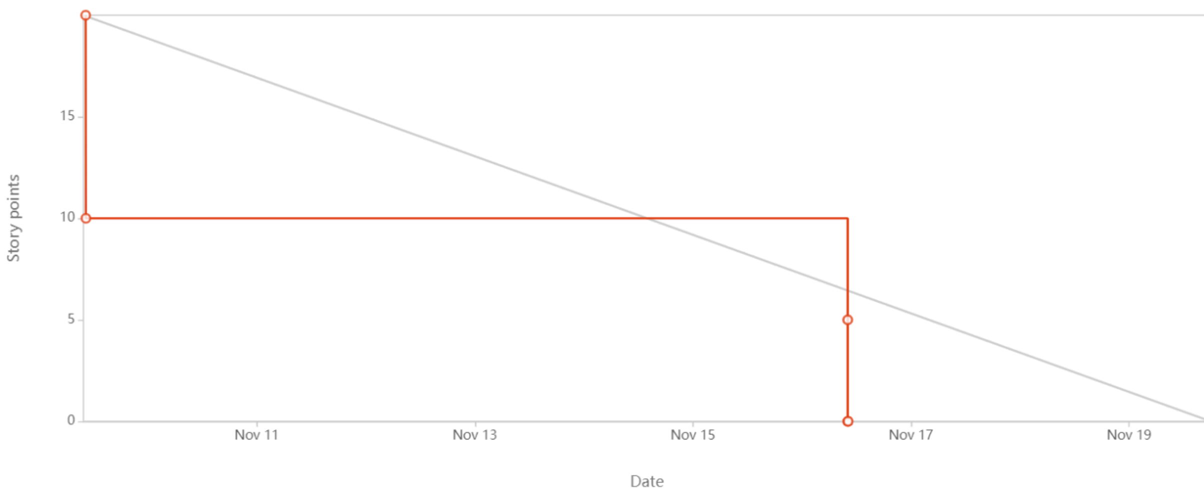
Sprint 2



Sprint 3



Sprint 4



CHAPTER NO : 7

CODING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Features 1

The Web-application was designed and created using flask, which is a micro web framework written in python.The web app utilises the OpenWeatherMap API to import and get live weather updates, from any pre-defined particular location

7.2 Features 2

Levels of production of wind energy are hard to predict as they rely on potentially unstable weather conditions present at the wind farm. In particular, wind speed is crucial for energy production based on wind, and it may vary drastically over time. Energy suppliers are interested in accurate predictions, as they can avoid overproduction by coordinating the collaborative production of traditional power plants and weather-dependent energy sources. This will ultimately result in substantial monetary saving. Random forest regression is help to predict the given dataset values for better accuracy model. It provides an effective way of handling missing data. It can produce a reasonable prediction without hyper-parameter tuning.

CHAPTER – 8

TESTING

8.1 TEST CASES

Test Cases For Registration Page

Test Cases	Features	Description	Steps to Execute	Expected Results
TC-001	Register to the system	To register for the application and provide a logon id and password.	1.Access URL 2. Login to the system 3. Select Register link 4. Enter user details	UI Should Work Properly
TC-002	Login to the system	Provides a log on access point to the system	1. Select Log on link 2. Enter User Name 3. Enter Password 4. Press Enter	User is logged into personal area

Test Cases For Home Page

Test Cases	Features	Description	Steps to Execute	Expected Results
TC-001	Required fields	Check user should by filling all the required fields	1.Enter valid values in the required fields	Users should be logged in successfully
TC-002	Required fields	Check user should by filling all the required fields	2.Click on the login button	A required field message should be displayed

Test Cases For Predict Page

Test Cases	Features	Description	Steps to Execute	Expected Results
TC-001	Select the required city	To predict the Wind speed in the selected city	1.Hit the drop down list box.	It shows the Cities
TC-002	Select the required city	To predict the Wind speed in the selected city	2.Select the required city in the list	The required city is selected.

TC-003	Check weather condition	To predict the pressure, temperature, humidity, wind speed	3.Hit the check weather condition button	Wind speed in m\s

Test Cases For Predict Page

Test Cases	Features	Description	Steps to Execute	Expected Results
TC-001	To predict energy	To predict the energy in kwh	Enter the predicted wind speed	Required field is filled
TC-002	To predict energy	To predict the energy in kwh	Enter the theoretical power in the field	Required field is filled
TC-003	To predict energy	To predict the energy in kwh	Hit the predict energy button	Output energy is predicted in kwh

8.2 USER ACCEPTANCE TESTING

1.Defect Analysis

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	6	4	2	7	19
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	20	10	5	26	61
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	1	0	0	1
Totals	29	18	12	35	94

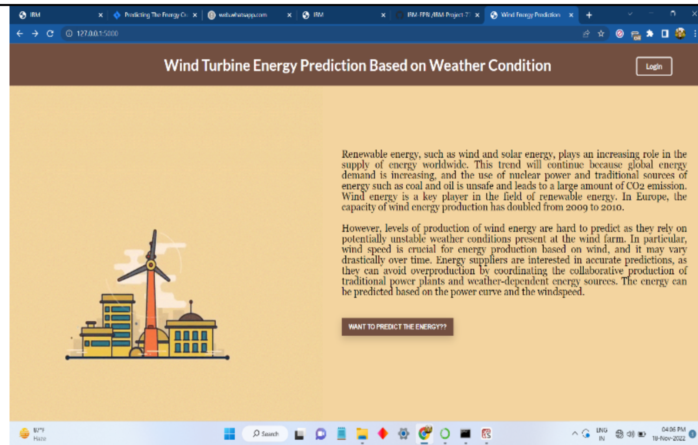
2.Test Case Analysis

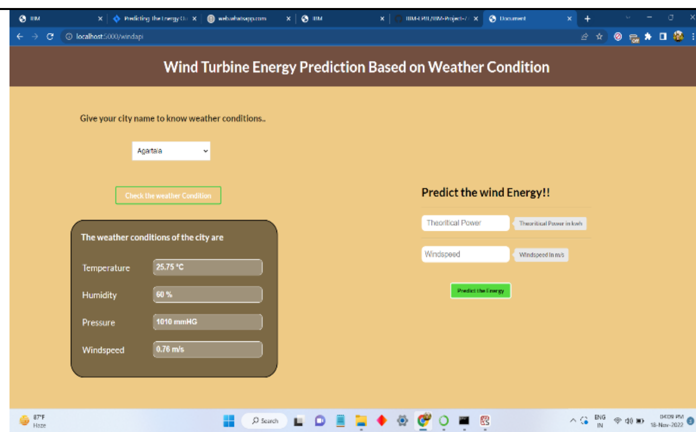
Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	2	5
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	6	0	0	6
Version Control	2	0	0	2

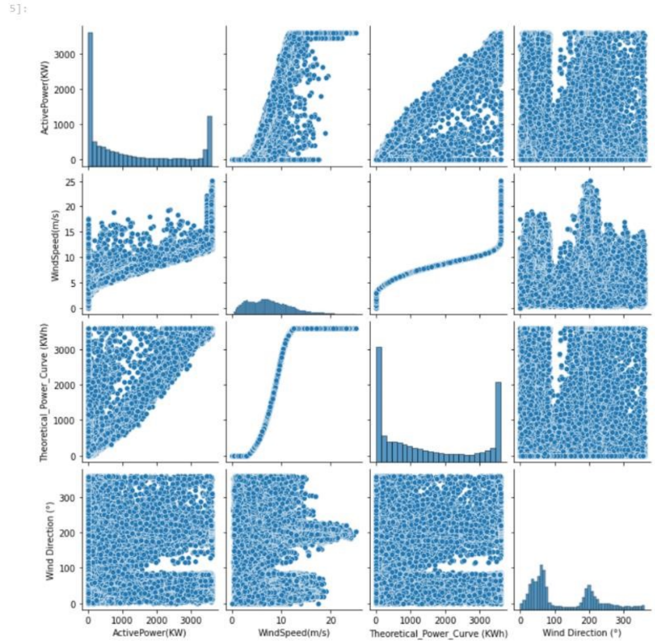
CHAPTER – 9

RESULTS

9.1 PERFORMANCE METRICS

<table>
<tr><th>S NO</th><th>Parameter</th><th>Values</th><th>Screenshots</th></tr>
<tr><td>1.</td><td>Model Summary</td><td>90</td><td>
</td></tr>
<tr><td>2.</td><td>Accuracy</td><td>Training Accuracy= 85

Validation Accuracy= 60</td><td>
</td></tr>
</table>

S.No.	Parameter	Values	Screenshot
1 .	Metrics	**Regression Model:** MAE – 0.6, MSE – 0.3, RMSE – 0.4, R2 score 0.7 **Classification Model:** Confusion Matrix - 4, Accuracy Score- 90	
2.	Tune the Model	Hyperparameter Tuning – 0.6 Validation Method – 0.8	

CHAPTER – 10

ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- The energy output of a wind farm is highly dependent on the weather conditions present at its site. If the output can be predicted more accurately, energy suppliers can coordinate the collaborative production of different energy sources more efficiently to avoid costly overproduction
- Generating energy from the wind does not release any carbon emissions.
- The energy used in manufacturing and installing wind turbines can also be paid back relatively quickly.
- It is a very clean energy source, which does not release any pollution or produce any waste during operation.

DISADVANTAGES

- Wind power must compete with other low-cost energy sources.
- Ideal wind sites are often in remote locations.
- Turbines produce noise and alter visual aesthetics.
- Wind plants can impact local wildlife.

CHAPTER – 11

CONCLUSION

We started with the aim of improving the predictions of power generated using wind energy and we have achieved that using Random forest Regression as machine learning model and performing model optimization on it. We have also observed that if the wind speed is less than 4 m/s the power generated by the system is zero.

CHAPTER – 12

FUTURE SCOPE

FUTURE SCOPE : 1

Time extension, as we are predicting the wind energy 72hrs prior, but in the future, we will increase the time to get the advanced prediction.

FUTURE SCOPE : 2

Now the prediction is based on the single turbine, in the future, we have the idea to apply it in a wind farm.

FUTURE SCOPE : 3

And Finally, we are just predicting the energy and displaying the accurate output, and in the future, if the user predicts the energy, the prediction output will be directly sent to the user's mail or mobile number.

CHAPTER -13
APPENDIX

13.1.SOURCE CODE

intro.html

```
<html>

    <head>
      <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/semantic-ui@2.5.0/dist/semantic.min.css">
                  <script src="https://cdn.jsdelivr.net/npm/semantic-ui@2.5.0/dist/semantic.min.js"></script>
    <title>Wind Energy Prediction</title>
    </head>
    <body>
      <div id="headbar">
      <header>Wind Turbine Energy Prediction Based on Weather Condition</header>
      <a href="{{url_for('loginpage')}}" id="loginPage">
           <button style="position: relative; bottom:25px;left: 630px;" class="ui inverted button">Login</button>
      </a>
      </div>
      <div class="second">
           <div class="inside">Renewable energy, such as wind and solar energy, plays an increasing role in the supply of energy worldwide. This trend will continue because global energy demand is increasing, and the use of nuclear power and traditional sources of energy such as coal and oil is unsafe and leads to a large amount of CO2 emission. Wind energy is a key player in the field of renewable energy. In Europe, the capacity of wind
```

```
energy production has doubled from 2009 to 2010.
        <a href="{{url_for('predict')}}" id="predict"><button type="button"
class="myButton" >Want to predict the energy??</button></a>
        </div>


        </div>
      </body>
</html>
```

predict.html

```
<!DOCTYPE html>
<html lang="en">
<head>
   <meta charset="UTF-8" />
     <meta name="viewport" content="width=device-width, initial-scale=1.0"
/>
<title>Document</title>
</head>
<body>
           <header>Wind Turbine Energy Prediction Based on Weather
Condition</header>
   <form action="{{ url_for('windapi')}}"method="post" >
   <div id="citycontent">
      <h3>Give your city name to know weather conditions..</h3>
      <br>
      <div id="dropdown">
         <select name="city"  required  class="ui dropdown">
            <option disabled value="">Select City</option>
               <option value ="Agartala">Agartala</option>
```

```
                <option value ="Ariyalur"        >       Ariyalur      </option>
                                <option  value ="Aizawl">Aizawl</option>
                                <option  value ="Bengaluru">Bengaluru</option>
                                <option  value ="Bhopal"       >       Bhopal

                <option value ="Salem" >       Salem        </option>
                                <option     value     ="Thiruvananthapuram"     >
Thiruvananthapuram    </option>
                                <option     value     ="Tirupati"       >       Tirupati
</option>
                <option value ="Vellore">       Vellore       </option>
                        <option value ="Virudhunagar"       >       Virudhunagar
</option>
            </select>
        </div>
        <div>
            <button  id="button1" class="ui inverted green button">Check the
weather Condition</button>
        </div>
    </div>
</form>
<form action="{{ url_for('y_predict')}}" method="post">
    <div id="output">
        <div>
        <h2>Predict the wind Energy!!</h2>
        </div>
        <div class="ui divider"></div>
        <div class="inline field">
            <input class="ip" type="text" name="theo" required placeholder="
Theoritical Power">
```

```
        <div class="ui left pointing label">
          Theoritical Power in kwh
        </div>
      </div>
      <div class="ui divider"></div>
      <div class="inline field">
                    <input class="ip" type="text" name="wind"required
placeholder="Windspeed">
        <div class="ui left pointing label">
          Windspeed in m/s
        </div>
      </div>
      <br><br>
      <div>
            <button style="color: black;" type="submit" id="button" class="ui
inverted standard button" >Predict the Energy</button>
         <br>
           <br>
         <br>
           <h3>{{ prediction_text }}</h3>
      </div>
        </form>

  </div>


  <div id="calculations">
      <div id="weathercalculationcontent">
        <h3> The weather conditions of the city are</h3>
      </div>
```

```
<table id="table">
  <tr>
    <td class="label"> <label for="Temperature">Temperature</label></td>
    <td class="input"> <input class="input1" disabled  value="{{temp}}" type="text" ></td>
  </tr>
  <tr>
    <td class="label"> <label  for="Humidity">Humidity</label></td>
    <td class="input"> <input class="input1" disabled  type="text" value="{{humid}}"></td>
  </tr>
  <tr>
    <td class="label"> <label  for="Pressure">Pressure</label></td>
    <td class="input"> <input class="input1" disabled  type="text" value="{{pressure}}"></td>
  </tr>
  <tr>
    <td class="label"> <label for="windspeed">Windspeed</label></td>
    <td class="input"> <input class="input1" disabled type="text" value="{{speed}}"></td>
  </tr>
</table>
</div>

</body>
</html>
```

app.py

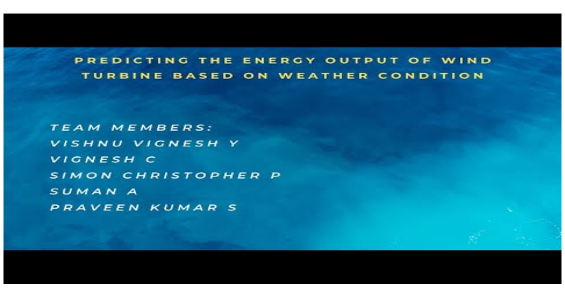
```
import numpy as np
from flask import Flask, request, jsonify, render_template
import joblib
import requests
app = Flask(__name__)
model = joblib.load('power_prediction.sav'
@app.route('/')
def home():
   return render_template('intro.html')
@app.route('/loginpage')
def loginpage():
   return render_template('loginpage.html')
@app.route('/SignUp')
def SignUp():
   return render_template('SignUp.html')
@app.route('/predict')
def predict():
   return render_template('predict.html')
@app.route('/windapi',methods=['POST'])
def windapi():
   city=request.form.get('city')
   apikey="c21dd661f7aac9a7720fe4ced3317b0a"
url="http://api.openweathermap.org/data/2.5/weather?q="+city+"&appid="
+apikey
   resp = requests.get(url)
   resp=resp.json()
   temp = str(resp["main"]["temp"]-273.15) +" °C"
   humid = str(resp["main"]["humidity"])+" %"
   pressure = str(resp["main"]["pressure"])+" mmHG"
```

```
    speed = str(resp["wind"]["speed"])+" m/s"
    return render_template('predict.html', temp=temp, humid=humid, pressure=pressure,speed=speed)
@app.route('/y_predict',methods=['POST'])
def y_predict():
    '''
    For rendering results on HTML GUI
    '''
    x_test = [[float(x) for x in request.form.values()]]
    prediction = model.predict(x_test)
    print(prediction)
    output = prediction[0]
    return render_template('predict.html', prediction_text='The energy predicted is {:.2f} KWh'.format(output))
if __name__ == "__main__":
    app.run(debug=False)
```

13.2 GITHUB & PROJECT DEMO LINK

Github: https://github.com/IBM-EPBL/IBM-Project-7785-1658899301.git

Demo Video:



CHAPTER-14

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