A study on price predictions for EV Charging Station

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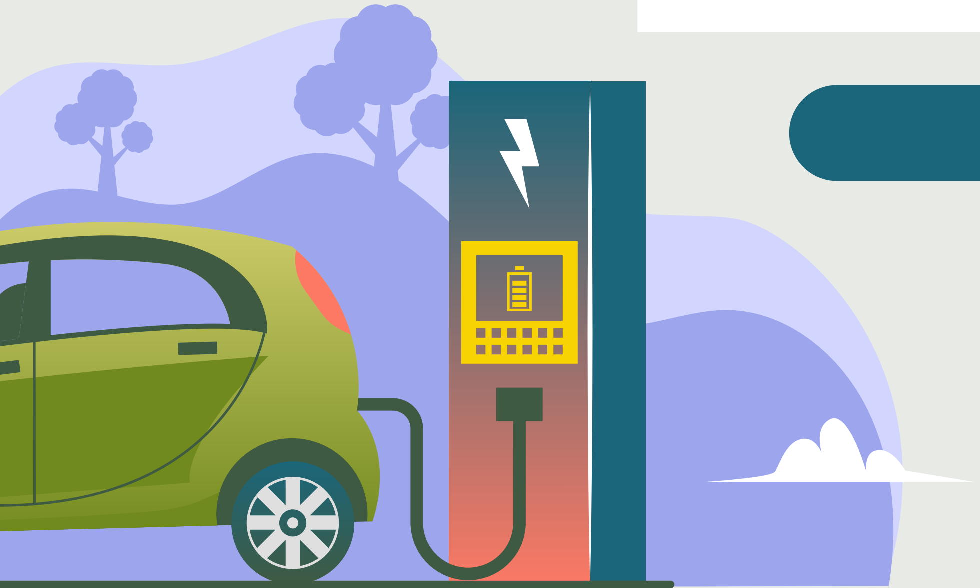
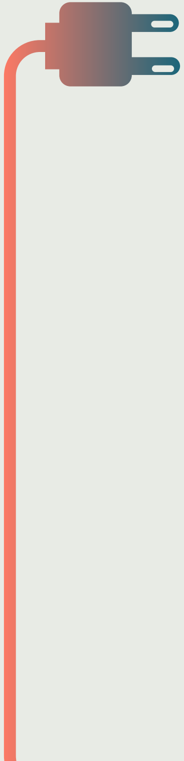
01

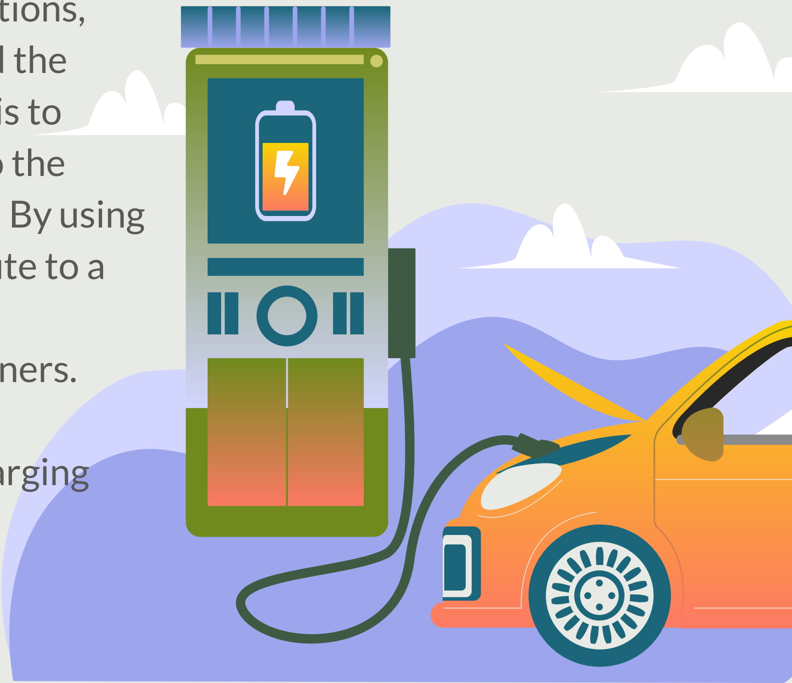
Introduction



Introduction



This presentation focuses on the evaluation of solar-powered EV charging stations and a charging calculator, which aims to estimate the cost of charging EVs using solar energy. This report analyzes the usage patterns of the charging stations, the reliability of the solar-powered energy source, and the accuracy of the charging calculator. The ultimate goal is to promote the adoption of EVs by addressing barriers to the deployment of solar-powered charging infrastructure. By using solar energy to power EVs, the report aims to contribute to a sustainable transportation system by reducing carbon emissions and lowering the cost of charging for EV owners. The report provides recommendations for addressing challenges in the deployment of solar-powered EV charging infrastructure.



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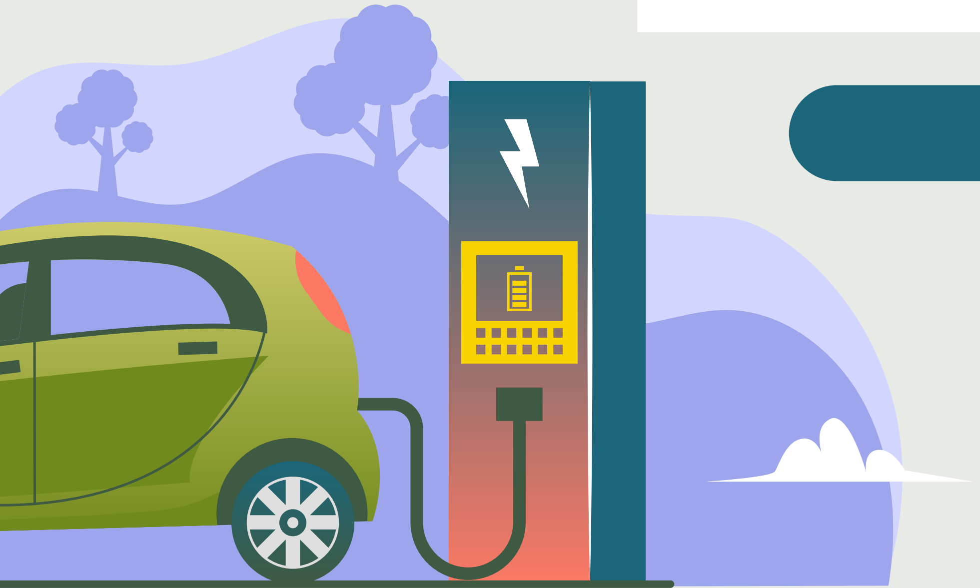
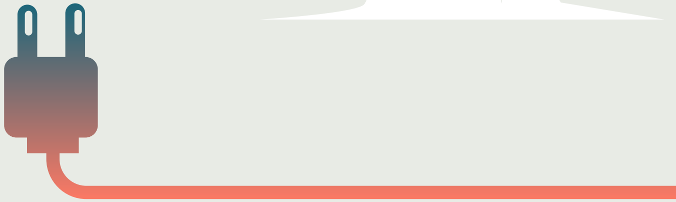
LITERATURE REVIEW





LITERATURE REVIEW

- Electric vehicles (EVs) are gaining popularity as a low-carbon alternative to traditional gasoline-powered vehicles, which is increasing the demand for reliable and accessible EV charging infrastructure.
- One promising approach to developing sustainable and cost-effective EV charging solutions is to use renewable energy sources such as solar power to power EV charging stations, which has several advantages over traditional grid-powered stations.
- In addition to solar power, other renewable energy sources, such as wind power and geothermal energy, have also been explored as potential energy sources for EV charging stations.

- Another study by Zhang and others in the year 2020 evaluated the economic feasibility of solar powered EV charging stations in the United States. The authors found that solar-powered charging stations could achieve cost savings of up to 40% compared to grid-powered stations, depending on the size and location of the station
- Overall, these studies suggest that renewable energy sources, such as solar and wind power, have the potential to provide sustainable and cost-effective energy for EV charging stations.

TYPES OF MODELS USED

Linear Regression

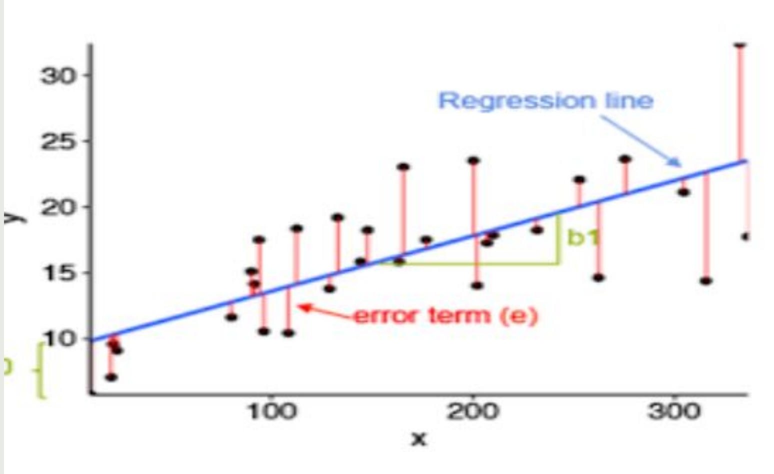
Support Vector Machine

Decision Tree

Neural Network

LINEAR REGRESSION

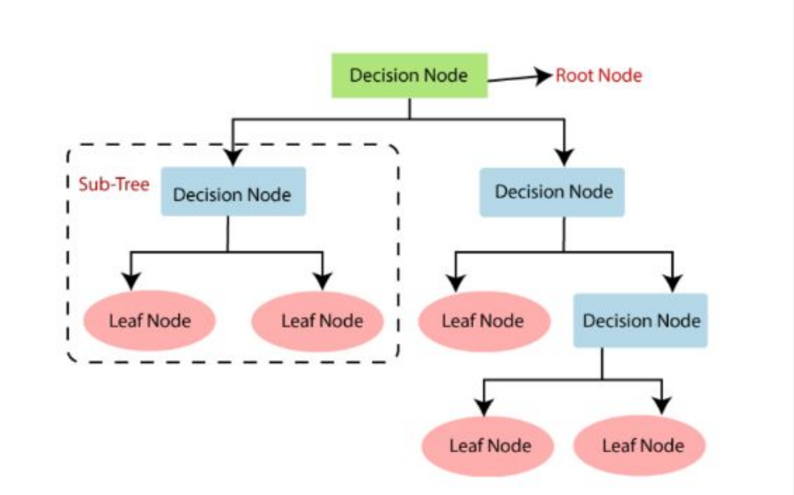
- Linear regression is a statistical method used to analyze the relationship between two or more variables. The linear regression model is a linear approach to modeling the relationship between a dependent variable and one or more independent variables.
- In a simple linear regression model, there is only one independent variable that is used to predict the dependent variable. The relationship between the two variables is modeled as a straight line, where the slope of the line represents the relationship between the two variables.



- The goal of linear regression is to find the best fitting line that describes the relationship between the variables. This is done by minimizing the sum of the squared differences between the observed values and the predicted values.

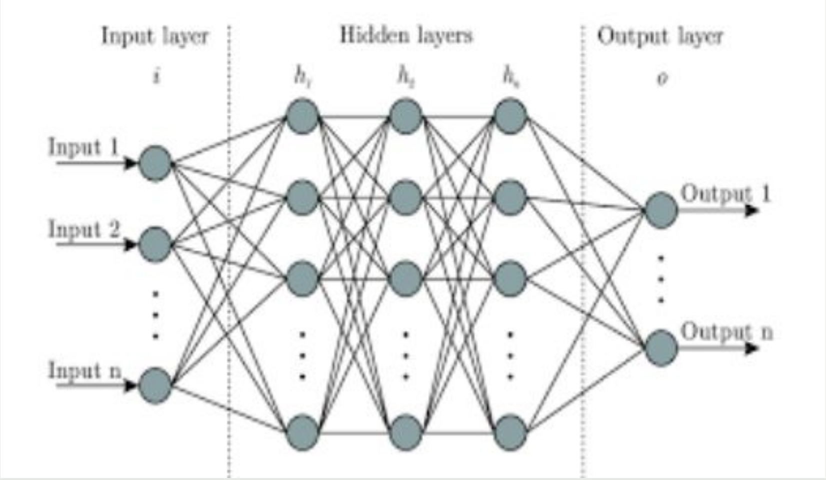
Decision Tree Model

- A decision tree is a graphical representation of a decision-making process, which is commonly used in machine learning and decision analysis. It consists of nodes and branches that represent decisions, actions, or events in a sequential order.
- The nodes in a decision tree represent the decision points, where a decision is made based on the available options or criteria. The branches represent the possible outcomes of each decision or action. The final outcomes are represented by the terminal nodes, also called leaves.
- Decision trees can be used for both classification and regression tasks in machine learning. In a classification task, the decision tree is used to classify a set of data into different classes based on a set of attributes. In a regression task, the decision tree is used to predict a numerical value based on a set of input attributes.



Neural Network

- Neural networks, also known as artificial neural networks (ANNs), are a type of machine learning model that are inspired by the structure and function of the human brain. Neural networks consist of interconnected nodes, called neurons, that are organized into layers. 3.2.
- The input layer of a neural network receives the input data, and the output layer produces the output.



- Between the input and output layers, there can be one or more hidden layers that perform computations on the input data. Each neuron in a neural network receives input from other neurons, performs a computation, and passes its output to other neurons.
- The connections between neurons in a neural network are weighted, and these weights are adjusted during the training process to optimize the performance of the network.
- The training process typically involves providing the network with a set of input-output pairs and adjusting the weights to minimize the error between the network's output and the desired output.

Support Vector Machine

- A support vector machine (SVM) is a machine learning model used for classification and regression analysis. The SVM algorithm works by finding the optimal boundary (or hyperplane) that separates the input data into different classes.
- In a binary classification problem, the SVM tries to find a hyperplane that maximizes the margin between the two classes. The margin is the distance between the hyperplane and the closest data points from each class. The SVM algorithm finds the hyperplane that maximizes this margin, which helps to reduce overfitting and improve generalization.

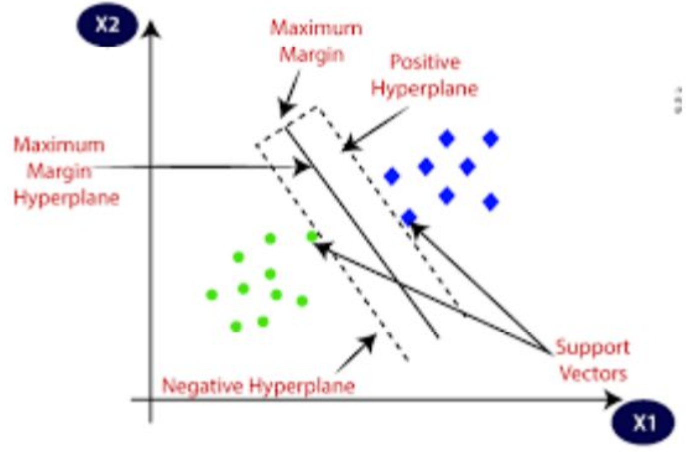


Figure 4 Support Vector Machine

Support Vector Machine

- If the input data is not linearly separable, the SVM can use a technique called kernelization to transform the input data into a higher-dimensional feature space, where the classes are separable. The kernel function maps the input data into this higher-dimensional feature space, and the SVM finds the hyperplane that separates the classes in this space.
- SVMs can also be used for regression analysis, where the goal is to predict a continuous value instead of a discrete class. In this case, the SVM finds a hyperplane that best fits the input data, minimizing the sum of the distances between the hyperplane and the data points.
- SVMs have been successfully applied in many areas, including image recognition, text classification, and bioinformatics. They are a powerful tool for machine learning and are widely used in research and industry

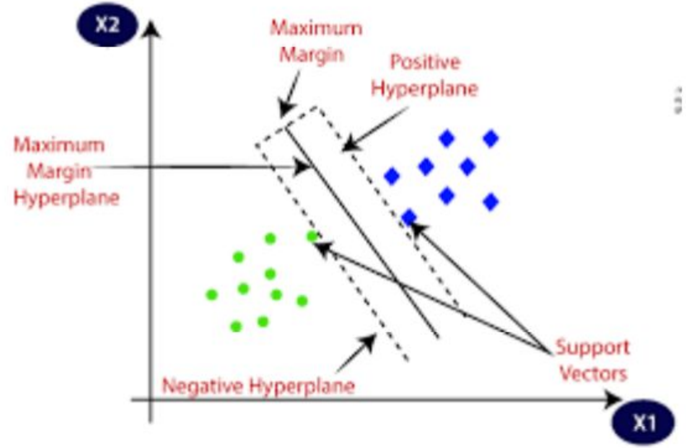


Figure 4 Support Vector Machine

Methodology

01
Solar Irradiance Data

02
Radiation vs Cost Data

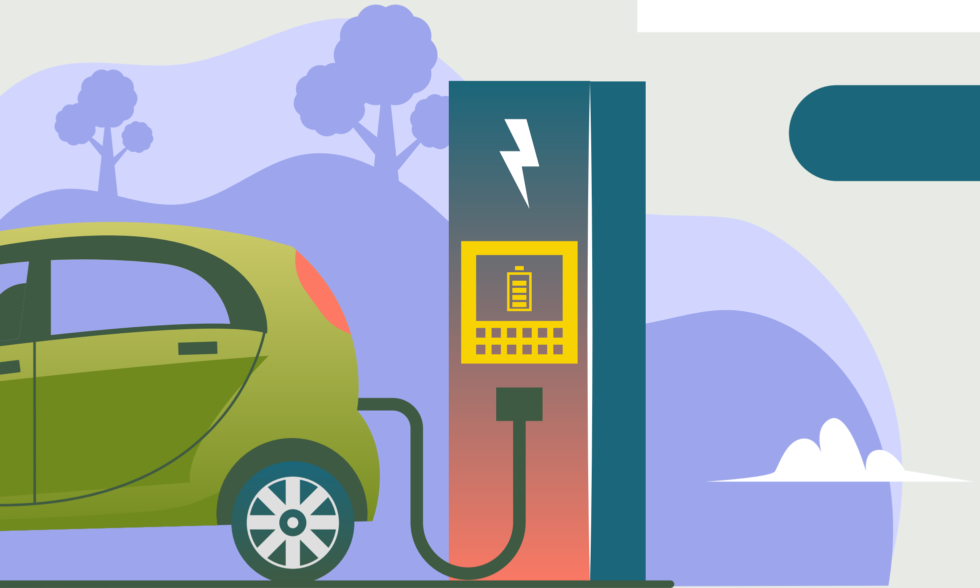
03
Grid power cost data

04
Solar vs grid power data

05
Integrated Dataset

04

ANALYSIS



Analysis

We used four dataset -

1. Solar irradiance data
2. Radiation vs cost data
3. Grid power cost data
4. Solar Vs Grid Power data

Using these four datasets we trained four models and compared their accuracy. Next, We integrated all the best performing models from all four dataset and created an integrated model for EV charging price prediction for the users.

DATASET 1: SOLAR IRRADIANCE DATA

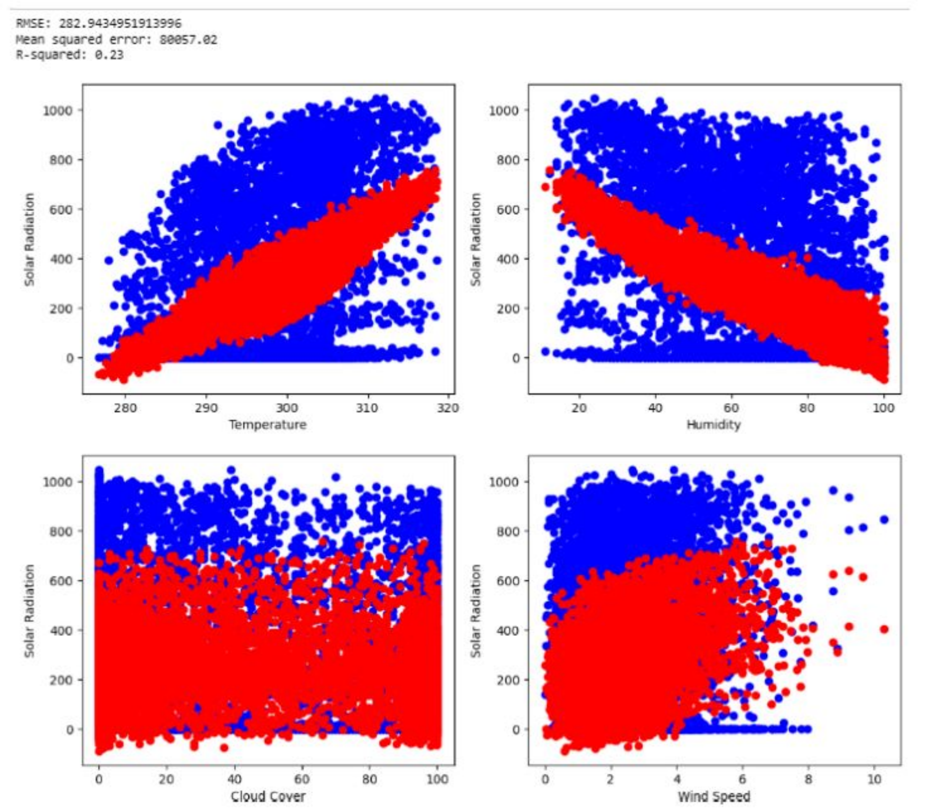
In this dataset, we are predicting the solar radiations per unit area depending on the weather conditions at that point of time.

Input -
Temperature, Humidity, Cloud Cover and Wind Speed

Output -
Solar Radiations per unit area

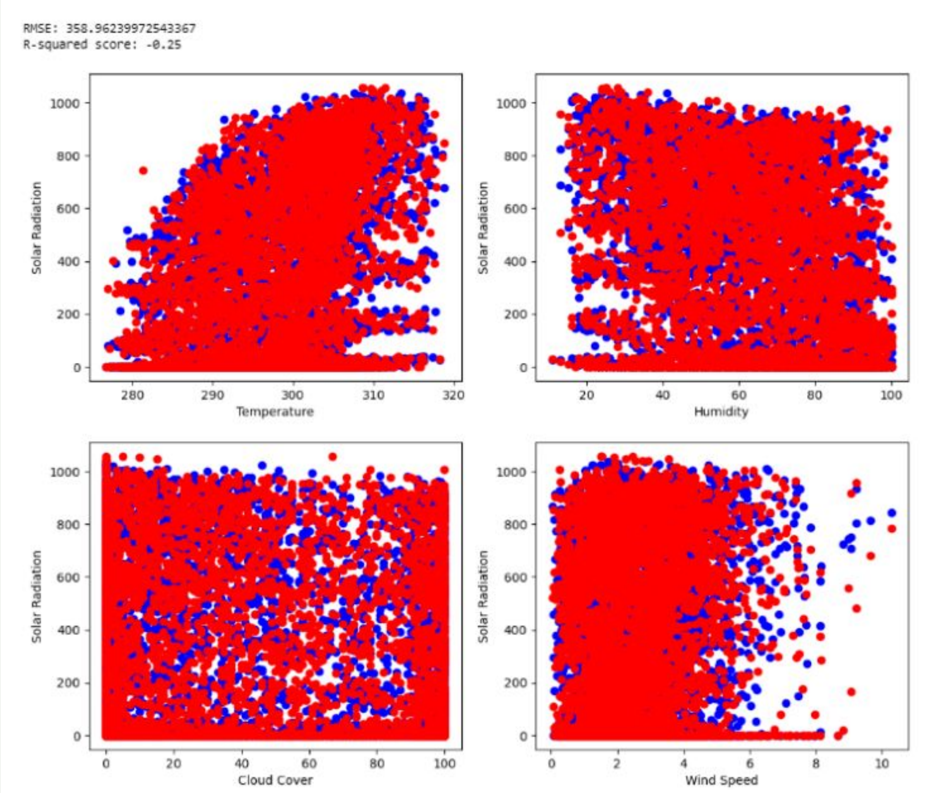
DATASET 1: SOLAR IRRADIANCE DATA

MODEL 1: Linear Regression



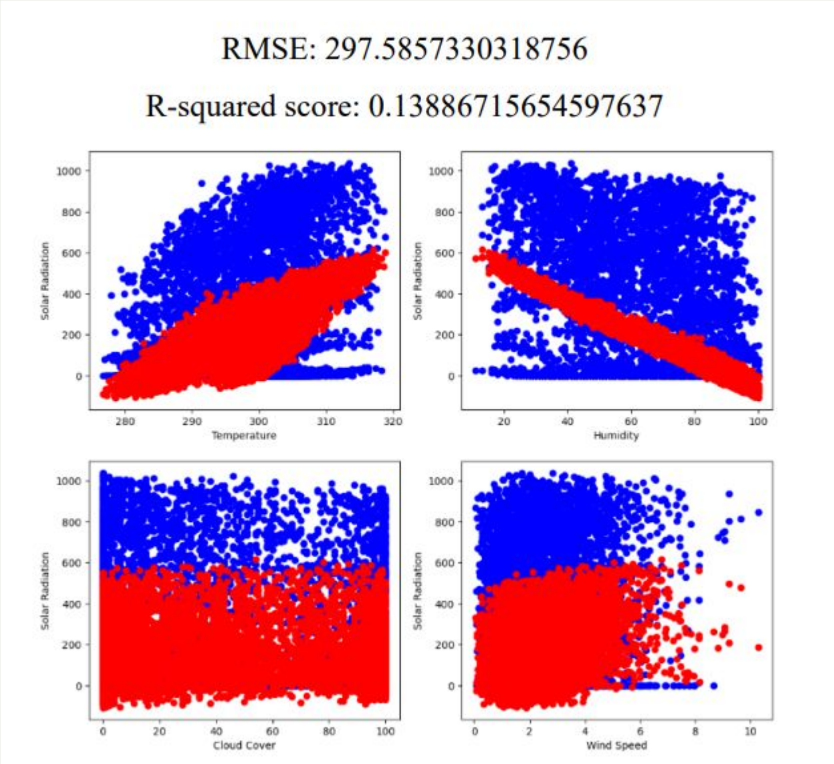
DATASET 1: SOLAR IRRADIANCE DATA

MODEL 2: Decision Tree



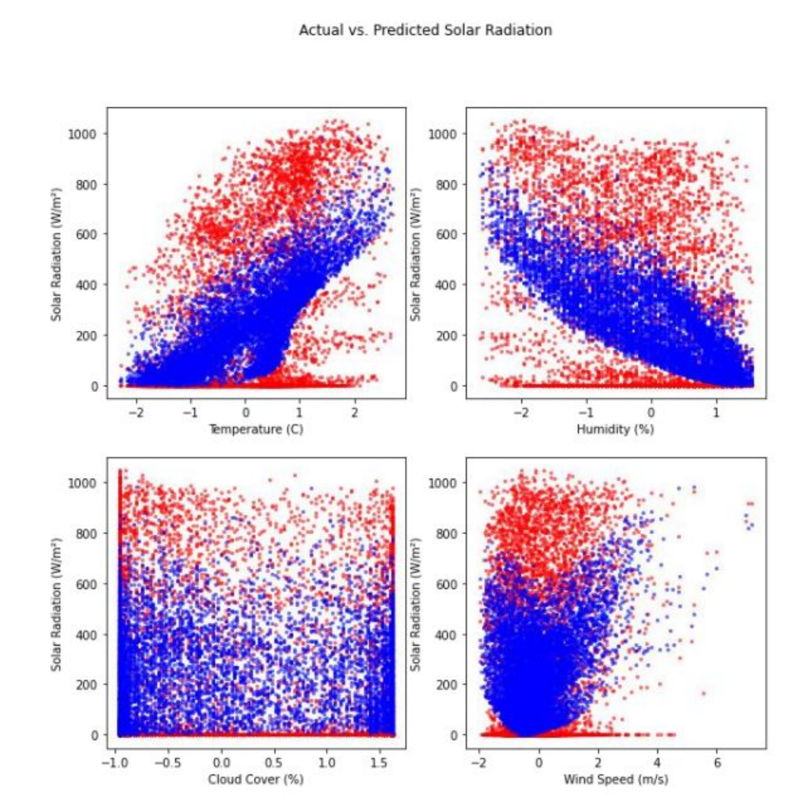
DATASET 1: SOLAR IRRADIANCE DATA

MODEL 3: SVM



DATASET 1: SOLAR IRRADIANCE DATA

MODEL 4: Neural Network



Output Results

INPUT: ['temp', 'humidity', 'cloud_cover', 'wind_speed'] = [279.46,91,30.0,3.07]

ACTUAL OUTPUT: 60.42

Linear Regression: Output on given input: [-2.4199398]
Decision Tree Model: Output on given input: [60.42]
Support Vector Machine: Output on given input: [60.42]
Neural Networks: Output on given input: [38518.934]

Best: SVM and Neural(in terms of time also)

DATASET 2: RADIATION VS COST DATA

In this dataset, we are predicting the cost of solar radiations

Input - Solar Radiations

Output - Cost per unit area

$$\text{Cost} = \frac{Mean\ radiations * Reference\ Cost}{New\ Radiation}$$

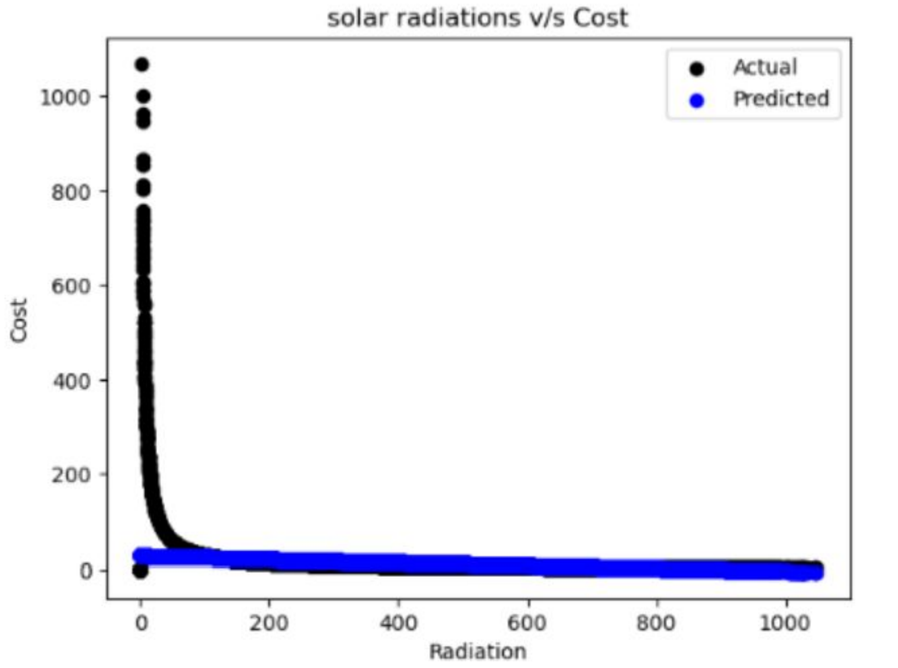
Dataset Description:

From the dataset, Mean value of Radiation is 4870.44
Reference cost- Rs.6

DATASET 2: RADIATION VS COST DATA

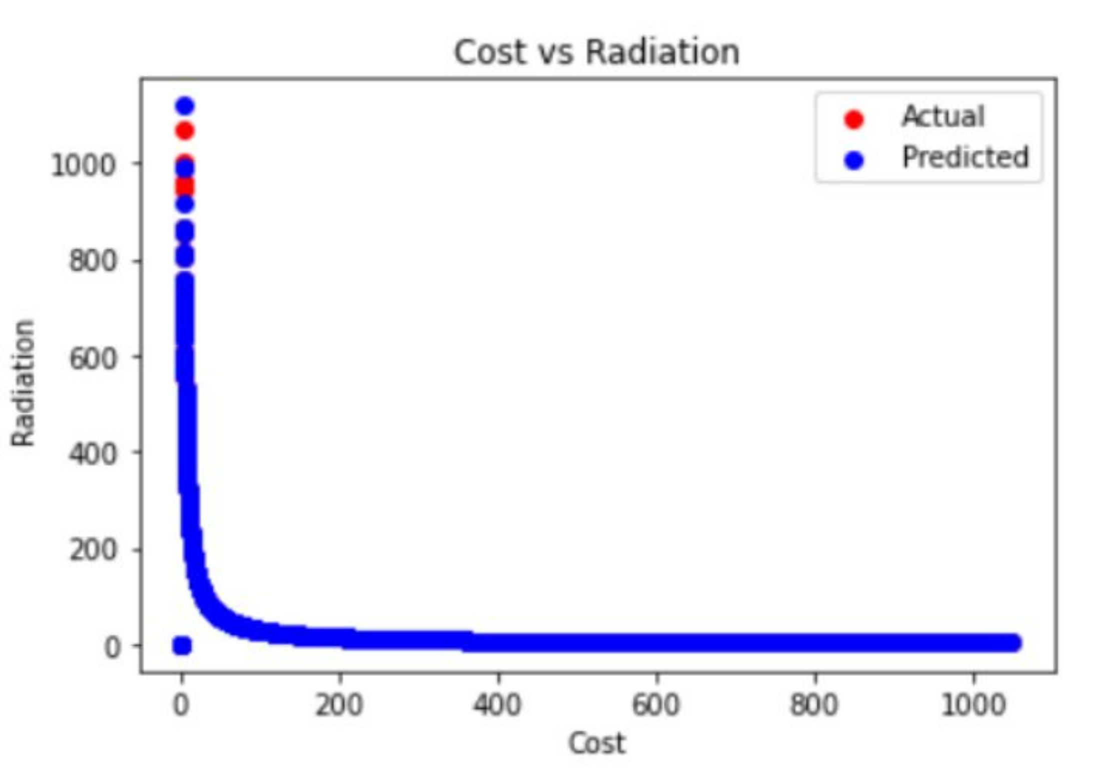
MODEL 1: Linear Regression

```
RMSE: 65.6906123732107
Mean squared error: 4315.26
R-squared: 0.01
```



DATASET 2: RADIATION VS COST DATA

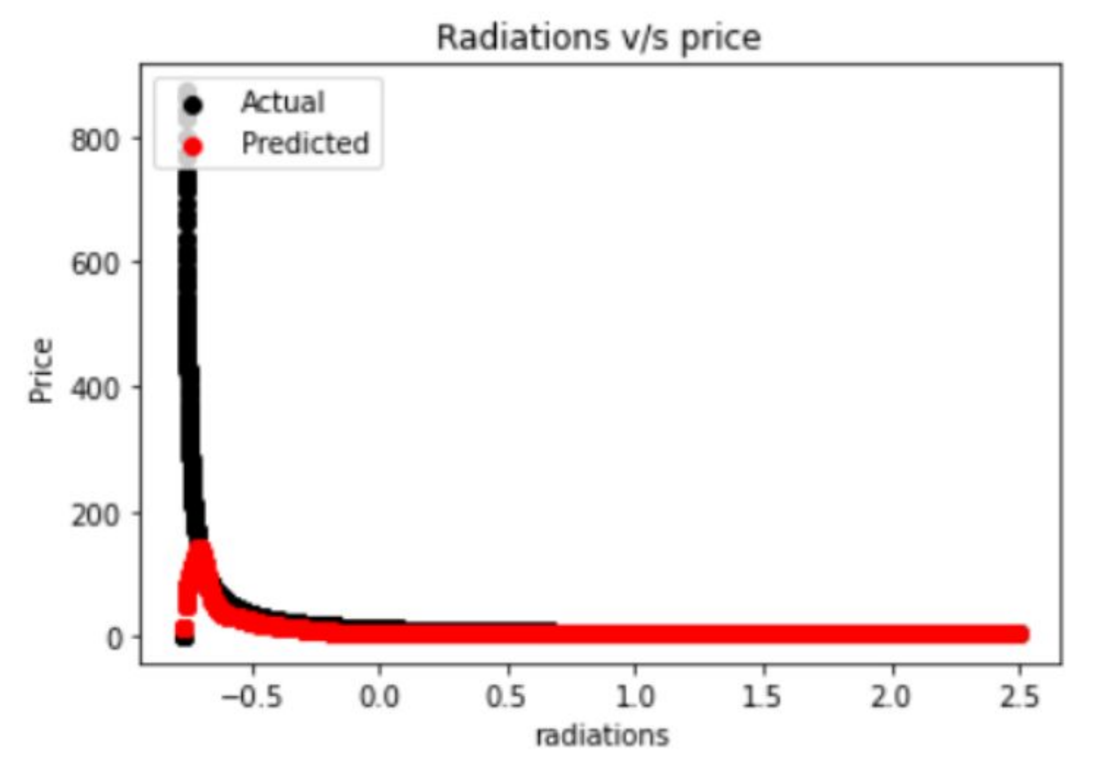
MODEL 2: Decision Tree




```
RMSE: 0.7638829221525513
R-squared score: 1.00
```

DATASET 2: RADIATION VS COST DATA

MODEL 3: Neural Network



Mean Squared Error: 2934.32

Mean Absolute Error: 14.29

Output Results

INPUT: ['temp', 'humidity', 'cloud_cover', 'wind_speed'] = [0]

ACTUAL OUTPUT: 0

Linear Regression: Output on given input: [27.40604502]
Decision Tree Model: Output on given input: [0.]
Neural Networks: Output on given input: [5.032529]

Best: Decision Tree

DATASET 3: GRID POWER COST DATA

In this dataset, we are predicting the cost of power taken from power grid.

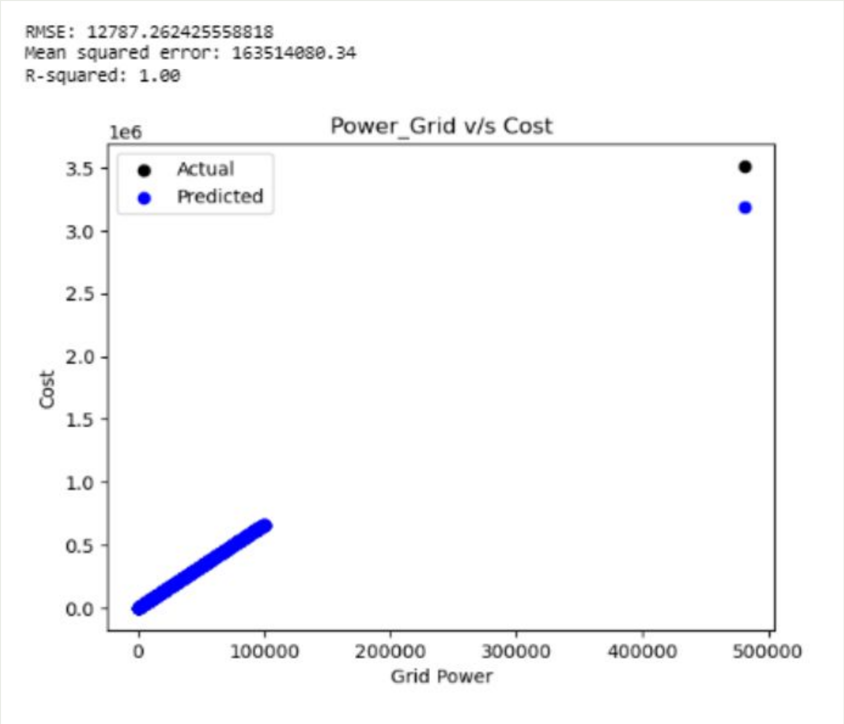
Input - Units required from grid
Output - Total price of grid power

Dataset Description:

Price of grid power $\propto$ Power consumption
Per unit cost variation:
For 1-1000 units, cost per unit is Rs. 5.84 .
For 1000-100000 units, cost per unit is Rs. 6.63 .
For 100000-500000 units, cost per unit is Rs. 7.3
For 500000-1000000 units, cost per unit is Rs. 7.5 .

DATASET 3: GRID POWER COST DATA

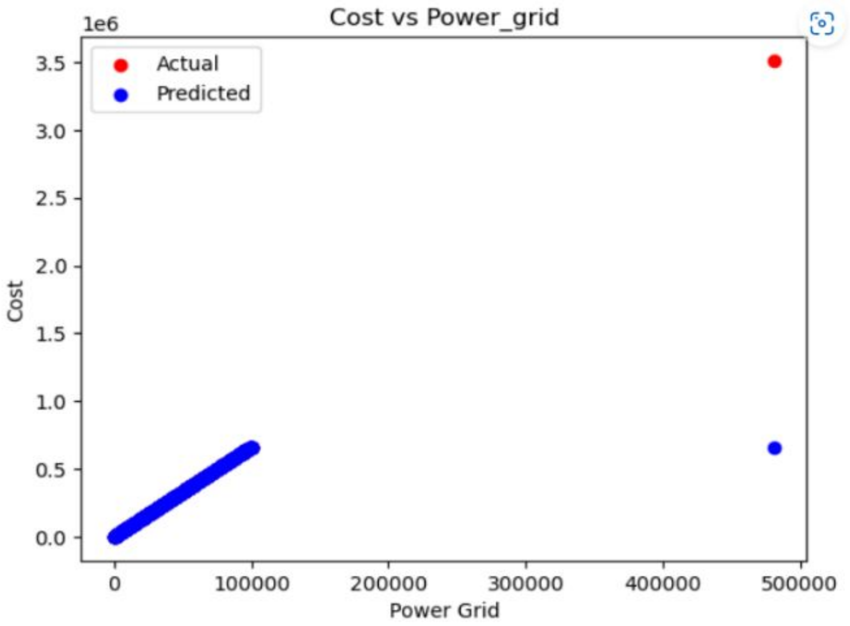
MODEL 1: Linear Regression



DATASET 3: GRID POWER COST DATA

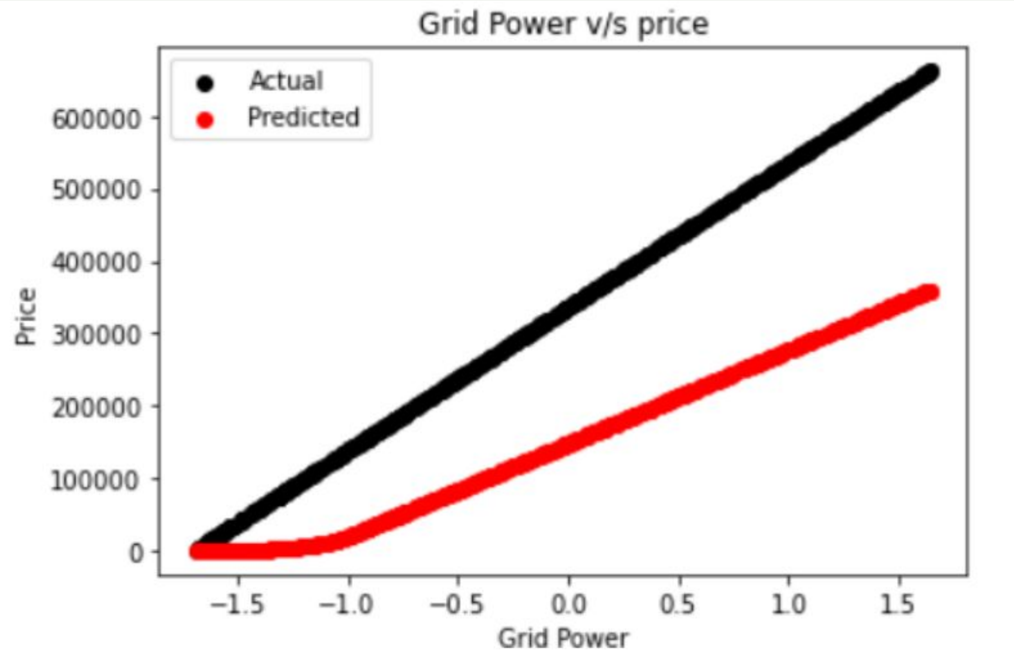
MODEL 2: Decision Tree Model

RMSE: 113053.77691383973
R-squared score: 0.76



DATASET 3: GRID POWER COST DATA

MODEL 3: Neural Network



Mean Squared Error: 36556247040.00

Mean Absolute Error: 174562.89

Output Results

INPUT: ['temp', 'humidity', 'cloud_cover', 'wind_speed'] = [27908.86972]

ACTUAL OUTPUT: 185035.8062

Linear Regression: Output on given input: [185027.94827264]
Decision Tree Model: Output on given input: [185035.8062]
Neural Networks: Output on given input: [3.90899e+09]

Best: Neural Networks

DATASET 4: SOLAR VS GRID POWER DATA

Dividing user demand into power taken from solar panels and power taken from grid on the basis of solar radiations available

Input - Demand of user, solar radiations available

Output - Power supplied from solar panel, power taken from grid

Dataset Description:

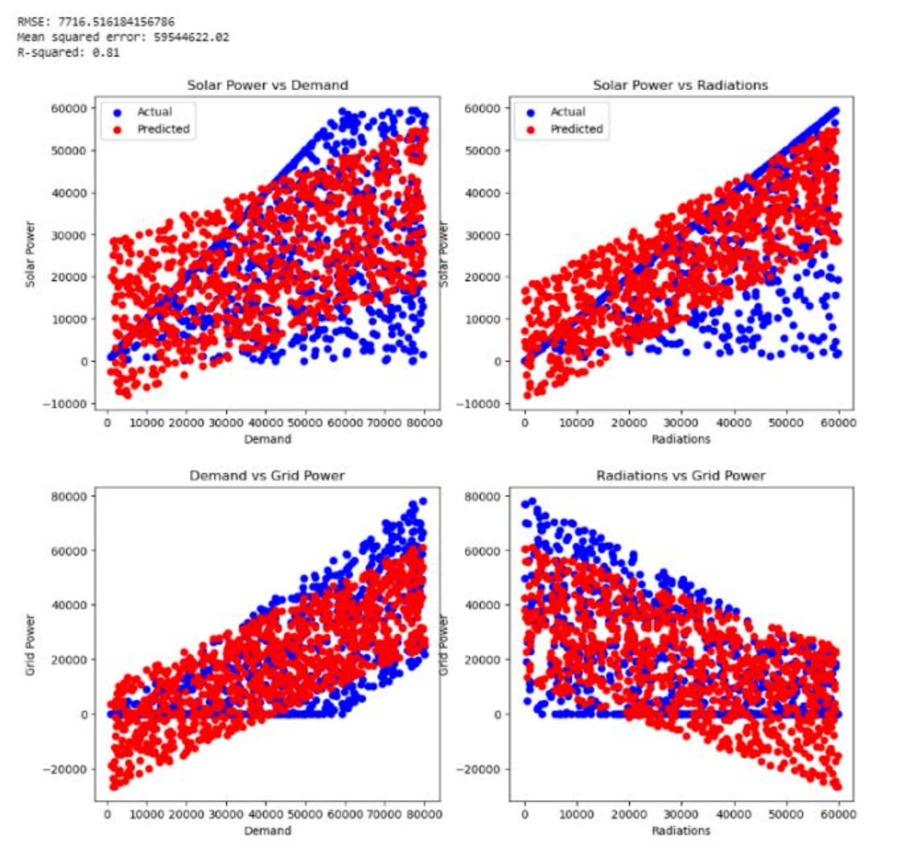
Logic:

Demand < Radiations Available , then Solar power will supply then demand.
Grid Power = 0

Demand > Radiations Available , then Solar power = till Maximum limit
Grid Power = Rest of the demand

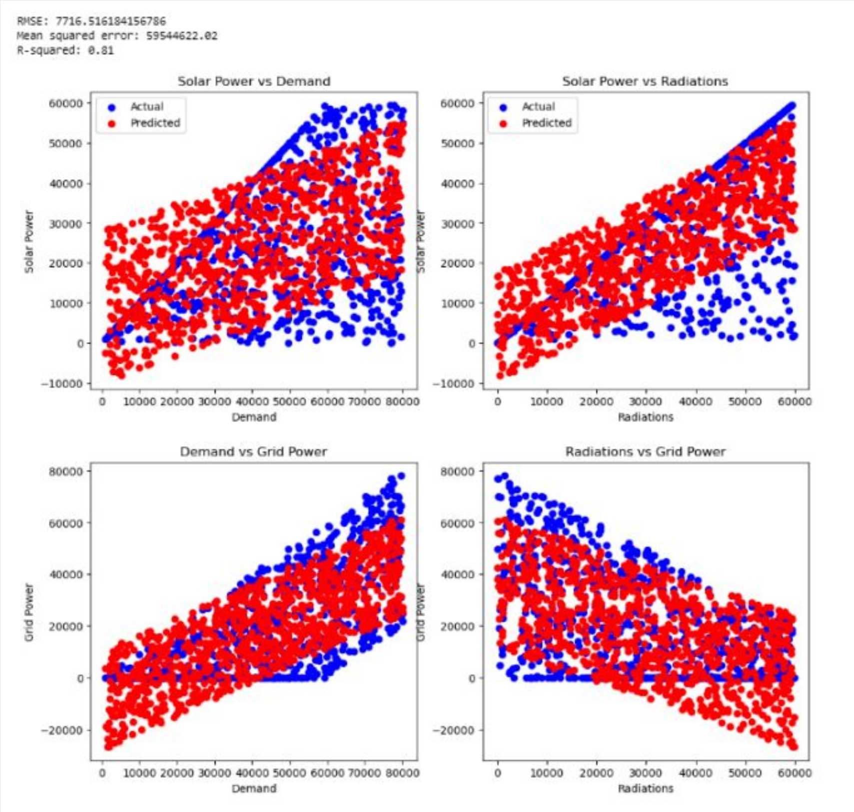
DATASET 4: SOLAR VS GRID POWER DATA

MODEL 1: Linear Regression



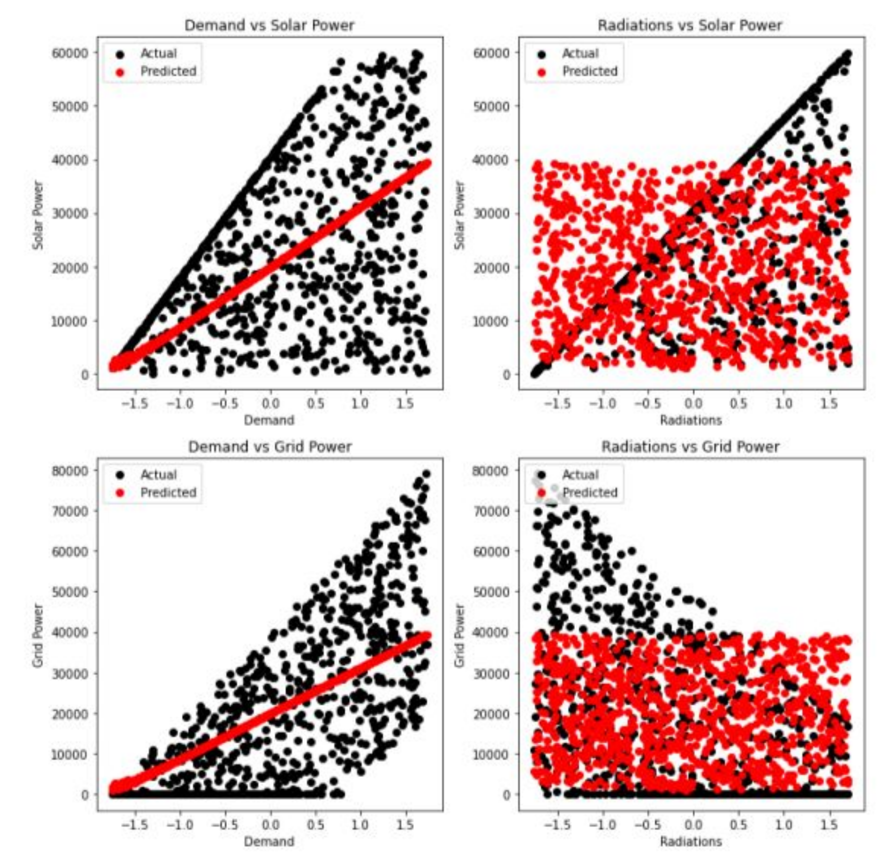
DATASET 4: SOLAR VS GRID POWER DATA

MODEL 2: Decision Tree



DATASET 4: SOLAR VS GRID POWER DATA

MODEL 3: Neural Network



Output Results

INPUT: ['temp', 'humidity', 'cloud_cover', 'wind_speed'] = [42075,32638]

ACTUAL OUTPUT: 32638,9437

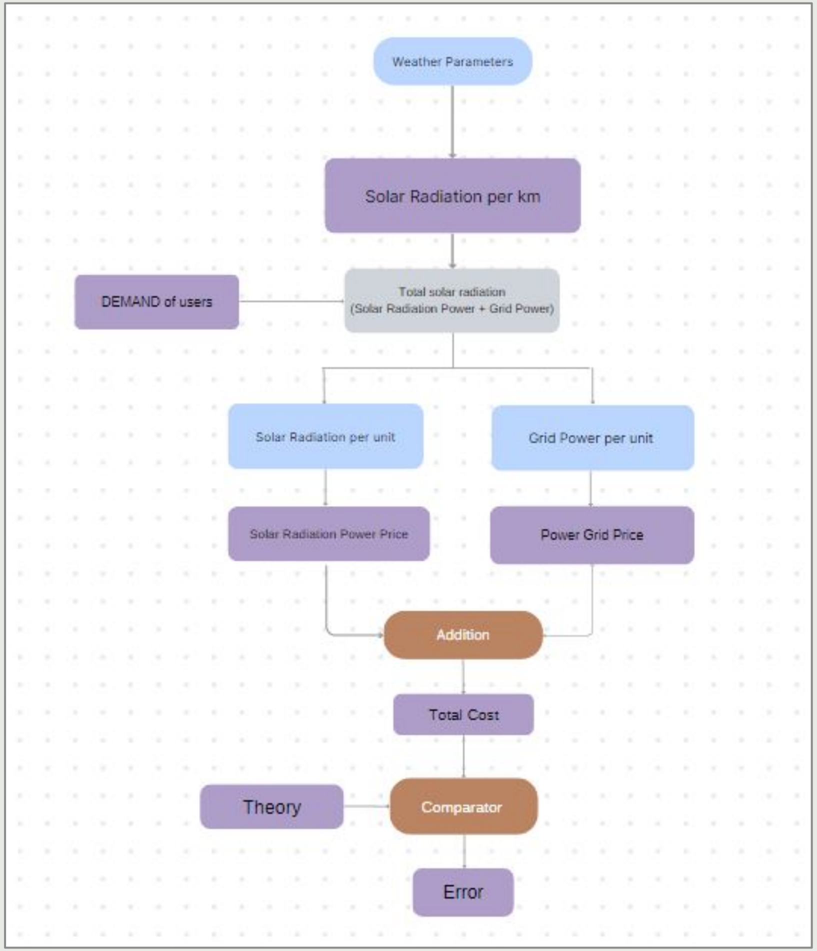
Linear Regression: Output on given input: [[25215.58858249 16859.41141751]]
Decision Tree Model: Output on given input: [[32638. 9437.]]
Neural Networks: Output on given input: [[4.6805312e+08]]

Best: Decision Tree

INTEGRATED MODEL

- We assessed the performance of all four models in every dataset.
- The effective model in every dataset is as follows:
  1. Solar irradiance data - Neural Network
  2. Radiation vs cost data - Decision Tree
  3. Grid power cost data - Linear Regression
  4. Solar Vs Grid Power data - Decision Tree
- We integrated all four efficient model to create an integrated model to predict EV charging price with respect to user input/demand and weather conditions;
- Input - weather conditions and demand of user
  Output - Final Cost

Workflow


Weather Parameters
Solar Radiation per km
DEMAND of users
Total solar radiation
(Solar Radiation Power + Grid Power)
Solar Radiation per unit
Grid Power per unit
Solar Radiation Power Price
Power Grid Price
Addition
Total Cost
Theory
Comparator
Error

Linear Best Case

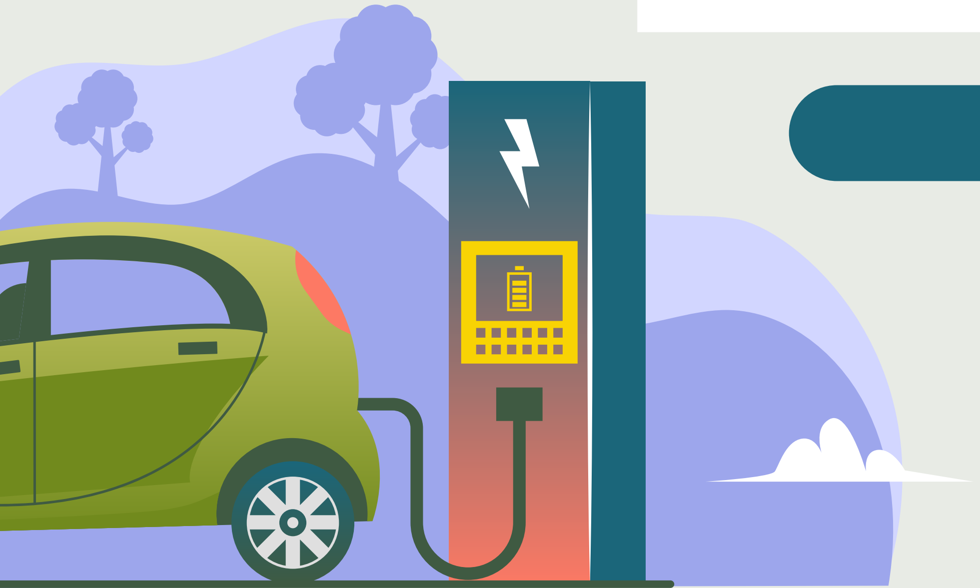
```
Radiations:  [180.44271377]
Demand from user:  5000
Power taken from solar panel:  [3000.54210513]
Power taken from power grid:  [1999.45789487]
Cost of solar power used:  26.439449786406755
Cost of grid power used:  13243.309165291459
Final Total Price (Predicted):  13269.748615077866
Final Total Price (Calculated):  0.5771328
Error:  2299153.935156322
```

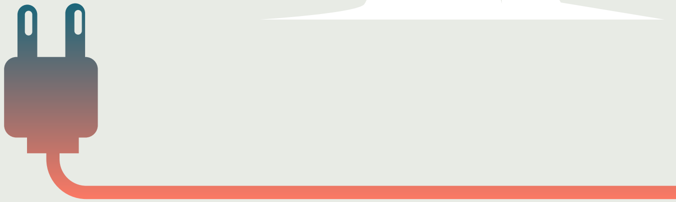
Overall Best Case

```
Radiations:  [[50362.914]]
Demand from user:  5000
Power taken from solar panel:  [4949.]
Power taken from power grid:  [0.]
Cost of solar power used:  58.29624
Cost of grid power used:  -13.500954477814957
Final Total Price (Predicted):  44.79528552218504
Final Total Price (Calculated):  0.5771328
Error:  7661.694625948316
```

05

COMPARISON





Comparison

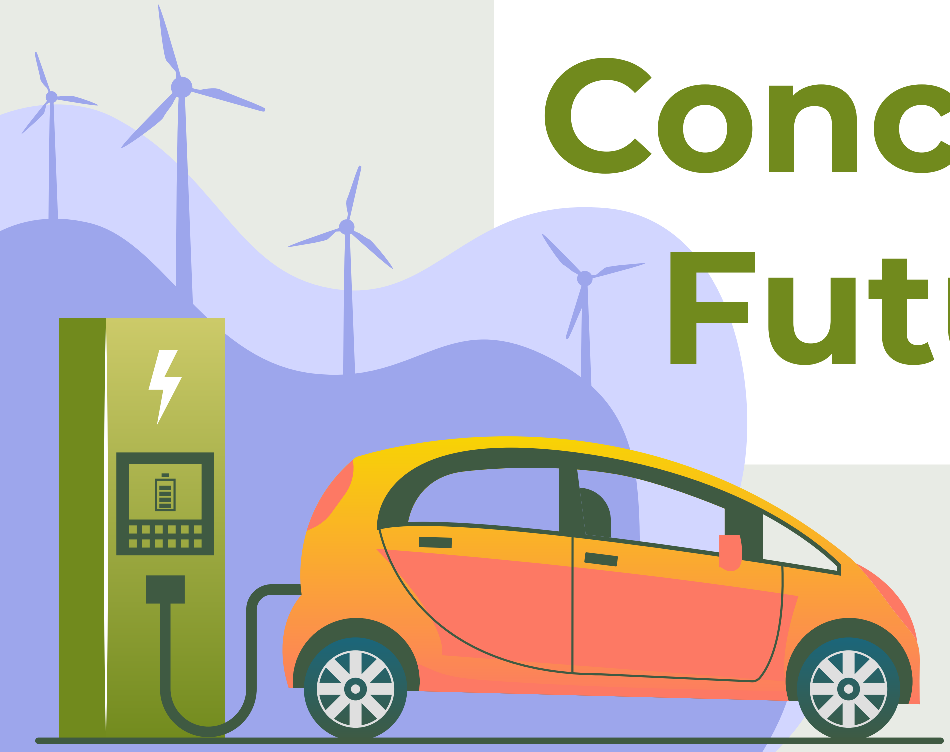
1. **Expansion of the dataset:** One of the potential areas of future work is to expand the dataset by adding more variables such as battery type, charging time, and energy consumption. This can improve the accuracy of our model and make it more suitable for a wider range of EV users.

2. **Real-time updates:** Our model could be further improved by incorporating real-time updates of solar irradiance and grid power prices. This will make the calculator more precise and up-to-date, providing users with the most accurate predictions of charging costs.

3. Use of machine learning algorithms: Our model utilizes machine learning algorithms, including linear regression, neural networks, decision tree, and support vector machine, to predict solar radiation, power cost, and power source. These algorithms have the advantage of being able to learn from data and improve their predictions over time. By utilizing machine learning algorithms, our model is able to provide more accurate and reliable predictions compared to models that rely on traditional statistical methods

4. Customization for location and vehicle type: Our charging calculator allows users to input their location and vehicle type to provide more customized and accurate predictions of charging costs. This customization is particularly important as location and vehicle type can significantly impact charging costs. By allowing users to input this information, we can provide a more accurate and reliable cost estimate compared to models that use generic assumptions about location and vehicle type.

Conclusion and Future Work

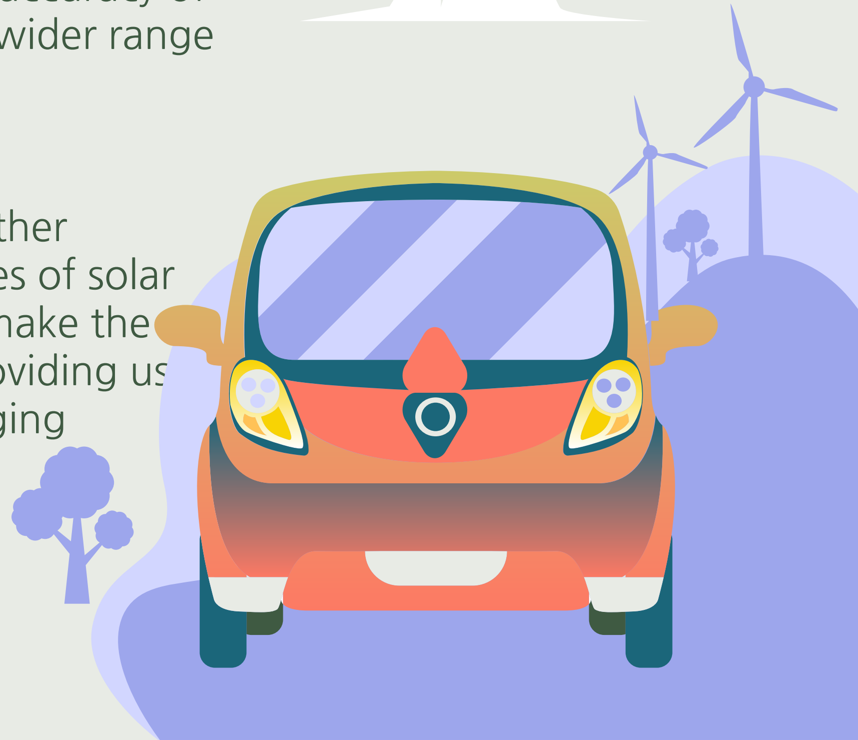


FUTURE WORK

1. **Expansion of the dataset:** One of the potential areas of future work is to expand the dataset by adding more variables such as battery type, charging time, and energy consumption. This can improve the accuracy of our model and make it more suitable for a wider range of EV users.

2. **Real-time updates:** Our model could be further improved by incorporating real-time updates of solar irradiance and grid power prices. This will make the calculator more precise and up-to-date, providing us with the most accurate predictions of charging costs.

3.



3. **Integration of renewable energy sources:** Another potential area of future work is to incorporate other renewable energy sources, such as wind and hydropower, to provide users with a more sustainable charging option. This could also improve the accuracy and reliability of our model.

4. **Mobile application:** Developing a mobile application for our model can make it more user-friendly and accessible to a wider range of users. This can allow users to access the calculator on-the-go, making it more convenient to use and increasing its overall utility.

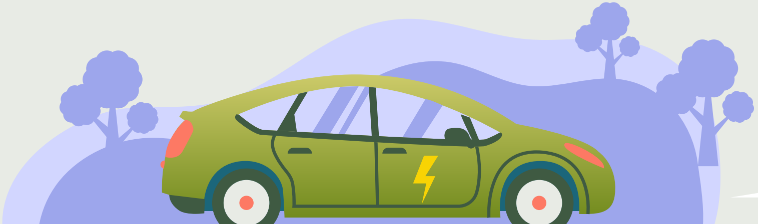
5. **User feedback:** Gathering feedback from users can help identify areas for improvement and guide future development of the calculator. This can be done through surveys, feedback forms, and user testing, allowing us to continuously improve and refine our model.

7. **Battery technology:** As battery technology continues to improve, it is expected to have a significant impact on the cost of electric vehicles. The prediction model can be used to analyze the impact of advancements in battery technology on electric vehicle pricing.

8. **Incorporate sustainability metrics:** We can include sustainability metrics, such as carbon emissions and energy efficiency, into our model to provide users with a more comprehensive understanding of the environmental impact of their charging choices.

Conclusion

- The study conducted on EV charging stations and the development of a comprehensive charging calculator provides a unique solution to the growing need for sustainable and affordable energy options for electric vehicle users.
- The model stands out from existing models due to its reliance on solar energy, integration of multiple datasets, and use of machine learning algorithms to provide accurate and customized predictions of charging costs.
- The need for reliable and efficient charging solutions for electric vehicles will only increase as the world shifts towards clean energy and sustainable practices.
- The model is a step towards fulfilling this need and making sustainable transportation more accessible to the masses.

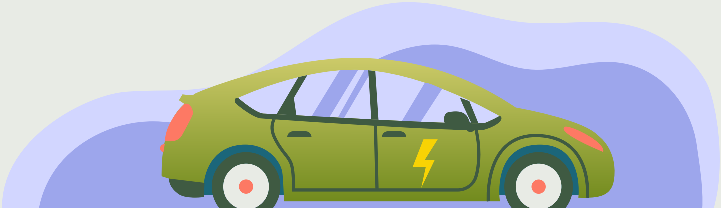


- There are several areas for future improvement, such as expanding the dataset, incorporating real-time pricing information, and developing a user-friendly interface.

- By continually improving and refining the model, the aim is to make it the go-to tool for electric vehicle users seeking a cost-effective and sustainable charging solution.

- The study demonstrates the potential of integrating renewable energy sources, data analytics, and machine learning algorithms to develop innovative and sustainable solutions for a greener future.

- The hope is that the work inspires further research and development in this area, and encourages individuals and organizations to embrace the power of clean energy and sustainable practices.



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