Predicting the energy output of wind turbine based on weather condition

Team Id :PNT2022TMID14768

Team size:5

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Team member 1:G.Lakshmi pranathi

Team member 2:G.Srinidhi

Team member 3:V.R.Romy Ann

Team member 4:J.Pavithra

INTRODUCTION

Project Overview:

Wind power generation is increasing rapidly and the availability of wind energy depends on wind speed, which is a random variable. This highly depends on the weather conditions at that place. We will carry out this problem on publicly available weather and energy data sets correlating and considering different features in our project.

Purpose:

In our project, we propose an intelligent technique for forecasting wind speed and power output of a wind turbine from several hours up to 72 hours ahead.This will enable us to cut down on production costs and collaborate on different energy sources more efficiently

LITERATURE SURVEY

Existing problem

Wind power generation is rapidly picking up in many countries. With the ever-increasing demand for electricity which powers our industries, technology and our homes, it is of utmost importance to consider using it in a responsible way. That is where the concept of non-conventional energy sources like wind energy comes in. The one disadvantage with this form of generating power is the uncertainty in the wind direction, speed, and other climatic changes in the concerned area.

References

[1] Multi-step wind speed and power forecasts based on a WRF simulation and an optimized association method

Author Name: Xia-Xiao, Jianzhou-Wang, Dezhong-Chi.

[2] A hybrid technique for short-term wind speed prediction

Author Name: Jianming-Hu, Jianzhou-Wang, Kailiang-Ma

[3] A Multi-Step Prediction Method for Wind Power Based on Improved TCN to Correct Cumulative Error

Author Name: Heifeng luo, Xun dou, Rong sun

[4] Remotely Sensed Winds and Wind Stresses for Marine Forecasting and Ocean Modeling

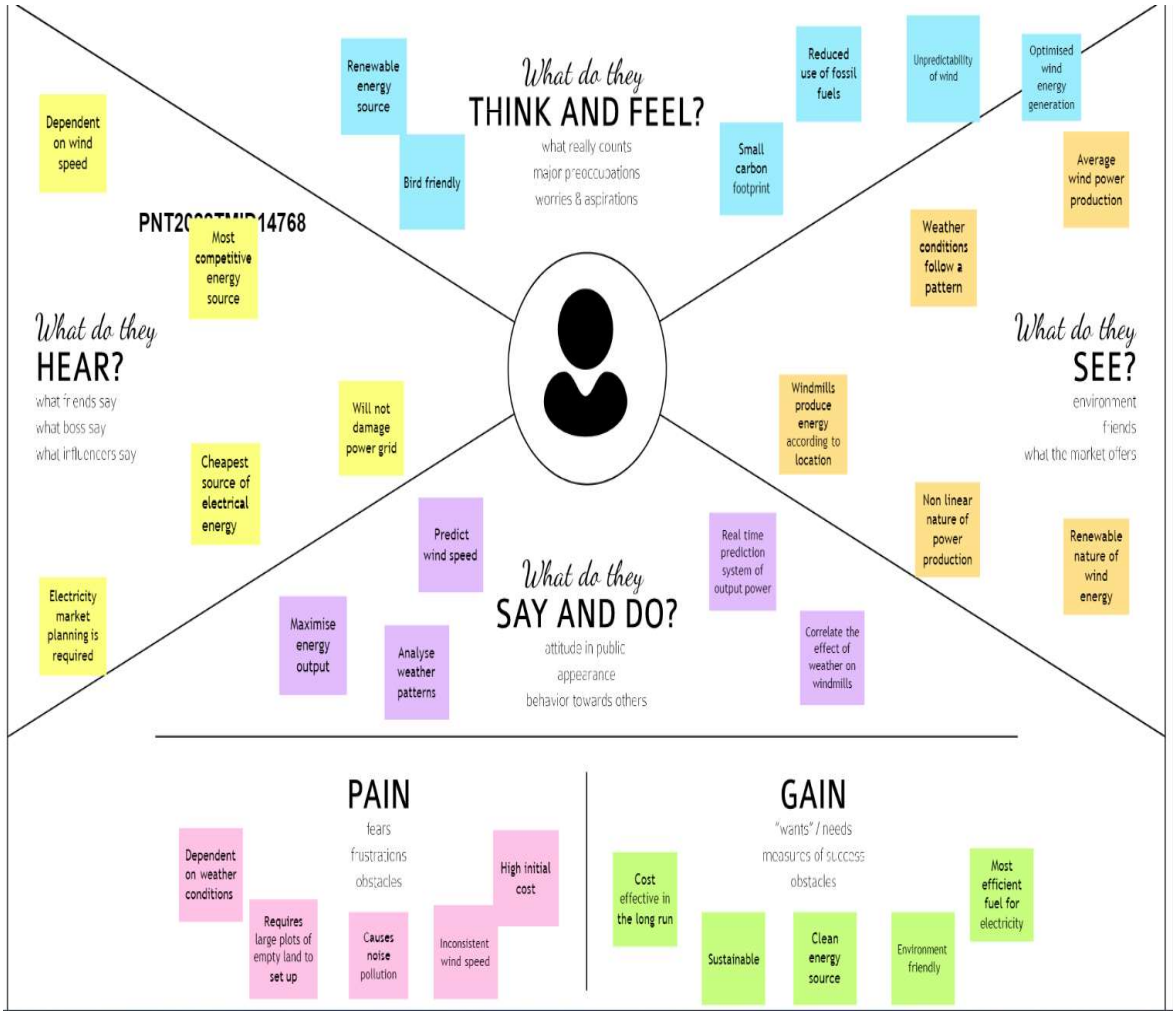
Author Name: Mark A. Bourassa, Thomas Meissner, Ivana Cerovecki.

[5] Wind Generation Forecasting Methods and Proliferation of Artificial Neural Network

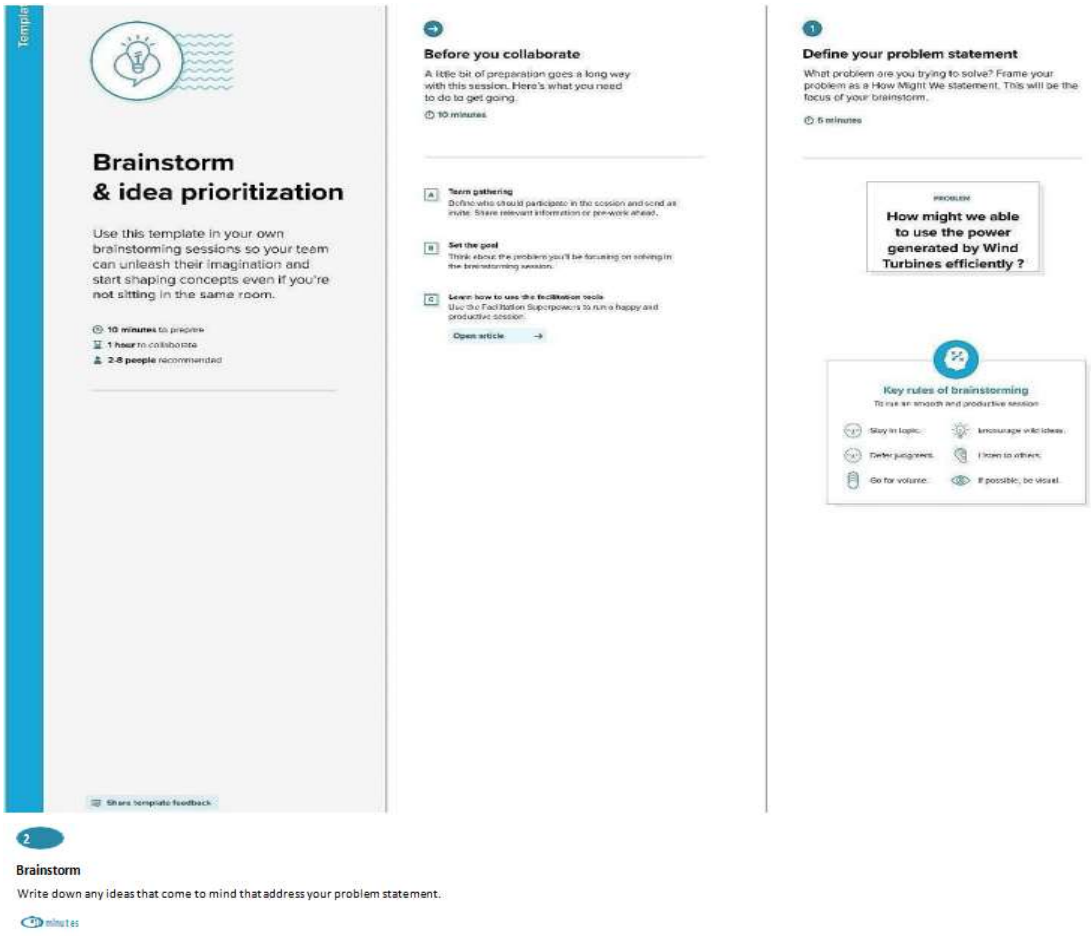
Author Name: Muhammad Shahzad Nazir, Fahad Alturise, Sami Alshmrany.

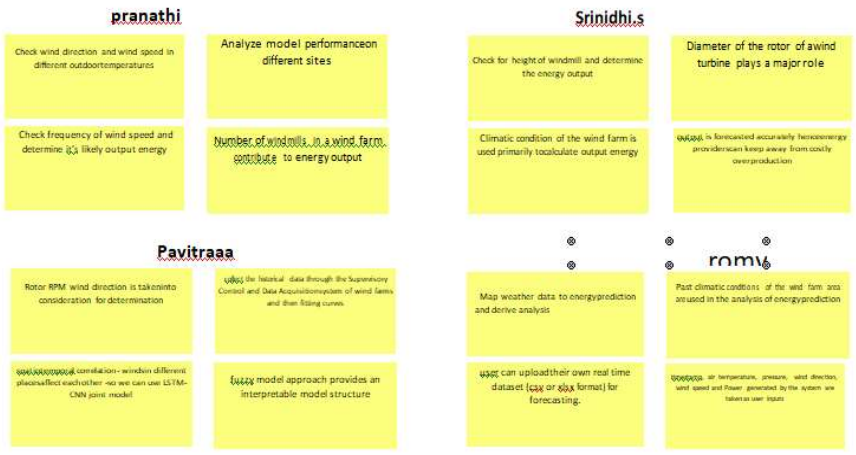
IDEATION & PROPOSED SOLUTION

Empathy Map Canvas:



Ideation & Brainstorming





3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

⏱ 20 minutes

Changes in the Hardware of the Wind Mill proves expensive and takes longer for R&D

Configuring the entire grid is challenging as nation wide it has to be implemented

Use past history along with Real time weather condition to predict Power output

Building a taller and bigger Wind Mill will not serve for its increased cost and complexity

Using only Weather Conditions for determining Power output is inaccurate

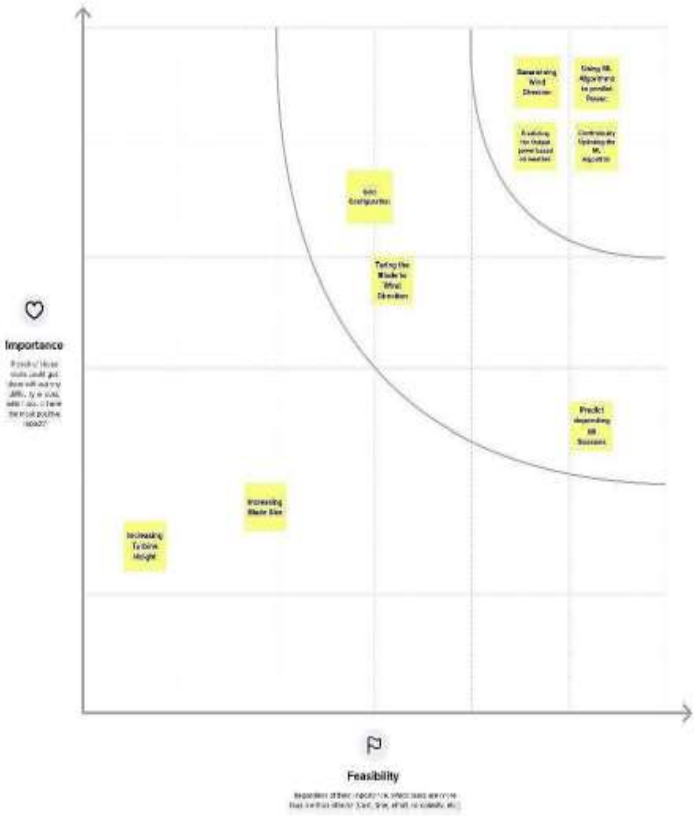
Continuously update the algorithm with the actual and predicted value

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



After you collaborate

You can export the mural as an image or pdf to share with members of your company who might find it helpful.

Quick add-ons

A **Share the mural**
Share a view link to the mural with stakeholders to keep them in the loop about the outcomes of the session.

B **Export the mural**
Export a copy of the mural as a PNG or PDF to attach to emails, include in slides, or save in your drive.

Keep moving forward

Strategy blueprint
Define the components of a new idea or strategy.
Open the template →

Customer experience journey map
Understand customer needs, motivations, and obstacles for an experience.
Open the template →

Strengths, weaknesses, opportunities & threats
Identify strengths, weaknesses, opportunities, and threats (SWOT) to develop a plan.
Open the template →

Share template feedback

Proposed Solution

Proposed Solution:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	The manufacturer needs to find a way to analyse the weather conditions of a region so they can choose regions that produce high quality and quantities of wind energy. Overproduction and cost of production needs to be reduced. Wind energy should be utilised in a way to provide a steady supply of electricity.
2.	Idea / Solution description	We examine the impact of different weather conditions on the energy output of wind farms. By accurately forecasting the wind-power, we reduce the need for additional balancing energy and reserve power to integrate wind power. A prediction system is developed with a method of combining statistical models and physical models. In this model, the inlet condition of the wind farm is forecasted by the auto regressive model.
3.	Novelty / Uniqueness	Currently, wind energy is not a primary source of electricity. Implementing our solution makes it possible to maximise energy output. This solution would make renewable energy sources more widely used. The user can upload their own data in real-time for forecasting.
4.	Social Impact / Customer Satisfaction	Local employment, better health, consumer choice, improvement of life standard, social bonds creation, income development, demographic impacts, and community development can be achieved by the proper usage of renewable energy system. Renewable energy improves human well-being and overall welfare well beyond GDP. Switching to clean sources of energy, thus helps address not only climate change but also air pollution and health.
5.	Business Model (Revenue Model)	Wind farm owners need a prediction model to predict the wind energy so they can provide a steady energy source. A subscription model would be efficient here, as the model will improve with time as it is used for forecasting using more and more data.
6.	Scalability of the Solution	This solution can be applied on a larger scale, to windfarms across the world.

Problem Solution fit:

Project Design Phase-I -Solution Fit Template

Project Title: Predicting the energy output of wind turbine based on weather condition

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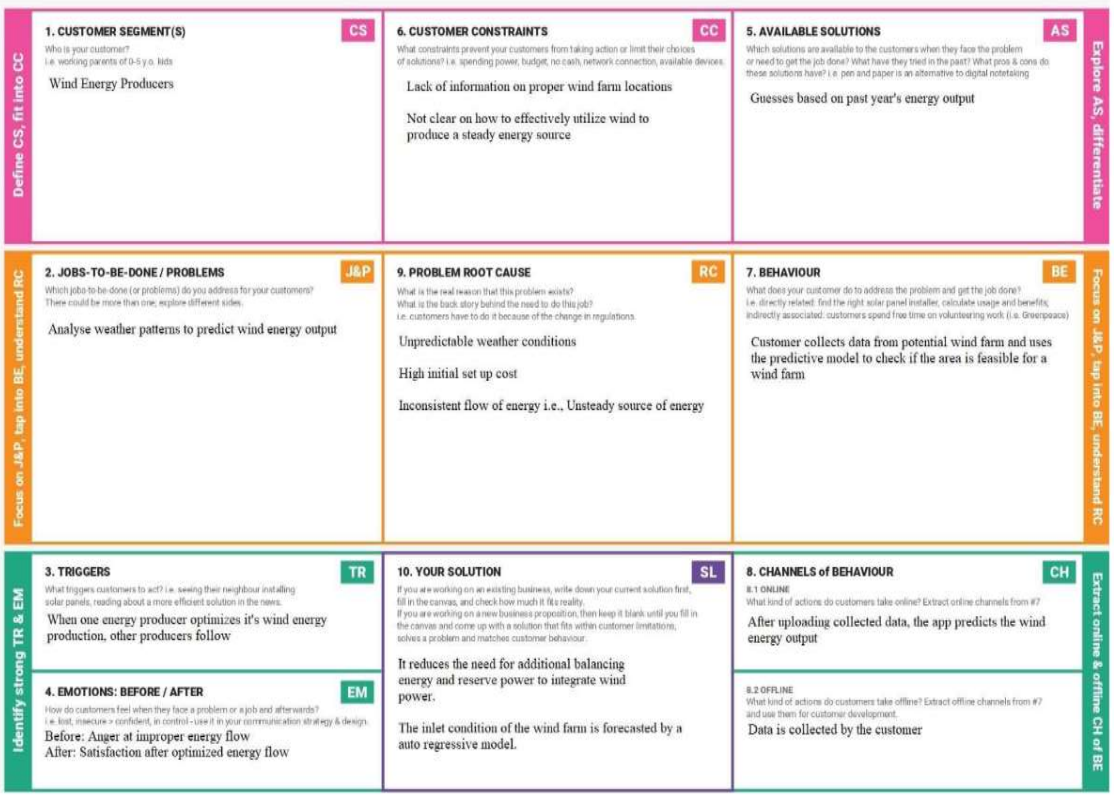


REQUIREMENT ANALYSIS

Functional requirement

The functional requirements of the project are:

1. A model to predict the power output of the turbine for the future
2. A database to store and update the values in real-time
3. A UI to display the results to the user.

Non-Functional requirements

NFR-1 -Usability The system satisfies the user goals and theapplication is easy to use.

NFR-2 -Security The data provided to system willbeprotected from attacks and unauthorized access .

NFR-3 Reliability The system will providethe consistency in outputwithout producing an error. NFR-4 Performance The performance willnever degrade eventheworkload is increased.

NFR-5 Availability The application is available for 24*7

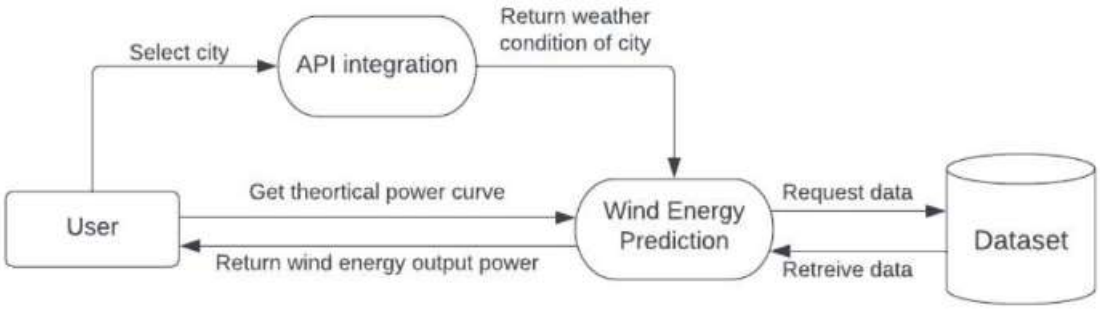
PROJECT DESIGN

Data Flow Diagrams:

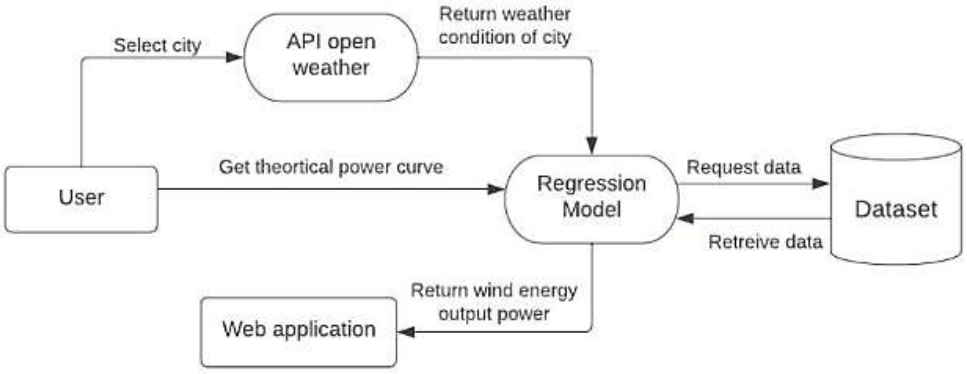
A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Level 0:

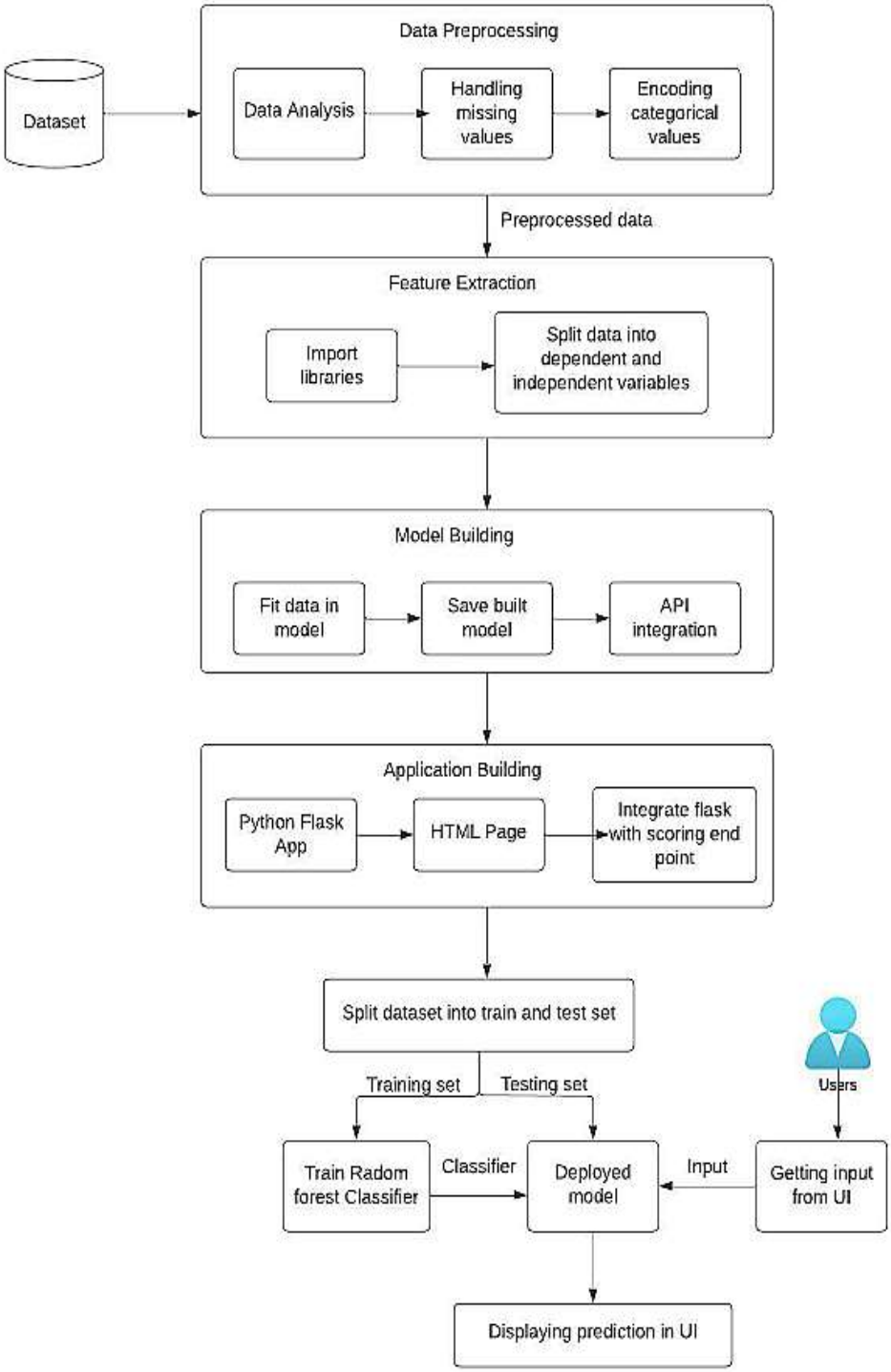
Level 1:



Level 2:



Solution & Technical Architecture:



User Stories:

User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As a user, I can register for the application through Gmail	I can register using existing email	Medium	Sprint-1
	Login	USN-4	As a user, I can log into the application by entering email & password	I can log in to the prediction application	High	Sprint-2
	Home Page	USN-5	As a user, after login I will be redirected to home page of the web app	I can have a overview of the predictor application	Low	Sprint-2
Administrator	Data Collection	USN-6	As an administrator, I have to collect dataset	dataset is available	High	Sprint-3
	Data Preprocessing	USN-7	As an administrator, I have to preprocess data and remove null fields	Cleaned dataset it ready for model building	Medium	Sprint-3
	Model Building	USN-8	As an administrator, I have to build regression model to predict wind energy output	Model is able to predict output	High	Sprint-3
	Training Model	USN-9	As an administrator, after model is built, it has to be trained to improve accuracy	Model is able to predict correct output at all times	High	Sprint-4
	API Integration	USN-10	As an administrator, API integration must be done to automatically input weather condition from the city entered by user	Weather condition is given as output when city is enetred	High	Sprint-4

PROJECT PLANNING & SCHEDULING

Sprint Planning & Estimation:

Product Backlog, Sprint Schedule, and 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, password, and confirming my password.	5	High	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 1		USN-2	As a user, I will receive confirmation email once Ihave registered for the application	5	High	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 1		USN-3	As a user, I can register for the application through Phone number	2	Low	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 1		USN-4	As a user, I can register for the application through Gmail	3	Medium	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 1	Login(User)	USN-5	As a user, I can log into the application by entering email & password.	5	High	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 2	Dashboard	USN-6	Once I have logged in, I can see my dashboard.	6	Medium	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R

Sprint 2	Web access	USN-7	As a customer I can access the website to predict the turbine power.	7	High	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R
Sprint 2	Prediction	USN-8	As a customer when I enter the weather details the website should predict the approximate turbine power.	7	High	SRINIDHI S SRINIDHI G PAVITRA J GAJJALA LAKSHMI PRANATHI ROMY ANN V R

Sprint Delivery Schedule:

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	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	03 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	10 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	17 Nov 2022

REPORT FROM JIRA:

Reporting helps you track and analyze your team's work throughout a project. Jira Software has a range of reports that you can use to show information about your project, versions, epics, sprints, and issues. A burnup chart highlights the work you've completed against your total project scope while a burn-down chart highlights the amount of work remaining in a project. A burnup chart contains a work completed line and a project scope line.

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

FEATURE 1

Python flask is the first feature that helps to complete this project. It allows the user to create a local server and host the website on a local machine. Software programs are constructed using a framework as their foundation. It gives software developers a base upon which to build a range of apps for particular platforms. It is a collection of built-in classes and functions that link to the system software and manage inputs and outputs.

```
from flask import Flask,render_template,request,url_for,redirect
```

Here we importall the necessary features of this project involvingin Python flask.

```
@app.route("/",methods=['POST','GET'])
def index():
return render_template("index.html")
```

Here we created a local client'sown server which serves the .html pages to the users. Here we use the inputsfrom the html pages which has to be get by using request methodin Python Flask. By validating the values from the database,we allow the user to accessthe home page. render_template : Used for rendering html pages on browser. url_for : Passing the control of the program to another function. session: Creates a separate session for the individual user

Feature 2

Different types of python libraries such as pandas, Sklearn, NumPy, matplotlib are used for processing the algorithms. Using exploration data analysis technique data was analyses in junketeer notebook.10-fold cross validation technique is used for spitting the data set into training and testing data. Then using random forest algorithm datasetwas processed.

TESTING

Test Cases

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:

```
data = pd.read_csv("T1.csv")
```

In [3]:

```
#head funtion and tail funtion
data.head()
```

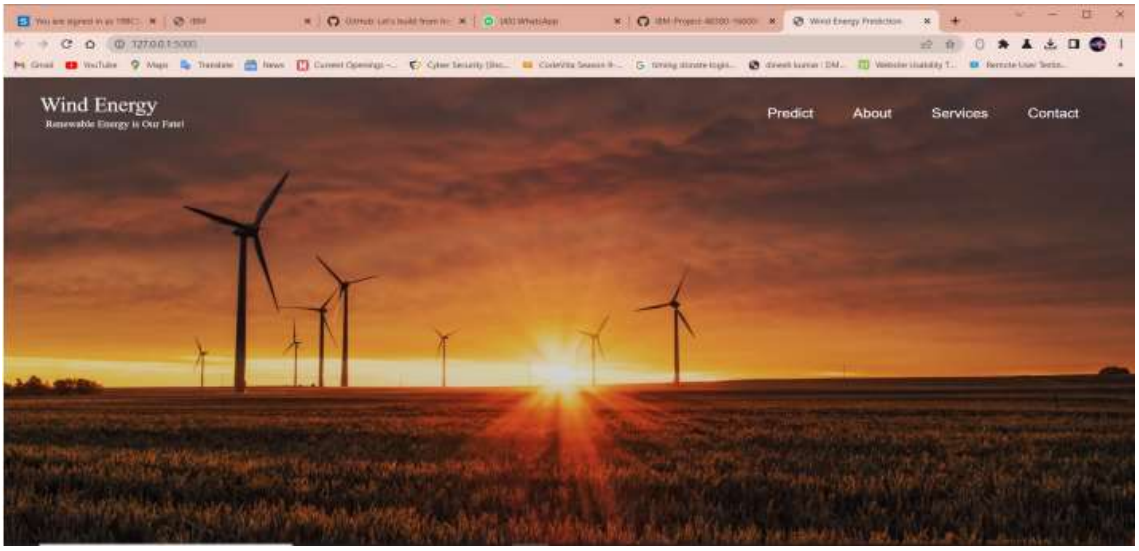
Out[3]:

	Date/Time	LV ActivePower (kW)	Wind Speed (m/s)	Theoretical_Power_Curve (KWh)	Wind Direction (°)
0	01 01 2018 00:00	380.047791	5.311336	416.328908	259.994904
1	01 01 2018 00:10	453.769196	5.672167	519.917511	268.641113
2	01 01 2018 00:20	306.376587	5.216037	390.900016	272.564789
3	01 01 2018 00:30	419.645905	5.659674	516.127569	271.258087
4	01 01 2018 00:40	380.650696	5.577941	491.702972	265.674286

In [4]:

User Acceptance Testing

HOME PAGE

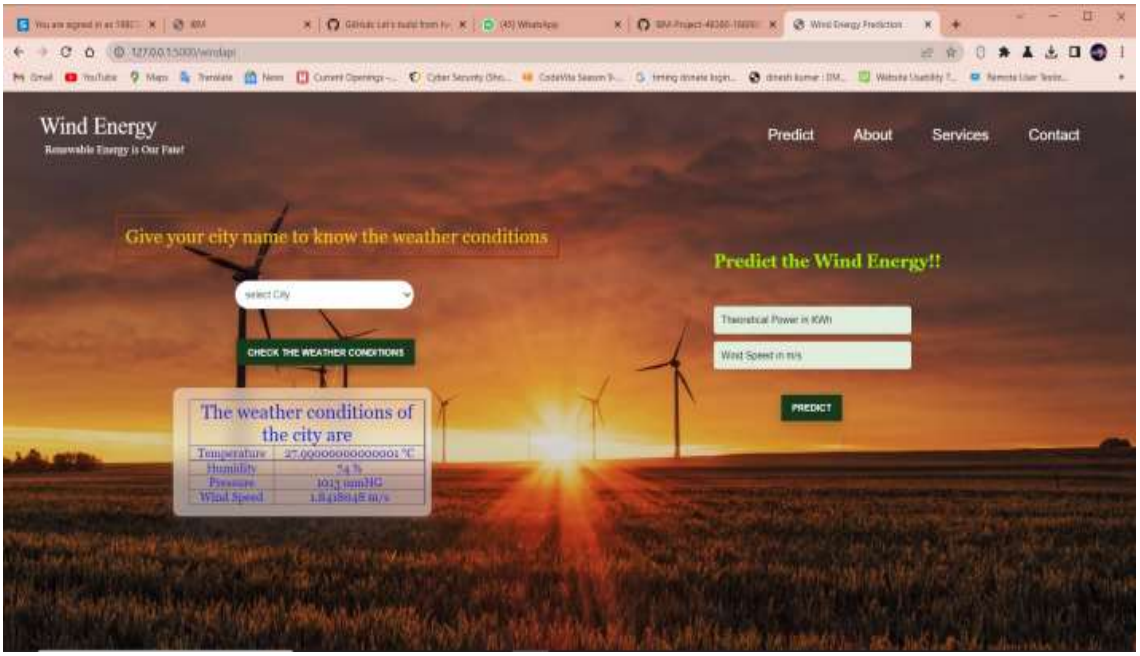


ABOUT PAGE

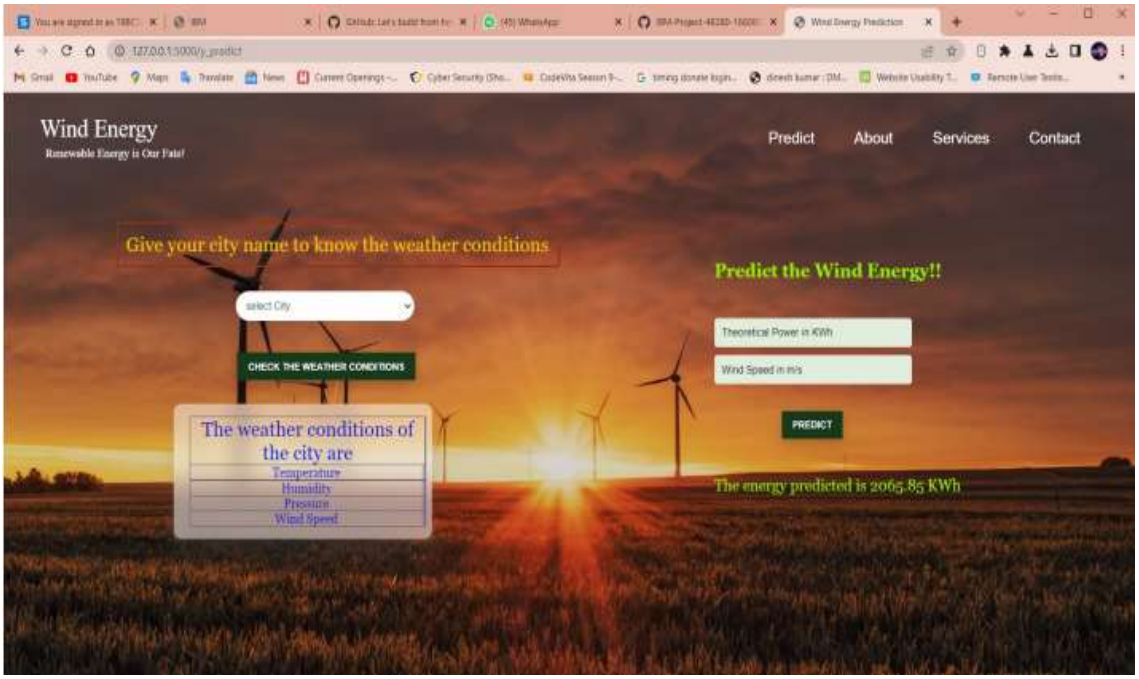
SERVICES PAGE

CONTACT PAGE

GATHERING WEATHER REPORT FROM API

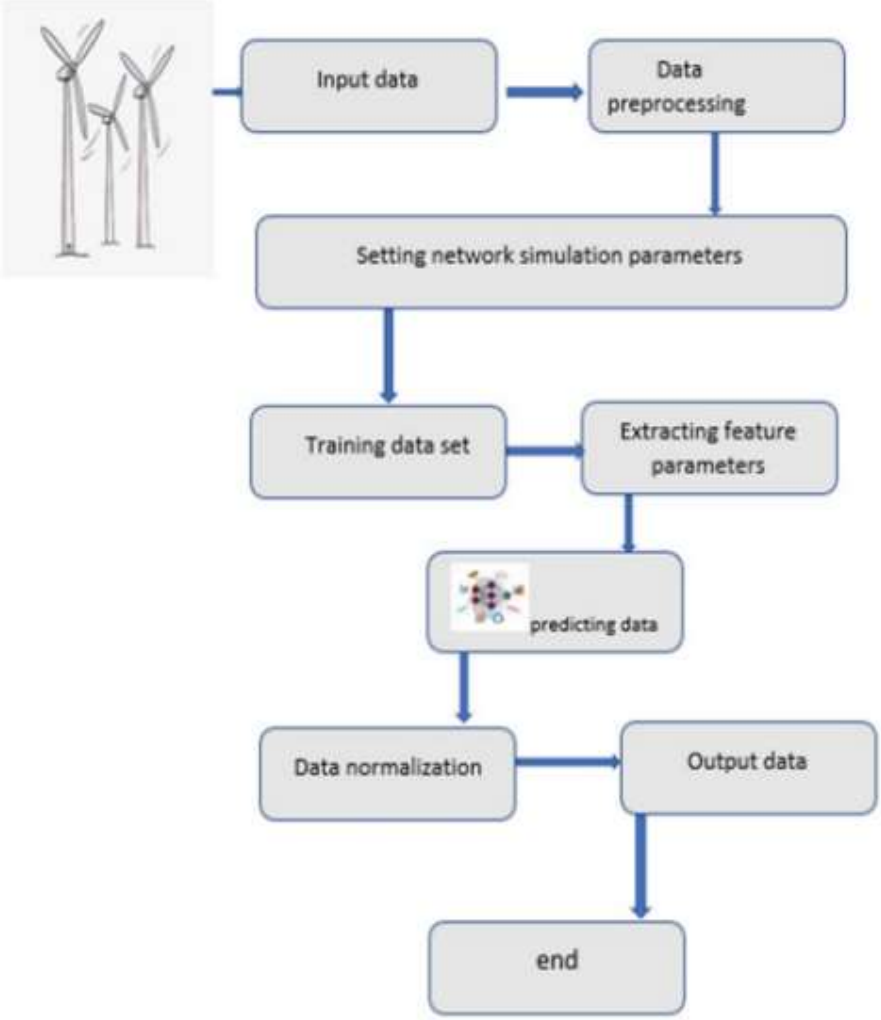


PREDICTING THE ENERGY OUTPUT OF WIND TURBINE



RESULTS

Performance Metrics



ADVANTAGES

- Extracting electricity from renewable resourceshas been widelyinvestigated in the past decades to decrease the worldwide crisis in the electrical energy and environmental pollution.
- For a wind farm which converts the wind power to electrical energy, a big challengeis to predict the wind power preciselyin spite of the instabilities.
- Predict the variation in the long-term wind speed over the site at the hub height of the machines, based on the long-term wind speeds at the mast locations.
- Predict the wake losses that arise as a result of one turbine operating behind

another – in other words in its wake; and calculate or estimate the other losses.

DISADVANTAGES

- In order to achieve better generalization for wind speed prediction, the input and output are to be modelledand the hidden neuron number should be appropriately selectedfor the neural network design.
- In the current scenario many prediction research fields have been heuristic. While numerousresearchers have developedprediction models for accurate wind speed prediction, no perfect model has been achieved.

CONCLUSION

This seems natural as neural techniques are motivated by mechanisms of natural neural systemsthat have to cope with dynamic environments. Wind is a very dynamicsystem. An important aspect is to manage its volatile and dynamic nature. The integration of wind energy into smart grids affords balancing capabilities, and balancing affordsunderstanding and forecasting. The examples presented in this work have shown how kernel techniques can help to cope with the dynamics of wind time series data. They turn out to be successful methods in modelling, forecasting and monitoring of wind energy time series data. Efficient implementations allow their application in real-time scenarios. It is subject to future projects to show the success of these and other kernel methods in real-world energy applications.

FUTURE SCOPE

Most wind power forecasting models study ‘regular’ wind conditions. The EU funded projectcalled ‘Safe wind’ aims to improve wind power prediction over challenging and extreme weather periods and at different temporal and spatial scales. Development activities are on-going to reduce error in wind power prediction, to improve regionalized wind power forecasting for on shore wind farms and to derive methods for wind power prediction for offshore wind farms. It is possible that the use of ensemble and combined weatherprediction methods togethermay enhance forecasting. Offshore wind farms pose more of a challenge in terms of accurate wind power forecasting because the environment is typically flat and smooth with very few obstacles so changes in wind speed and thermal effects are felt more acutely than onland as weather fronts pass over the wind farm

APPENDIX

Source Code

```
import flask
from flask import request, render_template
from flask_cors import CORS
import joblib
import pandas as pd
from xgboost import XGBRegressor
import requests
app = flask.Flask(__name__)
CORS(app)

# purposely kept API KEY since cuh is very less

API_KEY = "t1xJwH_pNvesyStso2tawTlpypHX0HEQJVMev99cmAtK"
token_response = requests.post('https://iam.cloud.ibm.com/identity/token',
data={"apikey":API_KEY, "grant_type": 'urn:ibm:params:oauth:grant-type:apikey'})
mltoken = token_response.json()["access_token"]

header = {'Content-Type': 'application/json', 'Authorization': 'Bearer ' + mltoken}



@app.route('/', methods=['GET'])
def home():
    return render_template('index.html')

@app.route('/about')
def about():
    return render_template('about.html')

@app.route('/predict')
```

```
def predict():
    return render_template('predict.html')

@app.route('/services')
def services():
    return render_template('services.html')



@app.route('/contact')
def contact():
    return render_template('contact.html')

@app.route('/windapi',methods=['POST'])
def windapi():
    city=request.form.get('city')
    apikey="86b1a085e43cad23bfd9c45d5fd88fc3"

url="http://api.openweathermap.org/data/2.5/weather?q="+city+"&appid="+apikey
    resp = requests.get(url)
    resp=resp.json()
    temp = str(float(resp["main"]["temp"])-273.15)+" °C"
    humid = str(resp["main"]["humidity"])+" %"
    pressure = str(resp["main"]["pressure"])+" mmHG"
    speed = str(float(resp["wind"]["speed"])*0.44704)+" m/s"
            return render_template('predict.html', temp=temp, humid=humid,
pressure=pressure, speed=speed)
@app.route('/y_predict',methods=['POST'])
def y_predict():
    ws = float(request.form['theo'])
    wd = float(request.form['wind'])
    X = [[ws, wd]]
    xgr = XGBRegressor()
```

```
        df = pd.DataFrame(X, columns=['WindSpeed(m/s)', 'WindDirection'])
        payload_scoring = {"input_data": [{"field": [['ws', 'wd']], "values":X}]}

        response_scoring = requests.post('https://us-south.ml.cloud.ibm.com/ml/v4/deployments/0644c680-478f-475f-bc23-2a64fc6490a5/predictions?version=2022-10-24', json=payload_scoring,headers={'Authorization': 'Bearer ' + mltoken})
        print(response_scoring)
        predictions = response_scoring.json()
        print(predictions)
        output = predictions['predictions'][0]['values'][0][0]
        print("Final prediction :", predict)
         return render_template('predict.html', prediction_text="The energy predicted is {:.2f} KWh".format(output))

    if __name__ == "__main__":
        app.run()
```

GitHub

https://github.com/IBM-EPBL/IBM-Project-31128-1660196401

Project Demo Link

https://drive.google.com/file/d/1WXrExiur7elHL8WA-dOlQ566EHnYqhk4/view?usp=drivesdk