PREDICTING THE ENERGY OUTPUT OF WIND-TURBINE BASED ON WEATHER CONDITIONS

Submitted by :

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Project Id :SPS_PRO_364

Project Title :

Predicting The Energy Output Of Wind Turbine Based On Weather Condition

Category :Machine Learning

INTRODUCTION

The re-emergence of the wind as a significant source of the world's energy must rank as one of the significant developments of the late 20th century. The first windmills on record were built by Persians around 900 A.D. These vertical axis windmills were not very efficient at capturing the wind's power and were particularly susceptible to damage during high winds. During the middle Ages, wind turbines began to appear in Europe. These turbines resembled the 4-bladed horizontal axis windmill typically associated with Holland. The applications of windmills in Europe included water pumping, grinding grain, sawing wood and powering tools. Like modern wind turbines, the early European systems had 2 degree of freedom that allowed the turbine to turn into the wind to capture the most power. The use of windmills in Europe reached their height in the 19th century just before the onset of the Industrial Revolution. At this time, windmill designs were beginning to include some of the same features found on modern wind turbines including yaw drive systems, air foil shaped blades and a power limiting control system. Wind turbines have continued to evolve over the past 20 years and the overall cost of energy required to produce electricity from wind is now competitive with traditional fossil fuel energy sources. This reduction in wind energy cost is the result of improved aerodynamic designs, advanced materials, improved power electronics, advanced control strategies and rigorous component testing. Over the last 25 years, wind turbines have evolved and are now cost competitive with traditional energy sources in many locations. The size of the largest commercial wind turbines, has increased from approximately 50 kW to 2 MW, with machines up to 5 MW under design .

PROJECT SUMMARY:-

The Typical Machine Learning Model Can Predict The Output Energy , Based On Weather Conditions .

This Model Works On Linear Regression Concept, It Is So Simple To Build

We Can Give Weather Conditions In Our Area To Get Approximate Values Of Energy Which Is Predicted By Our Model

The Major Weather Conditions Are:-

1. Air Speed ,

2. Air Density ,

3. Temperature In Our Area

PROJECT REQUIREMENTS:-

1. Project Planning and Kickoff

2. Explore IBM Cloud Platform

3. Explore IBM Watson Services

4. Predicting The Output Energy Of Wind Turbine Based On Weather Conditions

FUNCTIONAL REQUIREMENTS:-

Based On The Weather Conditions And by Assining the factors of output energy values we can find easily

TECHNICAL REQUIREMENTS:-

Python,IBMCloud,IBM Watson

SOFTWARE REQUIREMENTS:-

IBM services and IBM Studio

PROJECT DELIVERABLES:-

The Typical Machine Learning Model Can Predict The Output Energy , Based On Weather Conditions .

This Model Works On Linear Regression Concept, It Is So Simple To Build

PROJECT TEAM:- Team Of Four Members

PROJECT SCHEDULE:-

- **Project Planning &Kickoff**:-

1-Project Scope, Schedule, Team and Deliverables

2-Setup The Development Environment

- **Create IBM Cloud Platform**:-

  1-Create IBM Cloud Account

  2-Create A Node-Red Starter Application

- **Explore IBM Watson Services**:-

  1-Explore IBM Watson Use cases

  2-Study The Major Weather Conditions Which Can Effect The Output Energy

  3- Create Data Sets In MS-EXCEL

- **Predicting The Output Energy Of Wind Turbine Based On Weather Condition**:-

  1. Create Necessary IBM Cloud Services
  2. Collect Required Data Sets
  3. Configure Machine Learning Linear Regression Model
  4. Build Node-Red Flow To Integrate All Services
  5. Test the Model And Capture The Results
  6. Prepare the Project Report & Upload The Node-Red Flow to GitHub
  7. Create the Project Demo Video& Upload To YouTube

Purpose: *This Machine Learning - predicting model can predict the energy output of wind turbine based on weather condition*

Special Purpose: *This model has a great advantage that 'Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine'.*

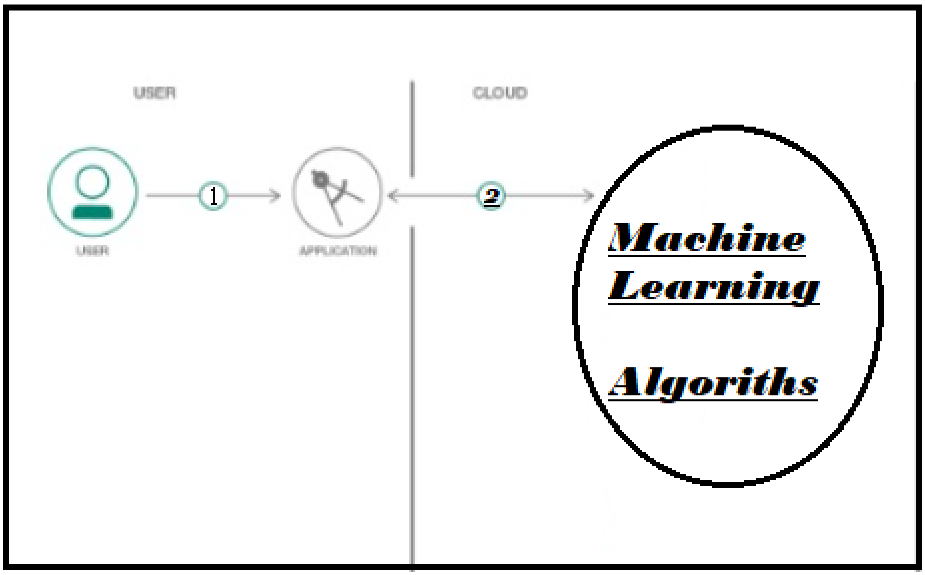
- **LITERATURE SURVEY :**

  - ***Existing problem:*** *As ,now a days we are depending on renewable energy sources in that one of the energy source is Wind Turbine , as we are placing them in different places we don't have any idea how this turbines can provide energy in different places , so if it is possible we can predict the output energy due to weather conditions in different places then it will be more helpful for us.*

  - ***Proposed Solution :*** *We can give past 1-2 years data on weather conditions of that place then our model can learn from that data , then it can be useful to predict the energy based on weather conditions for new data also , such that we can place our turbine where ever we want according to our predicted output*

- ***THEORITICAL ANALYSIS:***

Block/Flow Diagram:



Creating IBM cloud Account :

Step-1:

Browse the IBM Academic Initiative Page
https://www.ibm.com/academic

Step-2:

Click on Register Now Button

Step-3:

Enter your Academic Institution issued Email ID (i.e. name@iiitb.edu or name@iiitb.ac.in etc.) and click on Submit Button

Step-4:

If your college is already listed with IBM Academic Initiative, it show following screen. Enter the necessary information

Step-5:

Accept the Academic Initiative Agreement & Privacy Consent by clicking the links, Click Register Button & Proceed

Step-6:

Redirected to create an IBM ID Fill the necessary information and click NEXT

Step-7:

Verify Email by entering Verification Code, and click CONTINUE. It will open a pop-up on account privacy, click PROCEED

Step-8:

Congratulations!! Your IBM Academic Initiative account has been created.

Step-9:

Click on Learn More in IBM Cloud Tile

Step-10:

Click on Software Tab and Click Request IBM Cloud Feature Code for enhanced IBM Cloud Account

Step-11:

Copy the IBM Cloud Feature Code

Step-12:

How to Apply IBM Cloud Feature Code Open the IBM Cloud website: https://cloud.ibm.com/login . It willfetch your account information automatically, Click on Create Account Button.

Step-13:

Click on Continue Button, Enter Password and click Continue

Step-14:

From the main Dashboard click on Manage in the upper-right menu.

Step-15:

Click on Account in Drop-Down Menu

Step-16:

Click on Account Settings in the Left-Hand Menu. It shows Lite plan with 256MB Free Memory

Step-17:

Scroll down until you see the Subscription and Feature Code section and click on Apply Code

Step-18:

Enter (or copy/paste) your 25-character promo code and click Apply.

Step-19:

Congratulations!! Your cloud account has been converted to trail account with 2GB Memory .

Creating Node-Red app :

STEP 1 : FIND THE NODE-RED STARTER IN THE IBM CLOUD CATALOG

Follow these steps to create a Node-RED Starter application in the IBM Cloud.

- Log in to IBM Cloud.

- Open the catalogue and search for node-red .
- Click on the Software tab .
- Click on the Node-RED App tile .
- Catalogue entry Node-RED Starter Kit
- Click on the Create app button to continue

STEP 2 : CONFIGURE YOUR APPLICATION

Now you need to configure the Node-RED Starter application.

- On the App details page, a randomly generated name will be suggested – Node RED SSLPD in the screenshot below. Either accept that default name or provide a unique name for your application . This will become part of the application URL. Note: If the name is not unique, you will see an error message and you must enter a different name before you can continue.
- The Node-RED Starter application requires an instance of the Cloudant database service to store your application flow configuration. Select the region the service should be created in and what pricing plan it should use. Note: You can only have one Cloudant instance using the Lite plan. If you have already got an instance, you will be able to select it from the Pricing plan select box . You can have more than one Node- RED Starter application using the same Cloudant service instance.

STEP 3 : ENABLE THE CONTINUOUS DELIVERY FEATURE

At this point, you have created the application and the resources it requires, but you have not deployed it anywhere to run. This step shows how to setup the Continuous Delivery feature that will deploy your application into the Cloud Foundry space of IBM Cloud

- On the next screen, click the Deploy your app button to enable the Continuous Delivery feature for your application
- Enable continuous delivery in Node-RED app
- You will need to create an IBM Cloud API key to allow the deployment process to access your resources. Click the New button to create the key. A message dialog will appear. Read what it says and then confirm and close the dialog.
- Increase the Memory allocation per instance slider to 256MB. If you do not increase the memory allocation, your Node-RED application might not have sufficient memory to run successfully.
- The Node-RED Starter kit only supports deployment to the Cloud Foundry space of IBM Cloud. Select the region to deploy your application to. This should match the region you created your Cloudant instance in. Lite users might only be able to deploy to your default region.
- Select the region to create the DevOps toolchain.
- Click Create. This will take you back to the application details page.
- Create the Node-RED Starter app

- After a few moments, the Continuous Delivery section will refresh with the details of your newly created Toolchain. The Status field of the Delivery Pipeline will show In progress. That means your application is still being built and deployed.
- Continuous delivery status
- Click on the In progress link to see the full status of the Delivery Pipeline Delivery pipeline, view logs
- The Deploy stage will take a few minutes to complete. You can click on the View logs and history link to check its progress. Eventually the Deploy stage will go green to show

it has passed. This means your Node-RED Starter application is now running

STEP 4: OPEN THE NODE-RED APPLICATION

Now that you've deployed your Node-RED application, let's open it up!

•Open your IBM Cloud Resource list by selecting the sidebar menu (1) and then selecting Resource List .

You will see your newly created Node-RED Application listed under the Apps section

(1). You will also see a corresponding entry under the Cloud Foundry apps section (2).

Click on this Cloud Foundry app entry to go to your deployed application's details page. •From the details page, click the Visit App URL link to access your Node-RED Starter application.

STEP 5: CONFIGURE YOUR NODE-RED APPLICATION

The first time you open your Node-RED app, you'll need to configure it and set up security.

- A new browser tab will open with the Node-RED start page.
- Configure Node-RED app
- On the initial screen, click Next to continue.
- Secure your Node-RED editor by providing a username and password. If you need to change these at any point, you can either edit the values in the Cloudant database, or override them using environment variables. The documentation on nodered.org describes how to do this. Click Next to continue.

- The final screen summarizes the options you’ve made and highlights the environment variables you can use to change the options in the future. Click Finish to proceed.

Node-RED will save your changes and then load the main application. From here you can click the Go to your Node-RED flow editor button to open the editor.

STEP 6: ADD EXTRA NODES TO YOUR NODE-RED PALETTE

Node-RED provides the palette manager feature that allows you to install additional nodes directly from the browser-based editor. This is convenient for trying nodes out, but it can cause issues due to the limited memory of the default Node-RED starter application.

The recommended approach is to edit your application’s package.json file to include the additional node modules and then redeploy the application.

This step shows how to do that in order to add the node-red-dashboard module.

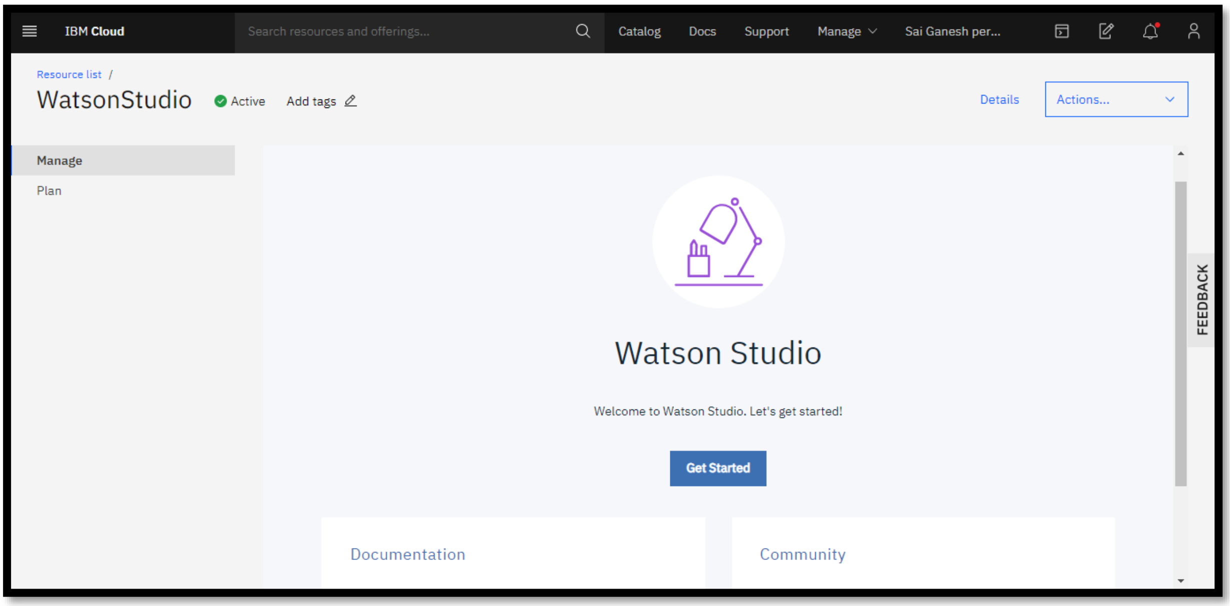
- On your application’s details page, click the url in the Continuous Delivery box. This will take you to a git repository where you can edit the application source code from your browser
- Scroll down the list of files and click on package.json. This file lists the module dependencies of your application
- Click the Edit button
- Add the following entry to the top of the dependencies section:
- At this point, the Continuous Delivery pipeline will automatically run to build and deploy that change into your application. If you view the Delivery Pipeline you can watch its progress. The Build section shows you the last commit

made and the Deploy section shows the progress of redeploying the application.

- Once the Deploy stage completes, your application will have restarted and now have the node-red-dashboard nodes preinstalled.

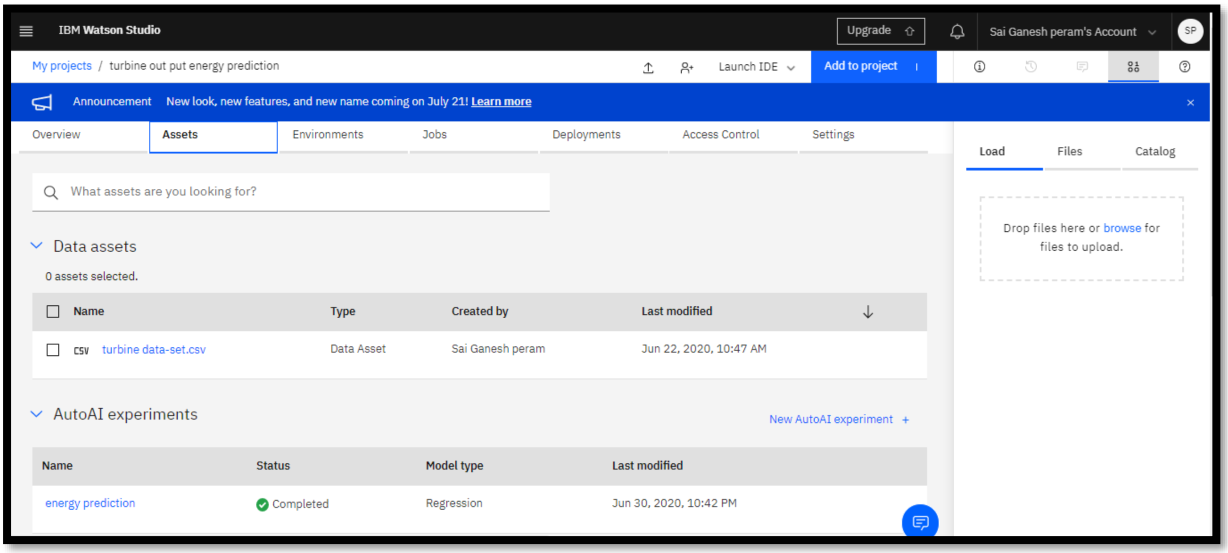
SCREENSHOTS:

➢ *Watson Studio :*



Watson Studio

Welcome to Watson Studio. Let's get started!



My projects / turbine out put energy prediction

Announcement New look, new features, and new name coming on July 21! Learn more

What assets are you looking for?

Drop files here or browse for files to upload.

Data assets

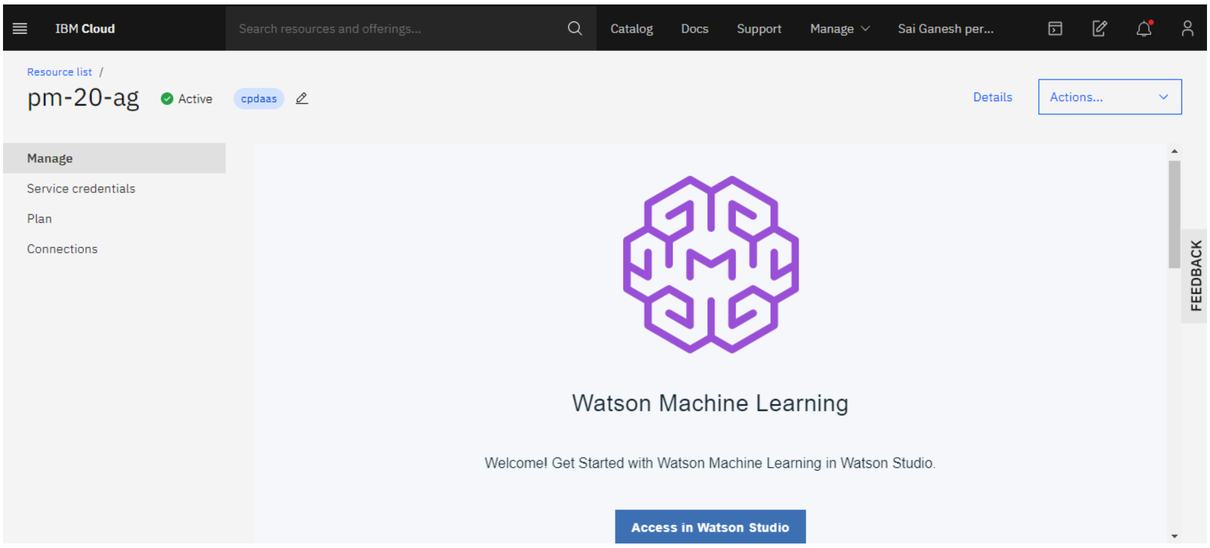
0 assets selected.

Name	Type	Created by	Last modified
CSV turbine data-set.csv	Data Asset	Sai Ganesh peram	Jun 22, 2020, 10:47 AM

AutoAI experiments

Name	Status	Model type	Last modified
energy prediction	Completed	Regression	Jun 30, 2020, 10:42 PM

- *Watson Machine Learning :*



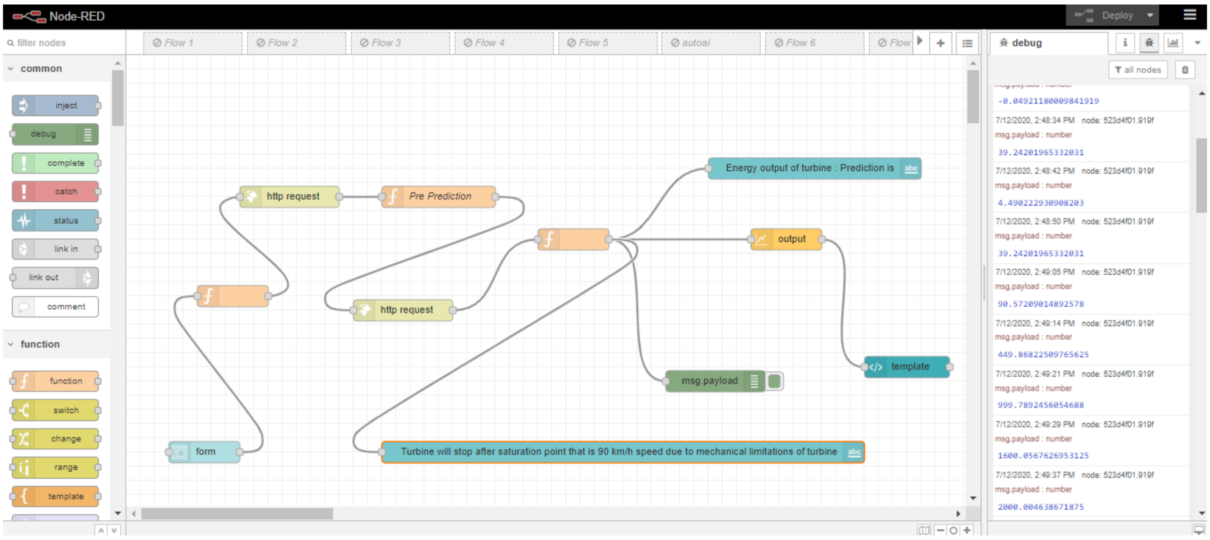
Resource list /

pm-20-ag Active cpdaas

Watson Machine Learning

Welcome! Get Started with Watson Machine Learning in Watson Studio.

- *Node Red Flow*



```
-0.04921180009841919
7/12/2020, 2:48:34 PM   node: 523d4f01.919f
msg.payload : number
39.24201965332031
7/12/2020, 2:48:42 PM   node: 523d4f01.919f
msg.payload : number
4.490222930908203
7/12/2020, 2:48:50 PM   node: 523d4f01.919f
msg.payload : number
39.24201965332031
7/12/2020, 2:49:05 PM   node: 523d4f01.919f
msg.payload : number
90.57209014892578
7/12/2020, 2:49:14 PM   node: 523d4f01.919f
msg.payload : number
449.86822509765625
7/12/2020, 2:49:21 PM   node: 523d4f01.919f
msg.payload : number
999.7892456054688
7/12/2020, 2:49:29 PM   node: 523d4f01.919f
msg.payload : number
1600.0567626953125
7/12/2020, 2:49:37 PM   node: 523d4f01.919f
msg.payload : number
2000.004638671875
```

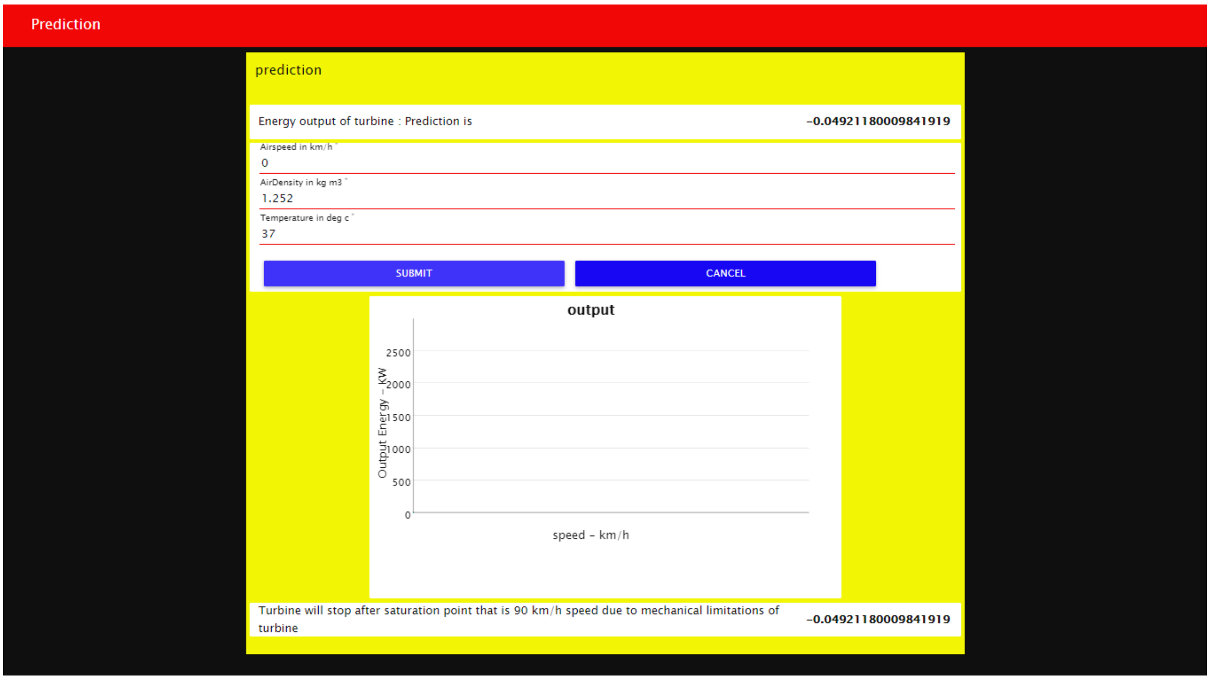
•FLOWCHART:

- Create flow and configure all nodes:
- At first go to manage palette and install dashboard.
- Now, Create the flow with the help of following node:

  a. Inject
  b. Debug
  c. Function node
  d. http request node
  e. template node
  f. text node
  g. Ui_Form
  h. Ui_Text

RESULTS : *Out-put predictions based on weather conditions*

- *At normal temperature , Air-Density in kg m3 , Airspeed in km/h at ‘0’ km/h*



Prediction

prediction

Energy output of turbine : Prediction is **–0.04921180009841919**

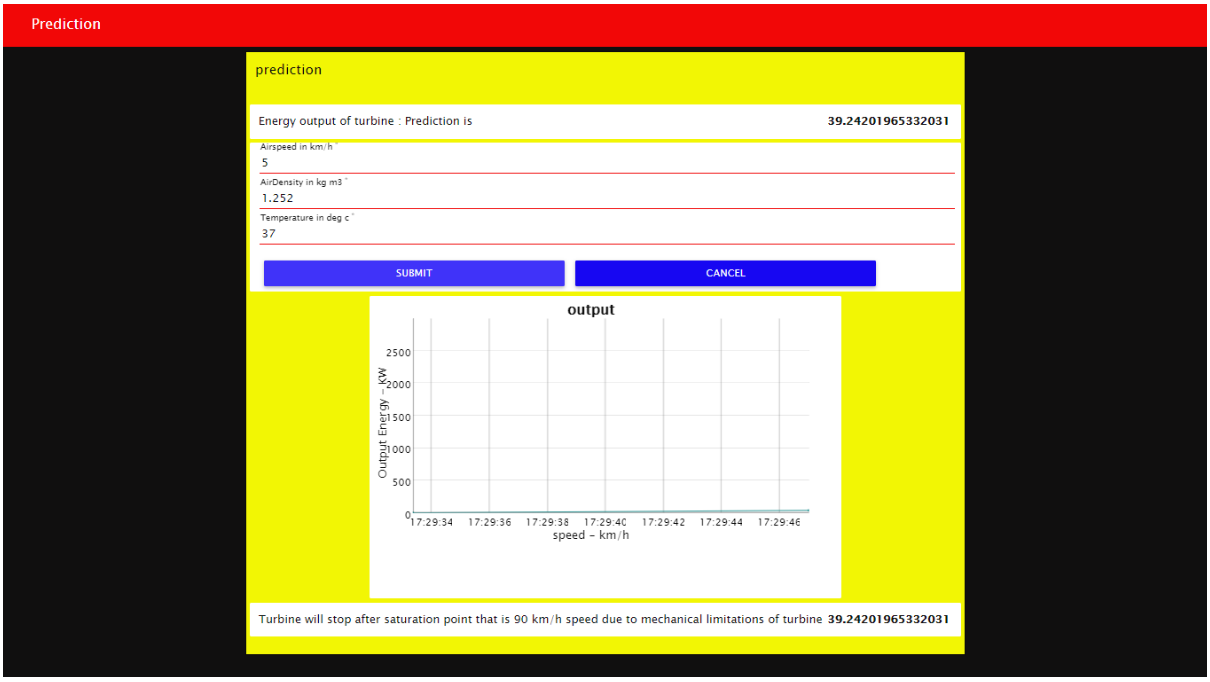
Airspeed in km/h *
0

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine **–0.04921180009841919**

- *At ‘5 km/h’:*



Prediction

prediction

Energy output of turbine : Prediction is **39.24201965332031**

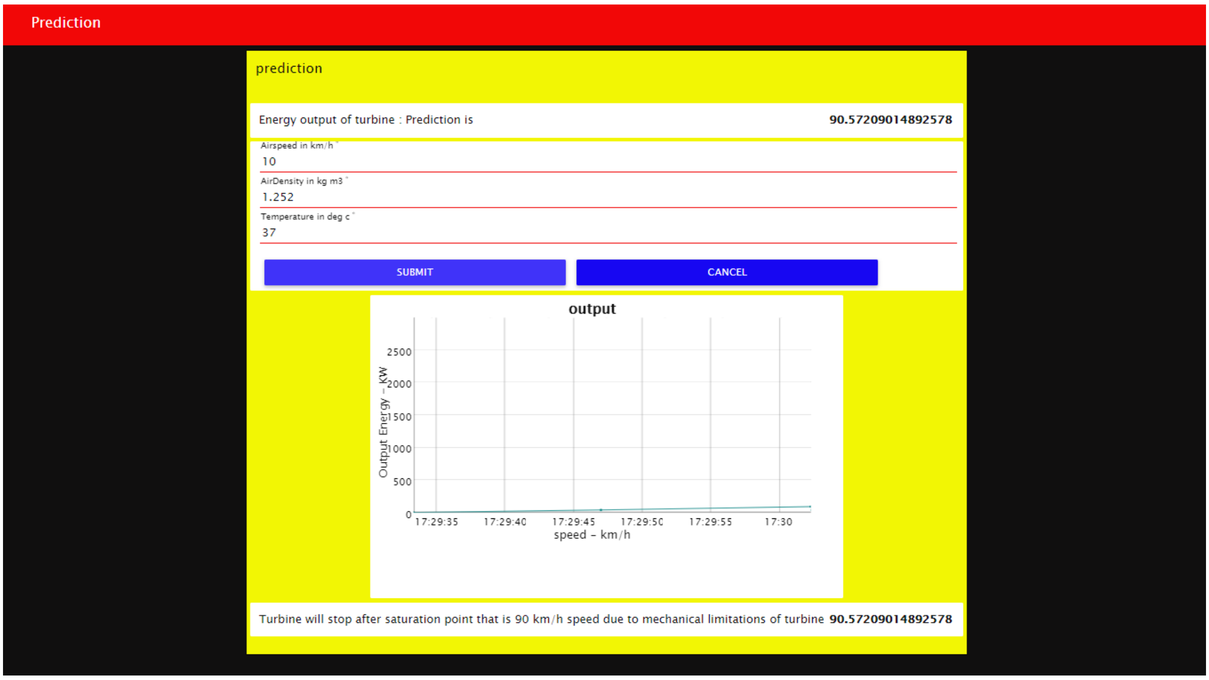
Airspeed in km/h *
5

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine **39.24201965332031**

- *At ‘ 10 km/h’*



Energy output of turbine : Prediction is **90.57209014892578**

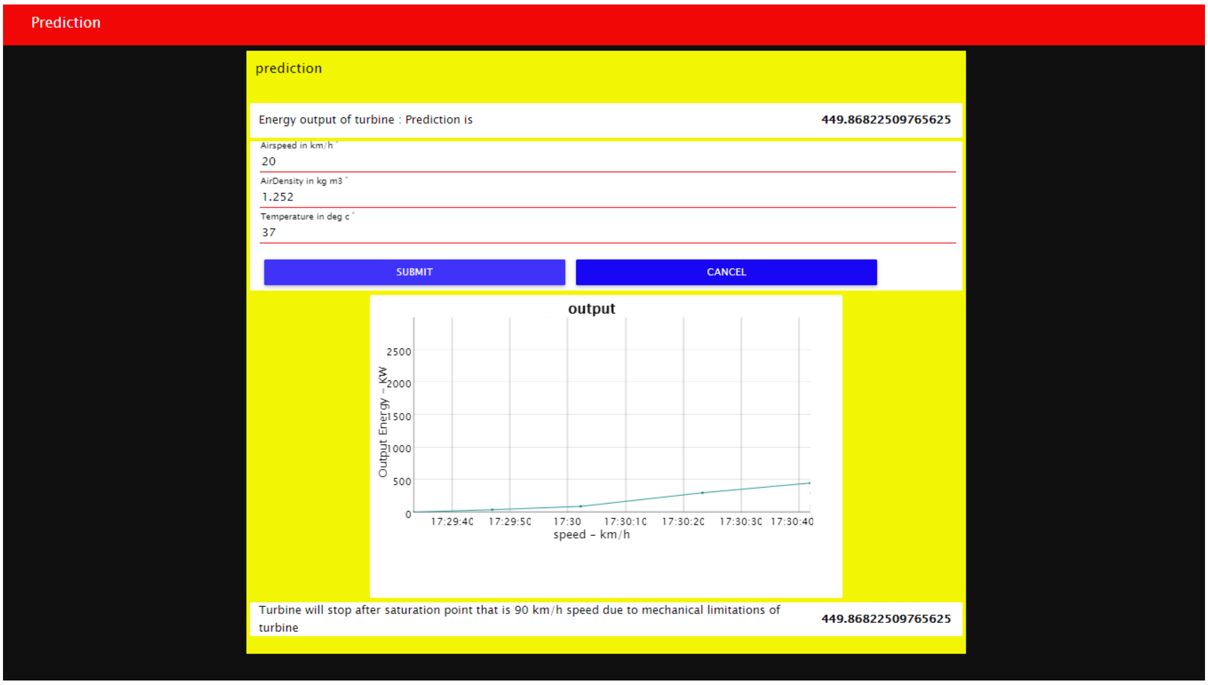
Airspeed in km/h *
10

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine **90.57209014892578**

- *At ' 20 km/h'*



Energy output of turbine : Prediction is **449.86822509765625**

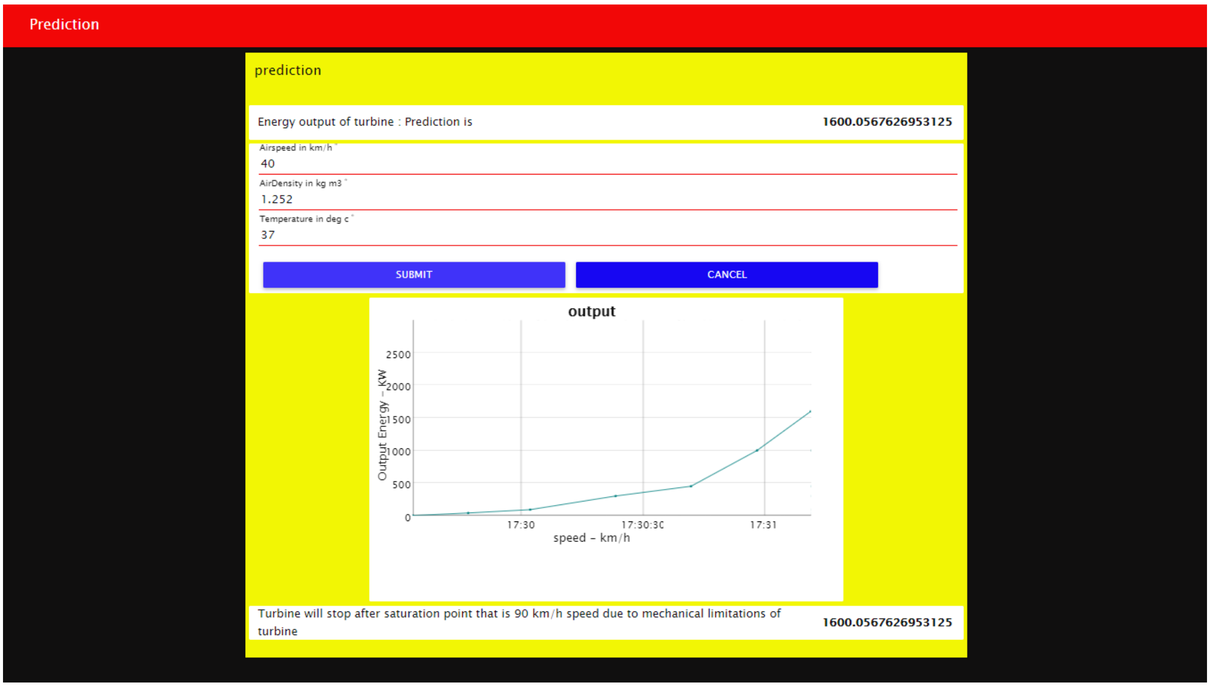
Airspeed in km/h *
20

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine **449.86822509765625**

- *At '40 km/h'*



Prediction

prediction

Energy output of turbine : Prediction is 1600.0567626953125

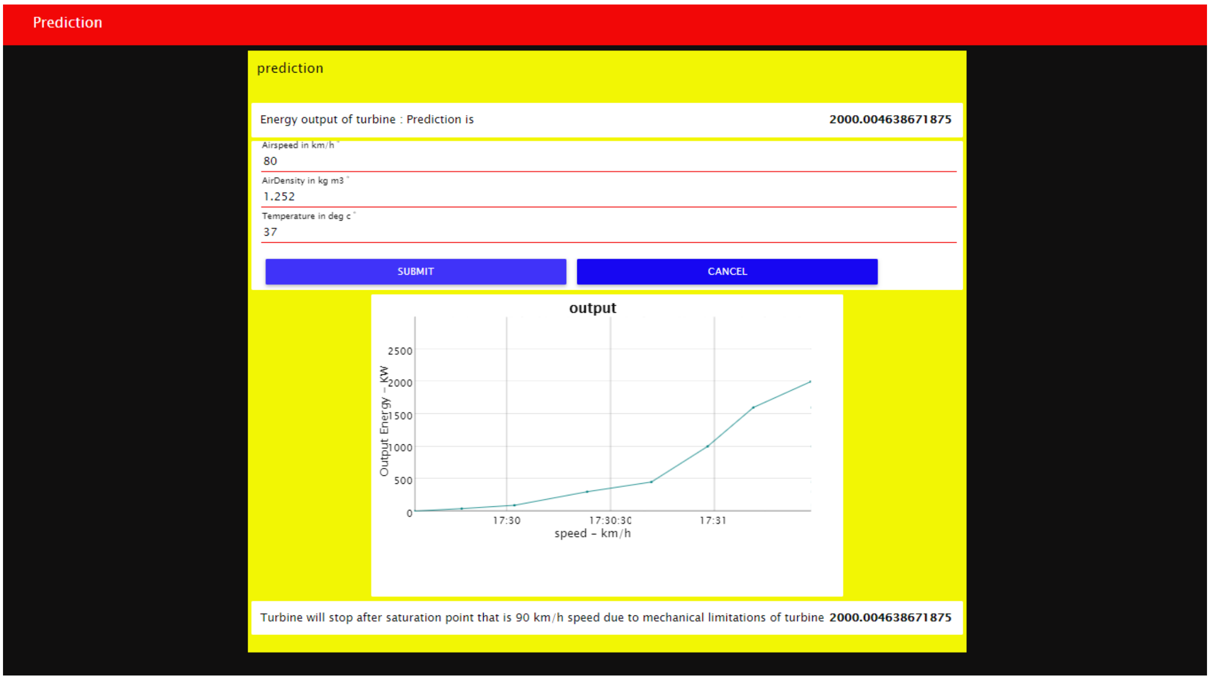
Airspeed in km/h *
40

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine 1600.0567626953125

- *At '80 km/h'*



Prediction

prediction

Energy output of turbine : Prediction is 2000.004638671875

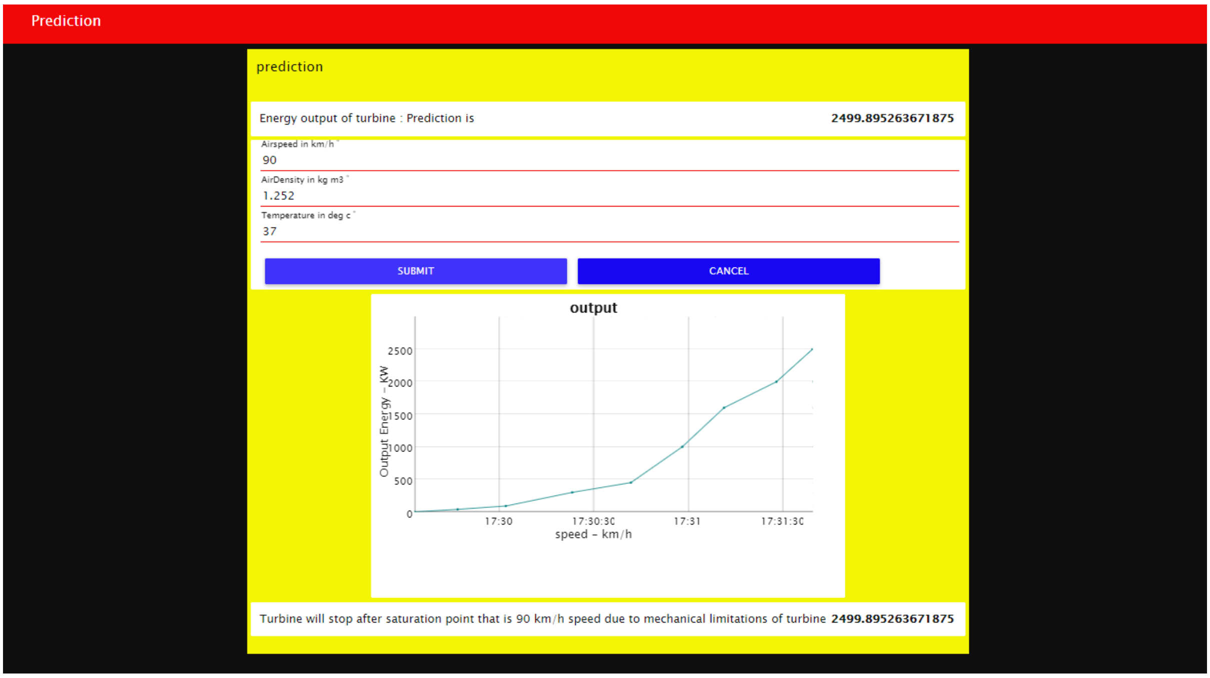
Airspeed in km/h *
80

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine 2000.004638671875

- *At Saturation Point '90 km/h'*



Prediction

prediction

Energy output of turbine : Prediction is 2499.895263671875

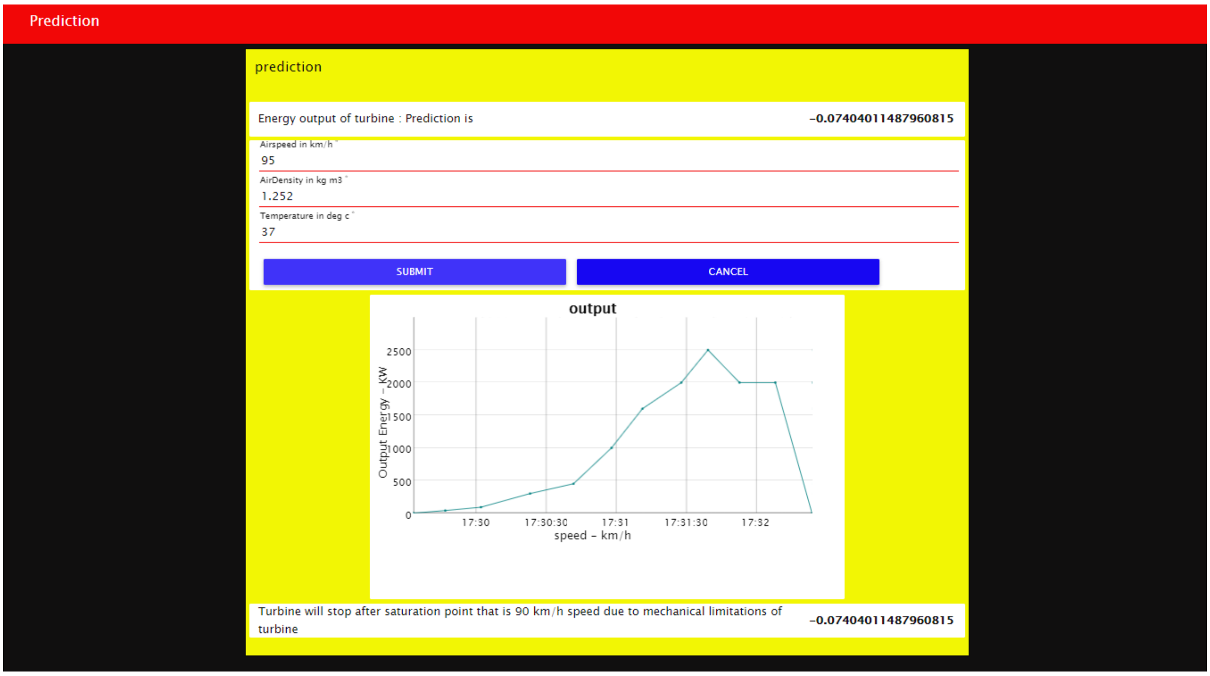
Airspeed in km/h *
90

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine **2499.895263671875**

- *As Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine*
- *After Saturation Point : At '95 km/h'*



Prediction

prediction

Energy output of turbine : Prediction is −0.07404011487960815

Airspeed in km/h *
95

AirDensity in kg m3 *
1.252

Temperature in deg c *
37

Turbine will stop after saturation point that is 90 km/h speed due to mechanical limitations of turbine −0.07404011487960815

ADVANTAGES & DISADVANTAGES :

Advantages:

- *By this Model we save more money such that it is cost-effective.*
- *Due to this model we can come to know where we can place this turbine to get more output energy.*
- *Our model has other advantage that, turbine will automatically switch-off when air speed reaches more than saturation point.*
- *Such that it will save a lot of money.*
- *As in real world we are predicting air speed for our satellite launchings we can find such data easily so we don't need to predict weather conditions and we can use them easily and we can predict our output of turbine easily.*

Disadvantages:

- *As it is not a dynamic ui we need to give the predicted values of Air speed, Air density, temperature. This disadvantage can become a advantage too , by linking live data to our ui*

APPLICATIONS:

- *It is more Applicable to Wind-Turbines and generators.*

CONCLUSION:

This Machine Learning - predicting model can predict the energy output of wind turbine based on weather condition mainly based on air speed.

FUTURE SCOPE :

- *This Model has great future scope because , in future we should depend more on* ***renewable energy sources in that one of the energy source is Wind Turbine, so we have more future scope due advantages of our model .***

BIBILOGRAPHY:

- *Node Red: (script is in github)*
- *Auto AI generated ML Best Pipeline : (IPYNB – file is in github)*
- *Data-set (.CSV - file is in github)*

Github Link:

https://github.com/SmartPracticeschool/SBSPS-Challenge-1205-Predicting-The-Energy-Output-Of-Wind-Turbine-Based-On-Weather-Condition

(remaining links and required documents are in github)

Thank You