CHAPTER 1

INTRODUCTION

Wind is used to produce electricity by converting the kinetic energy of air in motion into electricity. In modern wind turbines, wind rotates the rotor blades, which convert kinetic energy into rotational energy.

Wind speed/power has received increasing attention around the earth due to its renewable nature as well as environmental friendliness.

With the global installed wind power capacity rapidly increasing, the wind industry is growing into a large-scale business. Reliable short-term wind speed forecasts play a practical and crucial role in wind energy conversion systems, such as the dynamic control of wind turbines and power system scheduling.

A precise forecast needs to overcome problems of variable energy production caused by fluctuating weather conditions. Power generated by wind is highly dependent on the wind speed. Though it is highly non-linear, wind speed follows a certain pattern over a certain period of time. We exploit this time series pattern to gain useful information and use it for power prediction.

Extracting electricity from renewable resources has been widely investigated 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 challenge is to predict the wind power precisely in spite of the instabilities.To solve this problem, the prediction of wind energy over the climate change can be an effective way. With the prediction being around, the energy can be obtained at a stable level so that it can be distributed evenly in a precise manner.

The prediction can be done with the help of past data of the wind turbine which helps in the predicting the future output of the wind energy effectively. Here we use the past wind turbine energy data and then Machine learning algorithms to make the prediction clear.

The ability to predict the output of a wind turbine benefits all the end users. It provides economic benefits such as direct employment, land lease payments, local tax revenue.The data collected from the weather stations can be accessed in real time easily.

CHAPTER 2

LITERATURE SURVEY

S.NO	PAPER TITLE	AUTHORS	ADVANTAGES	REFERENCELINK
1.	Predicting the Energy Output of Wind Farms Based on Weather Data: Important Variables and their Correlation	Ekaterina (Katya) Vladislavleva, Tobias fedriech, Frank Neumann, Markus Wagner	wind energy output can be predicted from publicly available weather data with accuracy at best 80% R2on the training range and at best 85,5% on the unseen test data	https://www.researchgate.net/publication/229812149_Predicting_the_Energy_Output_of_Wind_Farms_Based_on_Weather_Data_Important_Variables_and_their_Correlation
2.	Current methods and advances in forecasting of wind power generation.	A. M. Foley, P. G. Leahy ,A.Marvuglia, and E. J. McKeogh.	Firstly, numerical wind prediction methods from global to local scales, ensemble forecasting, upscaling and downscaling processes are discussed. Then the techniques used for benchmarking and uncertainty analysis of forecasts are overviewed, and the performance of various approaches over different forecast time horizons is examined. Finally, current research activities, challenges and potential future developments are appraised.This paper presents an in-depth review of the current methods and advances in wind power	https://www.sciencedirect.com/science/article/abs/pii/S0960148111002850

			forecasting and prediction	
3.	Short-term prediction of wind farm power: A data mining approach	A. Kusiak, Zheng, and Z. Song.	This paper examines time series models for predicting the power of a wind farm at different time scales, i.e., 10-min and hour-long intervals. The time series models are built with data mining algorithms. Five different data mining algorithms have been tested on various wind farm datasets. Two of the five algorithms performed particularly well. The support vector machine regression algorithm provides accurate predictions of wind power and wind speed at 10-min intervals up to 1 h into the future, while the multilayer perceptron algorithm is accurate in predicting power over hour-long intervals up to 4 h ahead. Wind speed can be predicted fairly accurately based on its historical value	https://ieeexplore.ieee.org/document/4749292
4.	Analysis of wind energy time series with kernel methods and neural networks	O. Kramer and F. Gieseke.	This article shows how kernel methods and neural networks can serve as modeling, forecasting and monitoring techniques, and, how they contribute to a successful integration	https://ieeexplore.ieee.org/document/6022597

			of wind into smart energy grids. First, we will employ kernel density estimation for modeling of wind data. Kernel density estimation allows a statistically sound modeling of time series data. The orresponding experiments are based on real data of wind energy time series from the NREL western wind resource dataset. Second, we will show how prediction of wind energy can be accomplished with the help of support vector regression. Last, we will use self-organizing feature maps to map high dimensional wind time series to colored Sequences that can be used for error detection.	
5.	The prediction and diagnosis of wind turbine faults	Andrew Kusiak,Wenyan Li	The rapid expansion of wind farms has drawn attention to operations and maintenance issues. Condition monitoring solutions have been developed to detect and diagnose abnormalities of various wind turbine subsystems with the goal of reducing	https://www.sciencedirect.com/science/article/abs/pii/S0960148110002338?via%3Dihub

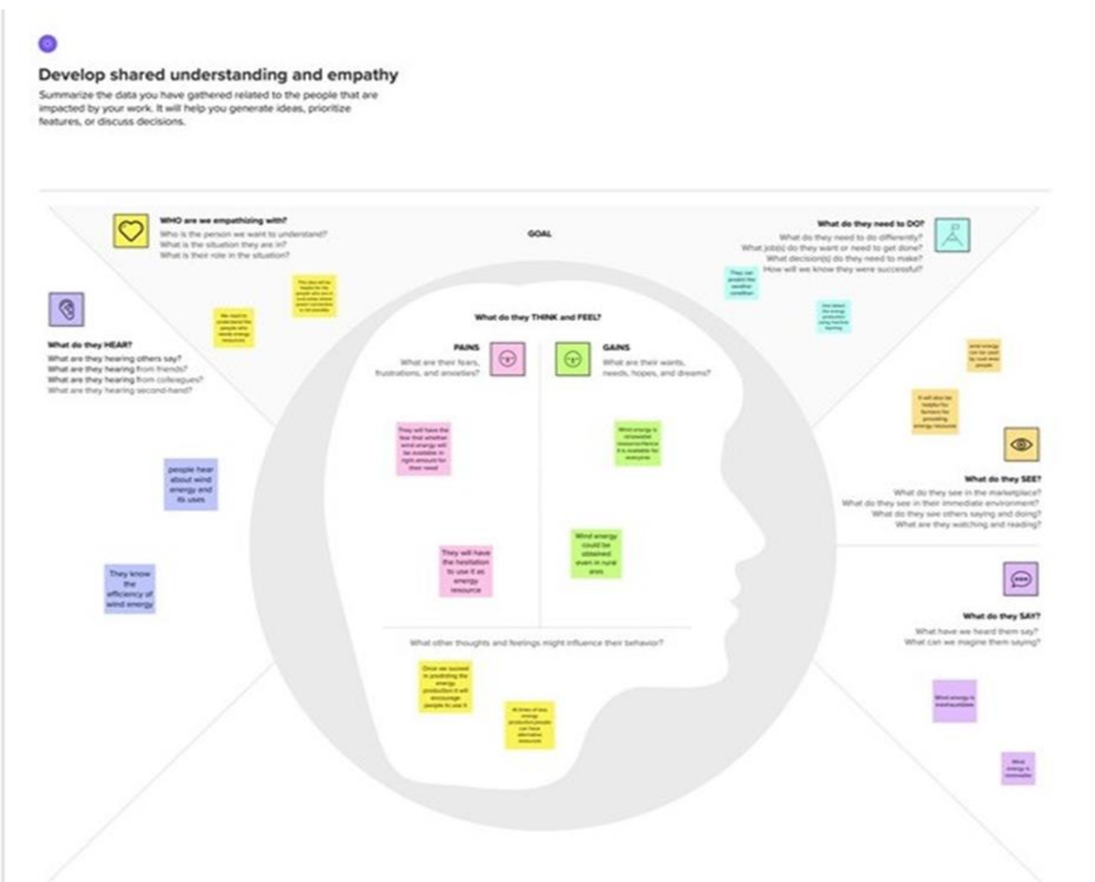
			operations and maintenance costs. This paper explores fault data provided by the supervisory control and data acquisition system and offers fault prediction at three levels: (1) fault and no-fault prediction; (2) fault category (severity); and (3) the specific fault prediction.	
6.	Predicting the Wind Turbine Power Generation based on Weather Conditions	S.Preethi,H.Prithika,M.Pramila, S.Birundha	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 Neural Network). It performs admirably in terms of capturing long-term dependencies along with the time steps and is hence ideal for wind power forecasting.	
7.	Machine learning ensembles for wind power prediction	Justin Heinnerman,Oliver Krammer	This paper propose the use of heterogeneous machine learning ensembles for wind power prediction.	https://www.sciencedirect.com/science/article/abs/pii/S0960148115304894?via%3Dihub

CHAPTER 3

3.1 EMPATHY MAP CANVAS:

An empathy map canvas is a more in-depth version of the original empathy map, which helps identify and describe the user's needs and pain points. And this is valuable information for improving the user experience.

An empathy map canvas helps brands provide a better experience for users by helping teams understand the perspectives and mindset of their customers. Using a template to create an empathy map canvas reduces the preparation time and standardizes the process so you create empathy map canvases of similar quality.

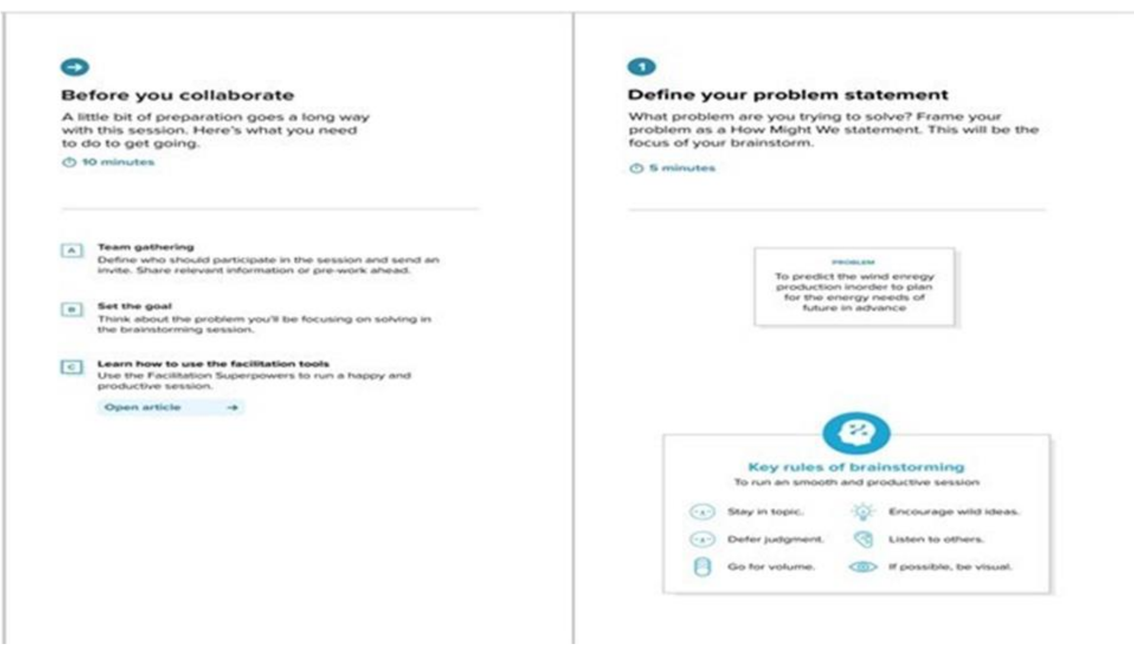


3.2 IDEATION & BRAINSTORMING

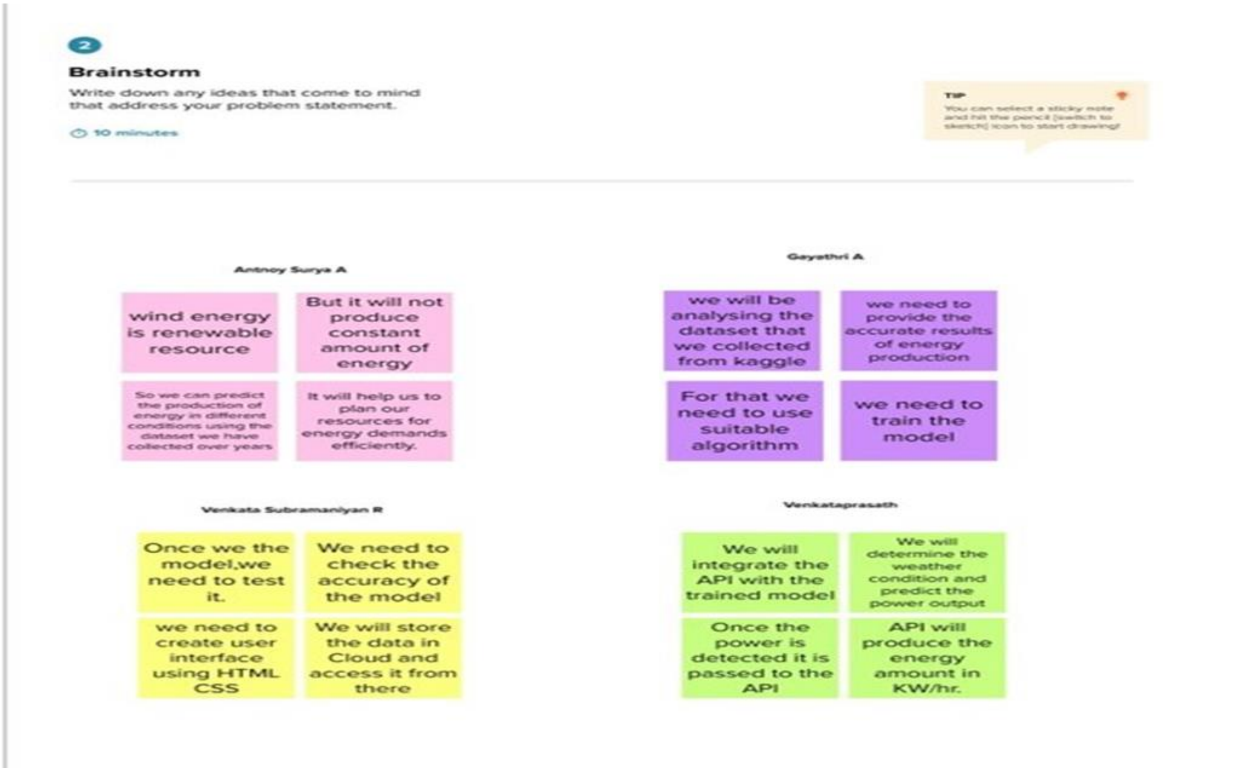
Ideation may present itself in any one of a wide variety of ways and arenas. The book "Ideation: The Birth and Death of Ideas," written by Douglas Graham and Thomas Bachmann, lists several different forms that ideation may take, including the following:

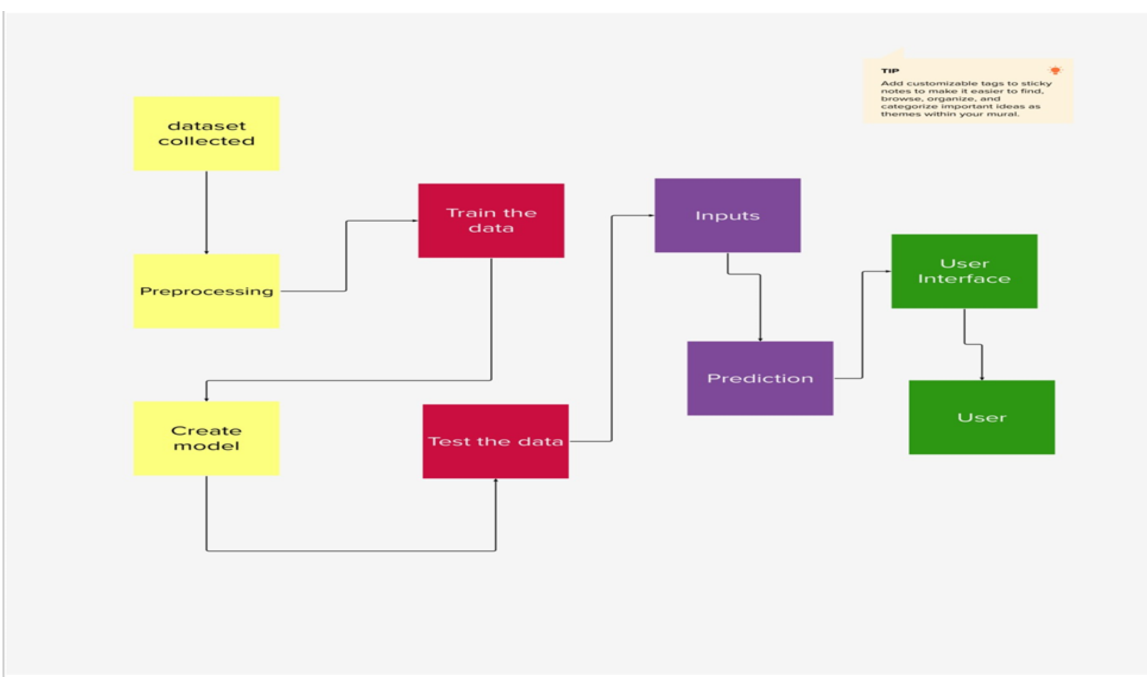
- **Solving Problems** – Ideation is often specifically aimed at problem-solving. For example, production managers at a company may be charged with coming up with ideas on how to reduce production costs.
- **Derivative Ideation** – Derivative ideation refers to building on an existing idea, such as developing complementary products or accessories to sell along with a company's main product.
- **Innovation** – An example of innovation ideation is the process of a pharmaceutical company developing new medicines. Such a type of ideation often involves doing extensive research and experimentation as part of the ideation process.
- **Development of a "Revolutionary Idea"** – Ideation sometimes ends up creating a totally new line of thought or set of ideas, such as the development of a new philosophy.
- **Serendipitous Ideation** – Serendipitous ideation refers to situations where someone just happens to come up with a new idea even though they weren't consciously trying to do so.
- **Combination Ideation** – Ideation often includes combining multiple ideas to create a new process or way of doing something.

Step-1: Team Gathering, Collaboration and Select the Problem Statement

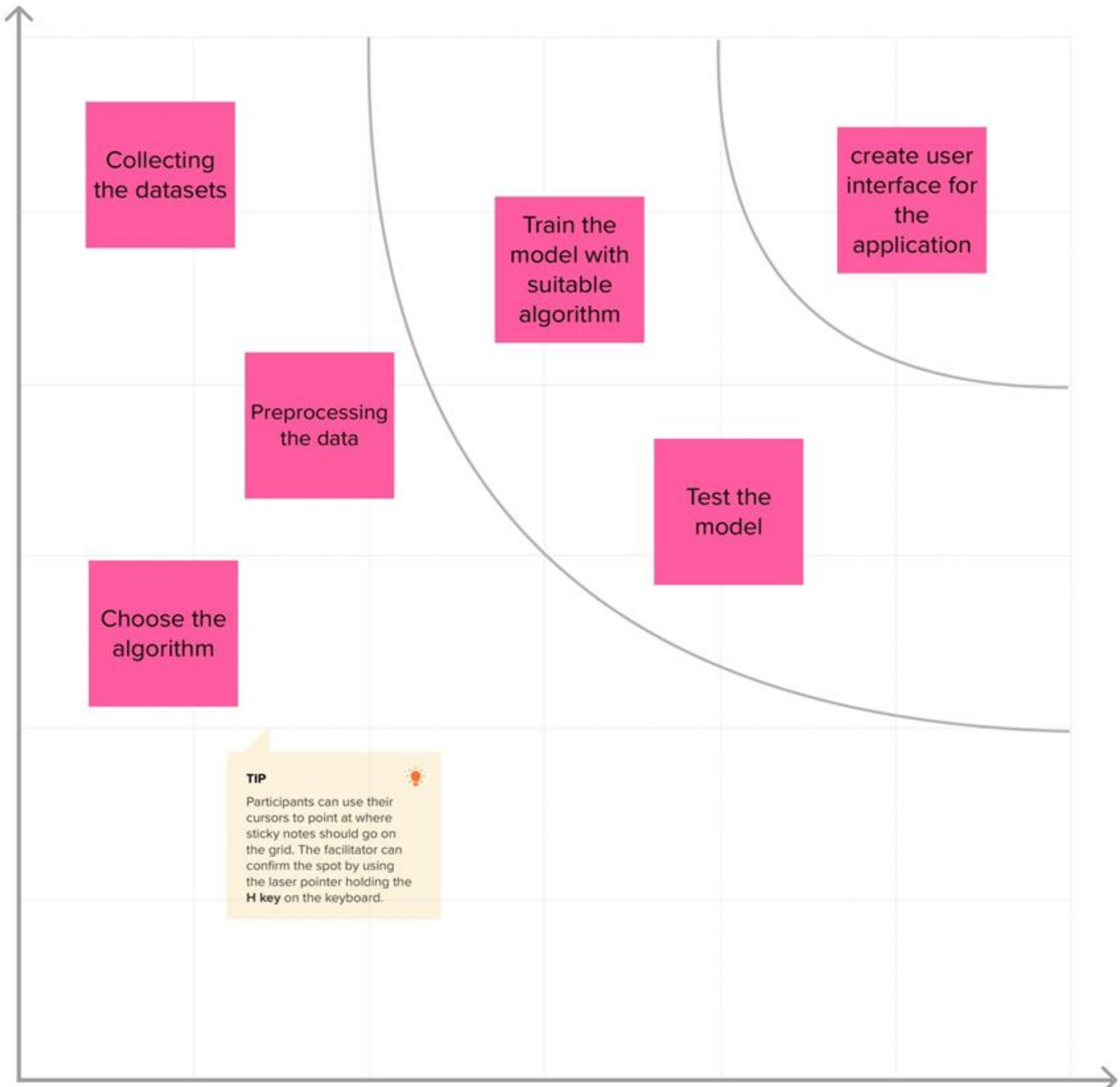


Step-2: Brainstorm, Idea Listing and Grouping





Step-3: Idea Prioritization



3.3 PROPOSED SOLUTION

CHAPTER 4

REQUIREMENT ANALYSIS

Functional Requirements:

Functional requirements are product features or functions that developers must implement to enable users to accomplish their tasks. So, it's important to make them clear both for the development team and the stakeholders. Generally, functional requirements describe system behaviour under specific conditions.

The system sends an approval request after the user enters personal information. A search feature allows a user to hunt among various invoices if they want to credit an issued invoice. The system sends a confirmation email when a new user account is created.

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration (For App and webpage)	Registration through E-Mail or Mobile number.
FR-2	User Confirmation	Confirmation message sent to registered E-Mail id or mobile number.
FR-3	Essential details	o City name o Wind speed o Wind direction o Temperature o Humidity
FR-4	Output	Wind Energy will be shown in KW/hr

Non-functional Requirements:

These are basically the quality constraints that the system must satisfy according to the project contract. The priority or extent to which these factors are implemented varies from one project to other. They are also called non-behavioral requirements.

They basically deal with issues like:

- Portability
- Security
- Maintainability
- Reliability
- Scalability
- Performance
- Reusability
- Flexibility

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	o User-friendly. o Need not any special knowledge.
NFR-2	**Security**	o Data provided by the user will be protected from the unauthorized access. o Datas are secured in cloud.
NFR-3	**Reliability**	o Weather Information are up to date because it uses weather API for weather prediction. o It will provide the consistency in output.
NFR-4	**Performance**	o Website activity is quite faster and reliable. o Output values are so accurate.
NFR-5	**Availability**	o Supports most of the device configurations. o Anyone can access the website with proper internet connection.
NFR-6	**Scalability**	o Often improving in technology and generating large amount of data, the website features also changes over a period.

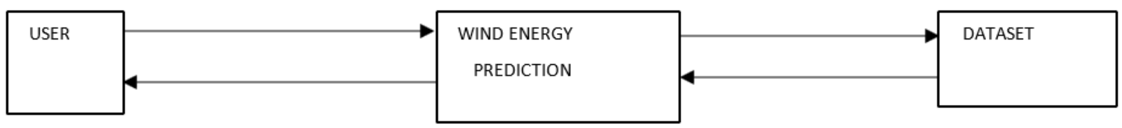
CHAPTER 5

PROJECT DESIGN

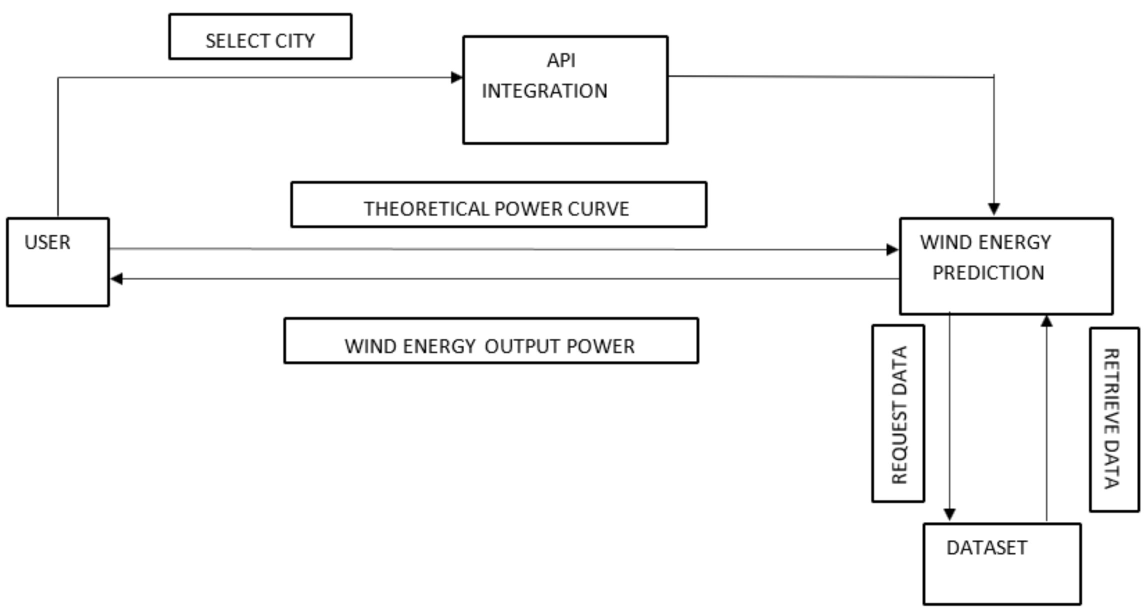
5.1 DATA FLOW DIAGRAM

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.

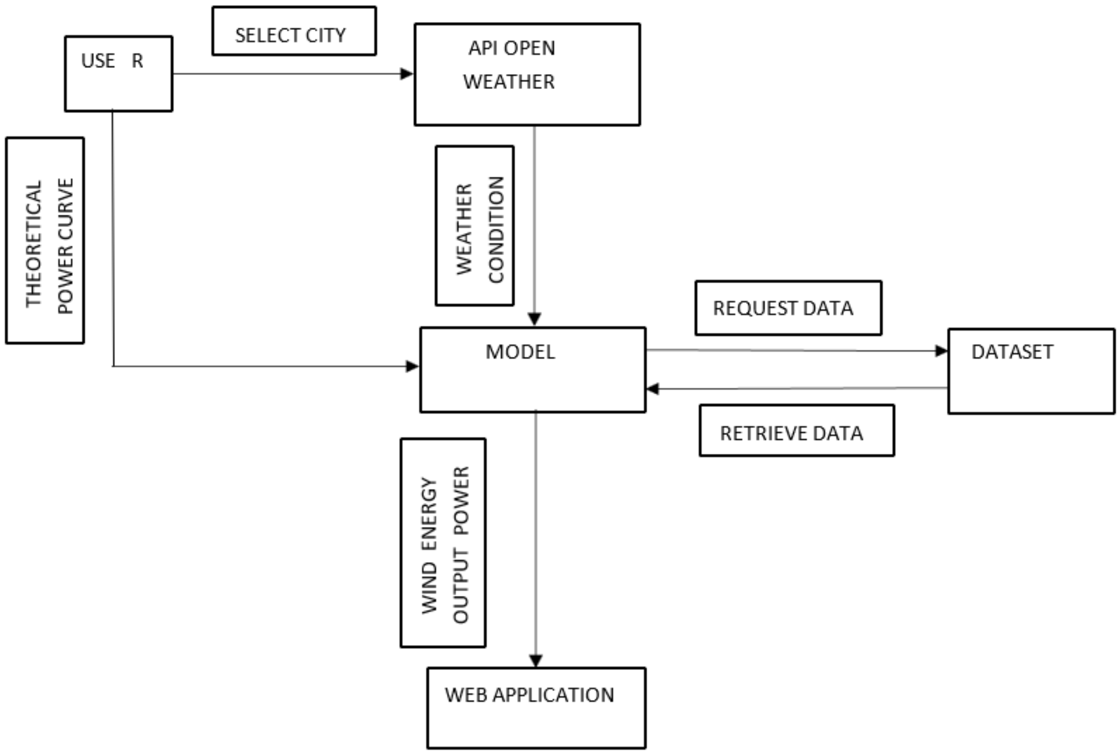
LEVEL 1:



LEVEL 2:



LEVEL 3:


USE R
SELECT CITY
API OPEN WEATHER
THEORETICAL POWER CURVE
WEATHER CONDITION
REQUEST DATA
MODEL
DATASET
RETRIEVE DATA
WIND ENERGY OUTPUT POWER
WEB APPLICATION

User Stories

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

User Type	Functional Requirement (Epic)	UserStory 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 confirming my password.	I can access my account / dashboard	High	Sprint-1
	Login	USN-2	As a user, I can login to the application by entering email & password	I can access my account/dashboard	High	Sprint-1
	Dashboard	USN-3	As a user, I can see all the details raised by me	I can get the information needed in the dashboard	Low	Sprint-2

	Address column	USN-4	As a user, I can enter the address based on my query	I can get the weather report based on my address	High	Sprint-2
	Forgot password	USN-5	As a user, I can able to reset my password	I can access my account again	Medium	Sprint-2
	Output	USN-6	As a user, I can get my weather report	I can generate the wind energy after submitting the necessary details	High	Sprint-2
Customer (Web user)	Login	USN-1	As a user, I can login to the application by entering email & password	I can access my account/dashboard	High	Sprint-2
	Dashboard	USN-2	As a user, I can see all the details raised by me	I can get the information needed in the dashboard	Low	Sprint-3

	Address column	USN-3	As a user, I can enter the address based on my query	I can get the weather report based on my address	High	Sprint-3
	Forgot password	USN-4	As a user, I can able to reset my password	I can access my account again	Medium	Sprint-3
	Output	USN-5	As a user, I can get my weather report	I can generate the wind energy after submitting the necessary details	High	Sprint-3
Customer Care Executive	Login	USN-1	As an admin, I can see the queries raised by user	I can resolve the issues raised by the user	Medium	Sprint-4
Administrator	Login	USN-1	As an administrator, I can login to the application by using the admin login	I can access my account/dashboard	High	Sprint-1

	Dashboard	USN-2	As an admin I can see all the orders raised in the entire system and lot more	I can assign agents by seeing those order.	High	Sprint-1
	Agent creation	USN-3	As an admin I can create an agent for clarifying the customers queries	I can create agents.	High	Sprint-2
	Assignment agent	USN-4	As an admin I can assign an agent for each order created by the customer.	Enable agent to clarify the queries.	High	Sprint-1

CHAPTER 6

PROJECT PLANNING & SCHEDULING

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.	2	High	Antony Surya, Gayathri, Venkataprasath, Venkata Subramaniyan
Sprint-1	Data collection and pre-processing	USN-2	Need to collect dataset for analysing and need to pre-process the data	1	High	Antony Surya, Gayathri, Venkataprasath, Venkata Subramaniyan
Sprint-2	Model Building	USN-3	We need to train the dataset and build model	2	High	Antony Surya, Gayathri, Venkataprasath, Venkata Subramaniyan
Sprint-3	Application Building	USN-4	We need to create a flask app with user interface built using HTML page	2	Medium	Antony Surya, Gayathri, Venkataprasath, Venkata Subramaniyan

Sprint-4	Train the Model on IBM Cloud	USN-5	We need to train the model on IBM Cloud.At the end we should have a application that is able to predict the wind energy if we specify a city	1	High	Antony Surya,Gayathri ,Venkataprasath,Venkata Subramaniyan

Project Tracker, Velocity & Burndown Chart:

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**	**31 Oct 2022**	**20**	**29 Oct 2022**
Sprint-2	**20**	**6 Days**	**01 Nov 2022**	**09Nov 2022**	**20**	**09 Nov 2022**
Sprint-3	**20**	**6 Days**	**10Nov 2022**	**13 Nov 2022**	**20**	**13 Nov 2022**
Sprint-4	**20**	**6 Days**	**14 Nov 2022**	**19 Nov 2022**	**20**	**19 Nov 2022**

CHAPTER 7

CODING & SOLUTIONING

The source code is uploaded in the Github Sprint wise folders.

- **GitHubLink:https://github.com/IBM-EPBL/IBM-Project-30029-1660138607/tree/main/Project%20Development%20Phase**
- **Demo Link: https://www.youtube.com/watch?v=4sTQNiHPSo4**

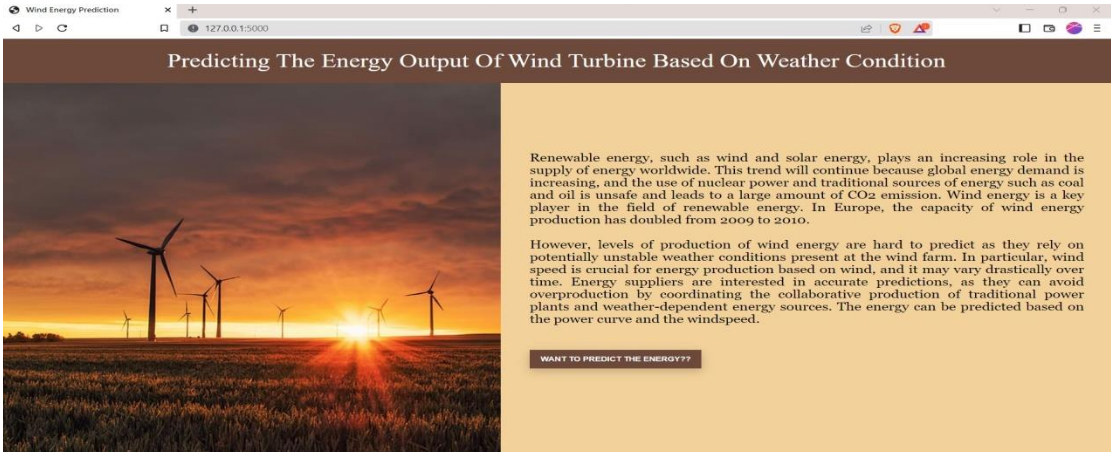
CHAPTER 8

TESTING

```
 * Serving Flask app 'app'
 * Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
 * Running on http://127.0.0.1:5000
Press CTRL+C to quit
127.0.0.1 - - [17/Nov/2022 22:00:35] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [17/Nov/2022 22:00:37] "GET /predict HTTP/1.1" 200 -
127.0.0.1 - - [17/Nov/2022 22:00:37] "GET /static/css/main.css HTTP/1.1" 404 -
127.0.0.1 - - [17/Nov/2022 22:00:37] "GET /static/css/media.css HTTP/1.1" 404 -
127.0.0.1 - - [17/Nov/2022 22:00:37] "GET /static/css/items_grid.css HTTP/1.1" 404 -
C:\Users\HP\anaconda3\envs\IBM\lib\site-packages\sklearn\base.py:450: UserWarning: X does not have valid feature names, but RandomForestRegressor was fitted with feature names
  warnings.warn(
[1739.4724141]
127.0.0.1 - - [17/Nov/2022 22:00:41] "POST /y_predict HTTP/1.1" 200 -
127.0.0.1 - - [17/Nov/2022 22:00:41] "GET /static/css/main.css HTTP/1.1" 404 -
127.0.0.1 - - [17/Nov/2022 22:00:41] "GET /static/css/media.css HTTP/1.1" 404 -
127.0.0.1 - - [17/Nov/2022 22:00:41] "GET /static/css/items_grid.css HTTP/1.1" 404 -
C:\Users\HP\anaconda3\envs\IBM\lib\site-packages\sklearn\base.py:450: UserWarning: X does not have valid feature names, but RandomForestRegressor was fitted with feature names
  warnings.warn(
```

CHAPTER 9

RESULTS



CHAPTER 10

ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

Ø Generating energy from the wind does not release any carbon emissions.

Ø Wind energy lead to an overall reduction in carbon emissions.

Ø The energy used for manufacturing and installing wind turbines can also be paid back relatively quickly.

Ø It does not release any pollution or produce any waste during operation.

Ø It is renewable and clean source of energy.

Ø Efficient use of land space.

Ø Wind energy is a job creator.

Ø It does not result in any acid rains.

DISADVANTAGES:

Ø For the best wind source, turbines needs to be higher than the nearest surrounding structures.

Ø Noise from wind turbines could be a concern for some rural locations.

Ø While siting and designing for wind turbines, it can interfere with radar and aircraft navigation systems.

Ø The electromagnetic radiation from wind turbines have been shown to be weak and do not present a health risk to local communities.

Ø If wind turbines are inappropriately located, it could have an impace on birds through collision, disturbance and habitat damage.

Ø Wind turbines are harmful to bats, in a similar way to bird populations.

Ø Wind turbines are able to design only on remote areas.

CHAPTER 11

CONCLUSION

By doing the above project, we successfully created an interactive energy prediction dashboard using Watson studio, Watson Machine Learning and Weather Data. The experimental investigations showed the integration of different IBM cloud services. The results show that the responses from the Application were relevant and helpful. Although, the Web- Application demands complex integration of services it can be deployed easily to leverage the energy prediction and improve the energy production, effectively. In conclusion, this project helps in determining the wind energy production with change in weather condition. So that we can plan the energy resources accordingly.

CHAPTER 12

FUTURE SCOPE

For future research can be guided to improve relevant results and response time. Simplification of integration of services can be achieved by normalizing the architecture. Also,a user feedback system can be incorporated to render the user queries and needs, but still we have given contact us portion for that part.