# Analysis of Household Energy Consumption of Gyalpozhing


## PROJECT (PRJ303) REPORT

## Bachelor of Science in Information Technology

## Submitted by

ANISHA RAI(12190041)

RASHMI GURUNG(12190072)

SONAM DEMA(12190081)

TASHI NAMGAY(12190086)

**Under the guidance of:**

Mr. Mulualem Teku

GYALPOZHING COLLEGE OF INFORMATION TECHNOLOGY MONGAR, BHUTAN, July 1, 2021

# 1 ACKNOWLEDGEMENT

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# 2 ABSTRACT

This web application is developed for the purpose to visualize, predict the price and energy consumption of individual household in Gyalpozhing. There is no awareness of the energy consumption patterns, identification of power optimization possibilities and data-driven planning and forecasting. Thus, this project aims to address the problems by developing a predictive model for Gyalpozhing Household price and energy consumption with the help of machine learning algorithms and provide this services to the users through an interactive website deployed in Heroku. The data is collected from Gyalpozhing BPC and is analyzed and preprocessed before it is used for model training and testing. The performance of each of the methods is compared based on MSE, RMSE, MAE metrics and R2 score.

# 3 TERMINOLOGY

| Term | Definition |
|---|---|
| Web Application | A web Application is an application program that is usually stored on a remote server, and users can access it through the use of Software known as web-browser. |
| Analysis | Detailed examination of the elements or structure of something |
| Data Cleaning | Data cleaning is the process of adding missing data and correcting, repairing, or removing incorrect or irrelevant data from a data set. |
| Prediction | The action of predicting something. |

# 4 LIST OF ABBREVIATIONS

| Abbreviation | Full Form |
|---|---|
| BPC | Bhutan Power Corporation Limited |
| GCIT | Gyalpozhing College of Information Technology |

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# 7 CHAPTER 1 INTRODUCTION

## 7.1 AIM

To analyze the household energy consumption of Gyalpozhing and make pertinent predictions.

## 7.2 GOAL OF THE PROJECT

To apply data analysis and ML techniques to the study of household energy consumption in our immediate vicinity.

## 7.3 OBJECTIVES OF THE PROJECT

1. To assess a time-bound energy consumption patterns of the town useful for creating awareness and identifying opportunities of optimization.
2. To present the household energy consumption of the town in a user-friendly manner to stakeholders.
3. To make relevant forecasts that would help stakeholders in appropriate data-driven planning and decision making.

## 7.4 SCOPE OF THE PROJECT

Analysis of Gyalpozhing household power consumption for the past three years.

## 7.5 PROBLEM STATEMENT

Bhutan is rich in electricity because it is generated within the country and not imported. Due to abundant sources of electricity in the country, there is no awareness of the energy consumption patterns, identification of power optimization possibilities and data-driven planning and forecasting.

In this project, we are focusing on Gyalpozhing and using electricity power consumption data for the past three years to predict patterns for power consumption of households. The key aspect of this project is to have knowledge on the amount of energy consumption and manage energy consumption. This could be advantageous for both the consumer and producer. For the consumer, they would save their money by having knowledge of their energy consumption in the future. They

could plan the usage of the eclectic energy in their household. For the producer, they would manage the production of energy which is sufficient for every household consumption.

## 7.6 LITERATURE REVIEW

Hydropower electricity is Bhutan's essential energy source and the dominant tenacity behind its rapid expansion of electricity access.

Domestic power demand has been continuously increasing throughout the years, keeping up with the country's economic expansion.The most important measure in the energy balance of Bhutan is the total consumption of 2.18 billion kWh of electric energy per year. Per capita this is an average of 2,830 kWh (Energy consumption in Bhutan, n.d.). The entire output of all electric energy producing facilities is 8 billion kWh, or 361 percent of the country's own consumption. Despite this, Bhutan engages in energy trade with other countries. Production, imports, and exports, in addition to pure consumption, have a major influence. Natural gas and crude oil are also employed as energy sources.

Energy Balance

| Electricity | total | Bhutan per capita | USA per capita |
|---|---|---|---|
| Own consumption | 2.18 bn kWh | 2,830.44 kWh | 11,842.76 kWh |
| Production | 7.88 bn kWh | 10,216.27 kWh | 12,428.52 kWh |
| Import | 84.00 m kWh | 108.86 kWh | 220.71 kWh |
| Export | 5.76 bn kWh | 7,468.78 kWh | 29.42 kWh |

100.0% of the country's population (as of 2019) has access to electricity.

The structure and policy of the power sector has witnessed substantial changes in the past decade with the initiation of a reform process. Including the 126 MW Dagachhu project, the current installed generation capacity is 1,606 MW. The three-mega projects of Punatsangchhu-I, II and Mangdechhu accounts for 2,940 MW of power. This would take the country's installed generation capacity to 4,546 MW by 2020. The total installed electricity-generating capacity in Bhutan, as of 2014, is approximately 1,606 MW from major hydropower plants, 8.2 MW from other small hydro and 10,352 kVA from diesel generators owned by BPC (BPC, 2014). In 2014, peak demand

increased to 314 MW, up from 284 MW in 2013. In 2013, BPC added 13,299 new clients, and in 2014, it served 159,796 consumers (BPC, 2014). The majority of the growth has come from the service connection of rural residences in rural areas, which has been made possible by broad Rural Electrification coverage. The domestic consumption without losses amounts to 1382.8 GWh in 2014.T

There are few hydropower generating plants in Bhutan, out of those hydropower Tala hydropower plants have the largest capacity and also generate more than half of the cumulative power generation. It accounted for approximately 65% of the total electricity generation from hydropower in 2014, followed by Chhukha Hydropower Plant which generated around 25% of the total power in the same year. Currently, the majority of the transmission lines across the country transmits electricity to various parts through 132kV and 66kV transmission lines.
The industries consume 83% of the electricity in the economy followed by the residential households consuming 11% and commercial & institutional buildings consuming around 6% of the total electrical energy supplied in the economy

Gyalpozhing, Mongar, on the Kurichhu River in Eastern Bhutan, is home to the Kurichhu Hydropower Plant. It is a run-of-river system with a dam 55 meters high (from its deepest foundation), a crest length of 285 meters, and a surface power house at the dam's toe. The Project has a total installed capacity of 60MW, comprising four 15MW units, and a mean annual energy generating capacity of 400 MU. The Kaplan turbine has a net head of 32 m and a discharge rate of 53 m3/sec per unit. The fish ladder for fish migration is a unique element of the project.

| | |
|---|---|
| **Catchment Area** | 9,135 sq.km |
| **Net Head** | 32 m |
| **Installed Capacity** | 60 MW |
| **Number of Units** | 4 x 15 MW |
| **Mean Annual Generation** | 400 GWh |
| **Type** | Kaplan |

A study was done by Luv Kumar Chhetri and Boonrod Sajjakulnukit (2018), to analyze and ascertain energy consumption patterns by households of Thimphu in 2017. The study was conducted on the use of various forms of energy sources namely, electricity, liquefied petroleum

gas, kerosene and firewood on energy consumption by common household appliances of different consumer groups. For the research, the data of 525 households were analyzed and it was found that the highly preferred energy mix was electricity (59.69%) followed by liquefied petroleum gas (22.31%). The energy mix was used for space heating end-use (38.58) and cooking (29.65). Appliances like rice cooker, water boiler, television and refrigerator were used by 90% of the household of Thimphu which shows their choice of fuel. Approximately 4,500 kWh of electrical energy is consumed by each household per year. It is concluded that the adoption of energy efficient technologies in probable end-use application would bring in considerable energy saving in households as the existing trend indicates rising energy consumption at the household for the years to come.

According to the survey of Domestic energy consumption patterns in urban Bhutan(2018) which was conducted on eight districts including Mongar, the sample households indicate that the urban areas in Bhutan have access to electricity and LPG: 92% of households use LPG or electricity as primary cooking fuel, 72% use electricity for space heating and 81% use electricity for water heating. This indicates that electricity subsidies provided by the Royal government are effective in making electricity accessible to urban households.

It is determined that 88% of households in the sample districts used electricity as their main source of lighting followed by candles (8%), kerosene/gas lamps (3%) and others (1%)(Lhendup et al., 2010).

Bhutan's sample districts are 100% electrified, yet there is marked difference in consumption level of different energy sources. Electricity is the popular energy source for lighting and other domestic applications like heating and cooling while LPG is a popular source of energy for cooking. Some of the urban households in the sample districts continue to use firewood for thermal energy needs. However, the trend is changing as more households are opting for kerosene heaters, which is a better choice than electricity since Bhutan's hydropower is seasonal.

# 8 CHAPTER 2 BACKGROUND OF THE PROJECT

## 8.1 BACKGROUND

Bhutan is known for the use of clean and green energy generated by hydropower. Almost the entire country is well connected with electricity. Hydropower has existed as a major sector in Bhutan's economy since the 2000s, as it accounts for 27% of Bhutan's revenue and about 14% of its GDP. Aside from that, Bhutan produces so much energy from hydropower that about 80% of its surplus power is exported to the neighboring country, India.

Technology holds an immense importances in today's world as it plays a multifold role in almost every sector and therefore is capable of generating a huge amount of data and information which are used for yielding valuable insights on every field. Likewise, Bhutan Power Corporation Limited (BPC) also carries a vision to be an innovative and efficient power utility driving the socio-economic transformation of Bhutan in future with the help of technology driven data analytics. Bhutan Power Corporation Limited (BPC) was launched as a Public Utility Company on 1st July 2002 with a mission to provide affordable, adequate, reliable and quality electricity services to customers. His Majesty the King of Bhutan- Jigme Khesar Namgyel Wangchuck has emphasized on the use of technology in solving the everyday social problems of the country which shows how important technology and data science is for the people and country of Bhutan. In the past, when the world was walking towards the path of innovation through technology driven data analytics, Bhutan was left behind. In later times, when this innovative technology was introduced, the country started to prevail as well. The lack of projects like Hydropower in the past has affected the social and economic of the country but after the launch of Hydropower has proven to be a climacteric point in the Bhutanese economy.

Due to all of the above reasons, it is only right to study and analyze the BPC data set to be aware of the monthly and yearly power consumption. Through these data analysis, not only will the power consumption be known but will also be able to identify the opportunities to optimize the consumption of electrical energy in Gyalpozhing community. Likewise, this project will be able to help the Gyalpozhing community to predict the monthly power consumption and will help them to conserve energy.

## 8.2 TECHNOLOGY USED

1. Python
    - Matplotlib
    - Pandas
    - Numpy
    - Seaborn
2. Plotly
3. Django
4. Django Plotly Dash
5. Google Colab
6. Heroku
7. Machine Learning
    - Scitkit-learn
        - ❖ preprocessing
        - ❖ metrics

# 9 CHAPTER 3 METHODOLOGY

## 9.1 MACHINE LEARNING ALGORITHMS

The machine learning algorithms used are as follows:

### 9.1.1 LINEAR REGRESSION

This algorithm is a statistical method that is used for predictive analysis. Linear regression makes predictions for continuous/real or numeric variables.
Linear regression algorithm shows a linear relationship between a dependent (y) and one or more independent (x) variables. Since linear regression shows the linear relationship, it finds how the value of the dependent variable is changing according to the value of the independent variable.
This algorithm helps to understand and to predict the behavior of complex systems or analyze experimental, financial, and biological data. Linear regression techniques are used to create a linear model.The general equation for a linear regression model is:

$$Y= a *X + b$$

In this equation:

- Y – Dependent Variable
- a – Slope
- X – Independent variable
- b – Intercept

### 9.1.2 RANDOM FOREST

Random forest is a Supervised Machine Learning Algorithm that is used widely in Regression problems. It builds decision trees on different samples and takes their majority vote for average in case of regression.

Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output.for example the greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.

Since the random forest combines multiple trees to predict the class of the dataset, it is possible that some decision trees may predict the correct output, while others may not. But together, all the trees predict the correct output

### 9.1.3 DECISION TREE

The Decision Tree algorithm belongs to the family of supervised learning algorithms. Unlike other supervised learning algorithms, the decision tree algorithm can be used for solving regression and classification problems too.

The goal of using a Decision Tree is to create a training model that can be used to predict the class or value of the target variable by learning simple decision rules inferred from prior data(training data).

In Decision Trees, for predicting a class label for a record we start from the root of the tree. We compare the values of the root attribute with the record's attribute. On the basis of comparison, we follow the branch corresponding to that value and jump to the next node.

### 9.1.4 K-NEAREST NEIGHBOR

The k-nearest neighbors algorithm, also known as KNN or k-NN, is a non-parametric, supervised learning classifier, which uses proximity to make classifications or predictions about the grouping of an individual data point. While it can be used for either regression or classification problems, it is typically used as a classification algorithm, working off the assumption that similar points can be found near one another.

**For Energy Consumption Prediction**

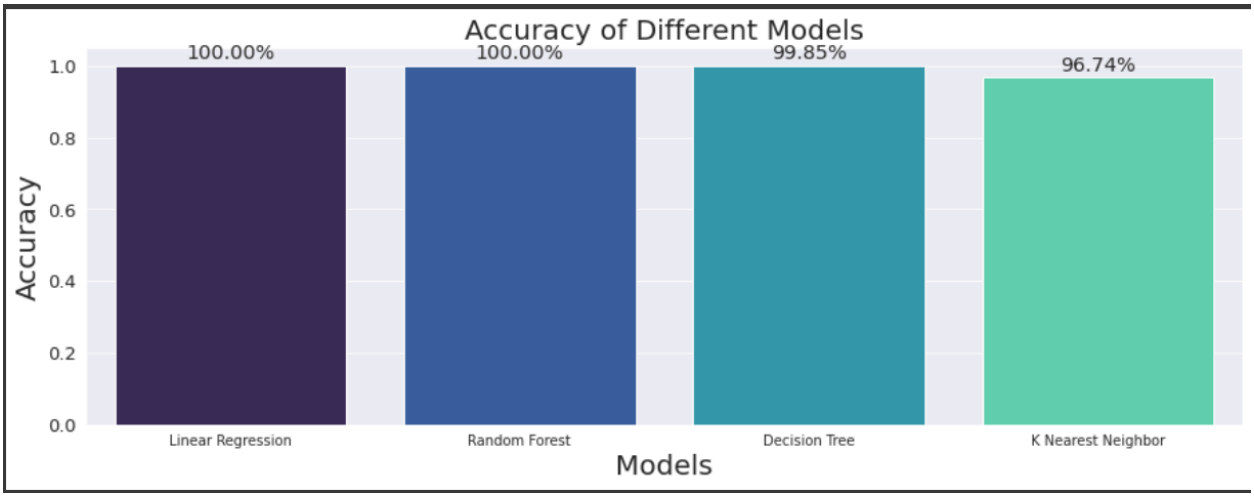


*Figure 9.1: Test Accuracy for Energy Consumption Prediction*

| | Model | MSE | RMSE | MAE | R2 |
|---|---|---|---|---|---|
| 0 | Linear Regression | 2.798070e-26 | 1.672743e-13 | 1.365840e-13 | 1.365840e-13 |
| 1 | Random Forest | 3.313624e-03 | 5.756408e-02 | 1.380365e-02 | 1.380365e-02 |
| 2 | Decision Tree | 1.312998e+01 | 3.623531e+00 | 2.977757e+00 | 2.977757e+00 |
| 3 | K Nearest Neighbor | 2.825224e+02 | 1.680840e+01 | 8.798600e+00 | 8.798600e+00 |

*Figure 9.2: MSE, RMSE, MAE and R2 for Energy Consumption Prediction*

From the above results we can conclude that the best algorithm is the Linear Regression Algorithm for this energy consumption prediction because it has higher accuracy and low Mean Absolute Error, Mean Squared Error, Root Mean Squared Error and and a good R-squared score compared to other algorithms.

**For Energy Charges / Price Prediction**

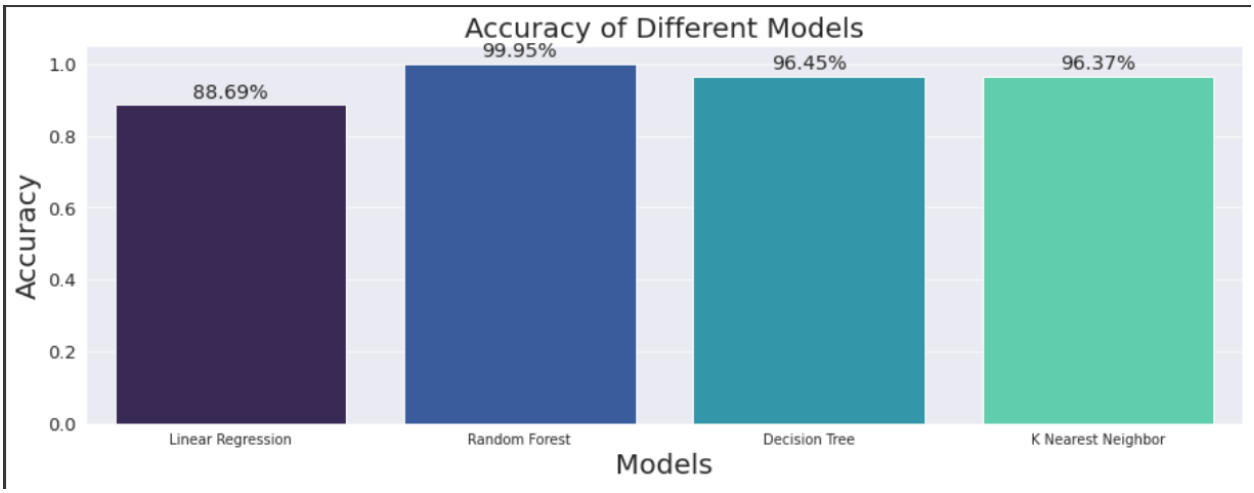


*Figure 9.3: Test Accuracy for Price Prediction*

| | Model | MSE | RMSE | MAE | R2 |
|---|---|---|---|---|---|
| 0 | Linear Regression | 6846.411828 | 82.743047 | 48.934705 | 48.934705 |
| 1 | Random Forest | 31.557200 | 5.617580 | 0.939948 | 0.939948 |
| 2 | Decision Tree | 2149.908824 | 46.367109 | 27.464740 | 27.464740 |
| 3 | K Nearest Neighbor | 2198.994483 | 46.893438 | 13.425674 | 13.425674 |

*Figure 9.4: MSE, RMSE, MAE and R2 for Price Prediction*

From the above results we can conclude that the best algorithm is the Random Forest Algorithm for the price prediction because it has higher accuracy and low Mean Absolute Error, Mean Squared Error, Root Mean Squared Error and a good R-squared score compared to other algorithms.

## 9.2 PROJECT ACTIVITIES

Followings are the key activities that will be carried out for the development of this Machine Learning module integrated web application:

1. Installation of software and tools: Text Editor(Sublime or Visual Studio Code)
2. Literature Review: Referring books, video tutorials, online reference related to machine learning and research papers for the literature review.
3. Interacting with the Gyalpozhing BPC employees for data collection.
4. Train a machine learning model and evaluate it.
5. Design and develop a website using Django.
6. Integrating the ML model with the Django website.
7. Test all the functionalities of the website.
8. Deploy in Heroku.
10. Report Writing/ Documentation.

**The Milestone of the project**

| No | Elapsed time from start (in months) of the project | Milestone | Deliverables |
|---|---|---|---|
| 1 | 01/03/2022 - 04/03/2022 | Topic Selection | Selection of topic done |
| 2 | 05/03/2022- 14/03/2022 | Project proposal preparation(aims, objectives, background,literature review,etc). | Project proposal report and presentation |
| 3 | 15/03/2022- 17/03/2022 | Data collection | BPC of Gyalpozhing |
| 4 | 18/03/2022- 19/03/2022 | Data Pre-processing | Cleaned data |
| 5 | 20/03/2022- 24/03/2022 | Extract, analyzing, manipulating data and interpreting result | Result |
| 6 | 25/03/2022- 27/03/2022 | Analytic or Machine Learning Model | Analytic or Machine Learning Model |
| 7 | 28/03/2022 | Analytics Model and Presentation | Presentation |
| 8 | 29/03/2022- 11/04/2022 | Dashboard(website)design | Dashboard(website)design |
| 9 | 12/04/2022- 08/05/2022 | Deploy analytics model in the local environment and testing | Demonstrates all the functionality of model |
| 10 | 09/05/2022 | Milestone Model Presentation | Presentation |
| 11 | 10/05/2022- 05/06/2022 | Deploy in GitLab then in Heroku | Live website |
| 12 | 06/06/2022 - 12/06/2022 | Making technical Poster and a Promotional video | Technical Poster and a Promotional video |
| 13 | 13/06/2022 | Presentation and demonstration | Presentation and Demonstration |

*Table 9.1: Project Milestone*

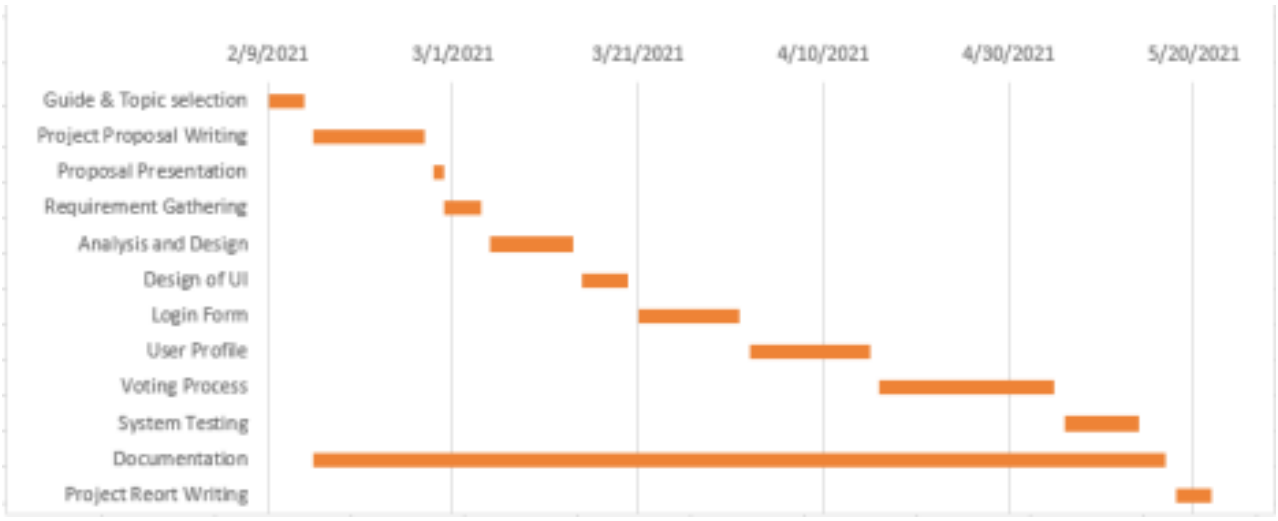


*Figure 9.5: Gantt Chart*

## 9.3 WORKFLOW DIAGRAM

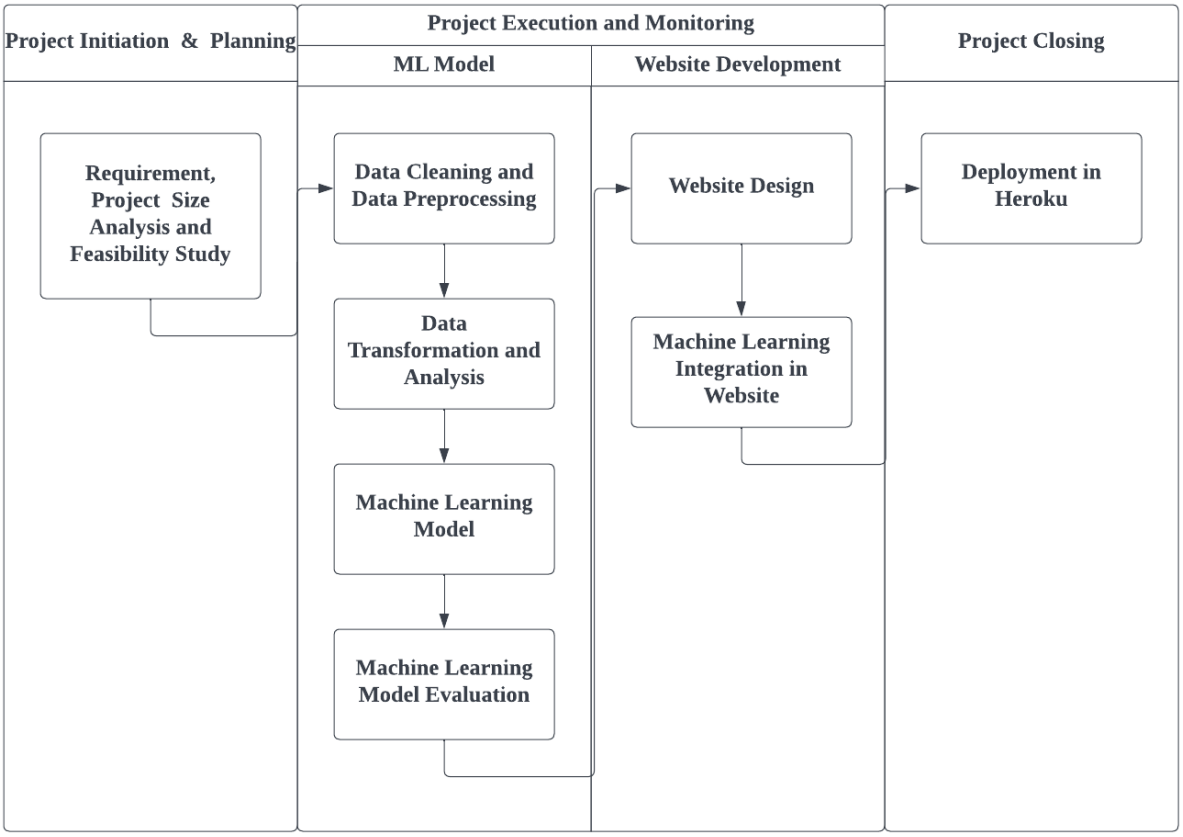


*Table 9.2: Workflow*

# 10 CHAPTER 4 REQUIREMENT SPECIFICATION

## 10.1 FUNCTIONAL REQUIREMENTS

Functional requirements are also referred to as functional specifications. It refers to the desired operations of a program or system. The users of this system would be both the power supplier of Gyalpozhing community(Gyalpozhing BPC) and residents of Gyalpozhing.

- View : The users will be able to view the visualization and About Page(website description and team members' information).
- Prediction: Users will be able to know the future power consumptions and price. The users have the options to predict the energy consumption and price.

## 10.2 NON-FUNCTIONAL REQUIREMENTS

- **Accuracy** : The system will provide high accuracy with regards to prediction.
- **Efficiency** : The system will be efficient by being able to perform within a few seconds.
- **User-friendly** : The UI of the system will be designed and developed in such a way that it is very easy for the users to use and navigate.
- **Portability** : The analysis and prediction of Gyalpozhing energy consumption will be displayed in a website deployed in Heroku, it will be highly portable. It can easily be viewed and accessed in various platforms such as laptop, computer desktop, mobile phones and tablets.
- **Availability** : As the system will be hosted in cloud(Heroku), it will be available to the system users for 24/7.

# 11 CHAPTER 5 SOLUTION AND IMPLEMENTATION

## 11.1 BUILDING MACHINE LEARNING MODEL

### 11.1.1 DATA COLLECTION

The performance of the model highly depends on the quantity and quality of the raw data. If the raw data is large in size with useful and related attributes, then the end ML model will be of high accuracy. The data can be acquired from an already existing database or it has to be collected/created and then compiled from scratch. Dataset can be in the form of XLSX, CSV, JASON and web scraping techniques can also be applied for acquiring the data.

So, for this project, the data was collected from Gyalpozhing BPC as the power consumption analysis and prediction is done on Gyalpozhing community. The dataset will contain the past power consumption details of each household of Gyalpozhing community for the past three years.

**Data Description**

To analyze the energy consumption of Gyelposhing, the data is acquired from Gyelposhing BPC. The data that is collected in this project is of three years. The attributes that we have selected for this project are as follows:

| **Energy Consumption Prediction** | **Price Prediction** |
|---|---|
| **X parameters chosen:** | **X parameters chosen:** |
| Year | Year |
| Month | Month |
| Current | Consumption |
| Voltage | Category |
| Category | Portion |
| Portion | |
| **Target** | **Target** |
| Consumption | Energy Charges(Price) |

*Table 11.1: Data Description*

**Category:** Category is the classification of customers that is grouped on the base of the type of consumer they are. For example, companies like RBA are classified as LV Agriculture for it is a company based for Agriculture. There are twelve types of different consumers in the Gyalpozhing community and they are as follows:

1. LV Agriculture
2. LV Bulk
3. LV Institutional
4. LV Power house
5. LV Religious Institution Customers
6. LV Rural Domestic Customers
7. LV Rural-Community Lhakhangs
8. LV Street light
9. LV Temporary
10. LV Urban Domestic Customers
11. LV Rural-Cooperatives and Agriculture
12. MV Industrial

**Portion:** Portion in here represents the classification of the area where each customer lies. The areas(such as town, rural,ect) of each household in Gyalpozhing community. The location is mainly divided into two parts which are as follows:

1. P17-40
2. P17-41

**Voltage:** It is the voltage that is being supplied to all the consumers and the value of the voltage is static.

**Current, consumption** and **energy charges** are the value that varies from each customer and it also represents the value of each attribute that is consumed by the customer.

**Year** attribute used in this project for three years, from 2019 to 2021.

The unit used for voltage is Volt, current is Ampere, consumption is KiloWatt and energy charges are Ngultrum.

### 11.1.2 DATA PREPARING

The data preparation involves the following steps:

**Data Cleaning:** The data which are duplicates and null values are being dropped from the dataset. The features or the attributes that are irrelevant are also being dropped out from the dataset.

**EDA and Visualization:** To gain insight into the vast amounts of data, the data visualization is being used. It benefits to recognize new patterns and errors in the data. Making sense of these patterns helps to pay attention to areas that indicate progress or not. It also helps in finding the distribution and relationship between two data too. For example the distribution of data between current and consumption attributes using bar graphs.

**Preprocessing**

Outliers Detection and Removal

Firstly the outlier in the dataset is detected. The points that are considered "abnormal," or which don't fit a particular pattern in the dataset are being removed from the dataset. To detect outliers and remove it, the method called interquartile range is used. The interquartile range is used to measure how the data point is spread out from the mean of the dataset. To visualize the outlier of the data, boxplot is being used.

Encoding

The categorical variable that cannot be represented in numerical data so to represent it in numerical value, encoding method is used especially for those categorical data which are nominal. Label encoding is used to represent categorical data like portion and category in numeric value. For this project, the categorical data are the category and portion.

### 11.1.3 TRAIN AND TEST

Before the data has been used for the training and testing, the X and Y parameter or the target is being chosen from the dataset. The X parameters that are selected for the energy consumption prediction(target value/ Y parameter) are year, month, current, category, portion and voltage. And for the price prediction(target value/ Y parameter), the X parameters that are selected are year, month, consumption, category and portion.

After the selection of the parameters, the data is splitted for training and testing. From all the splitting of data, the best split of the data that results in high accuracy is 70 % for training and 30% for testing for both the predictions. The Machine Learning algorithms used for training and testing the data are Linear Regression Algorithm, Random Forest Algorithm, Decision Tree and KNN algorithm.

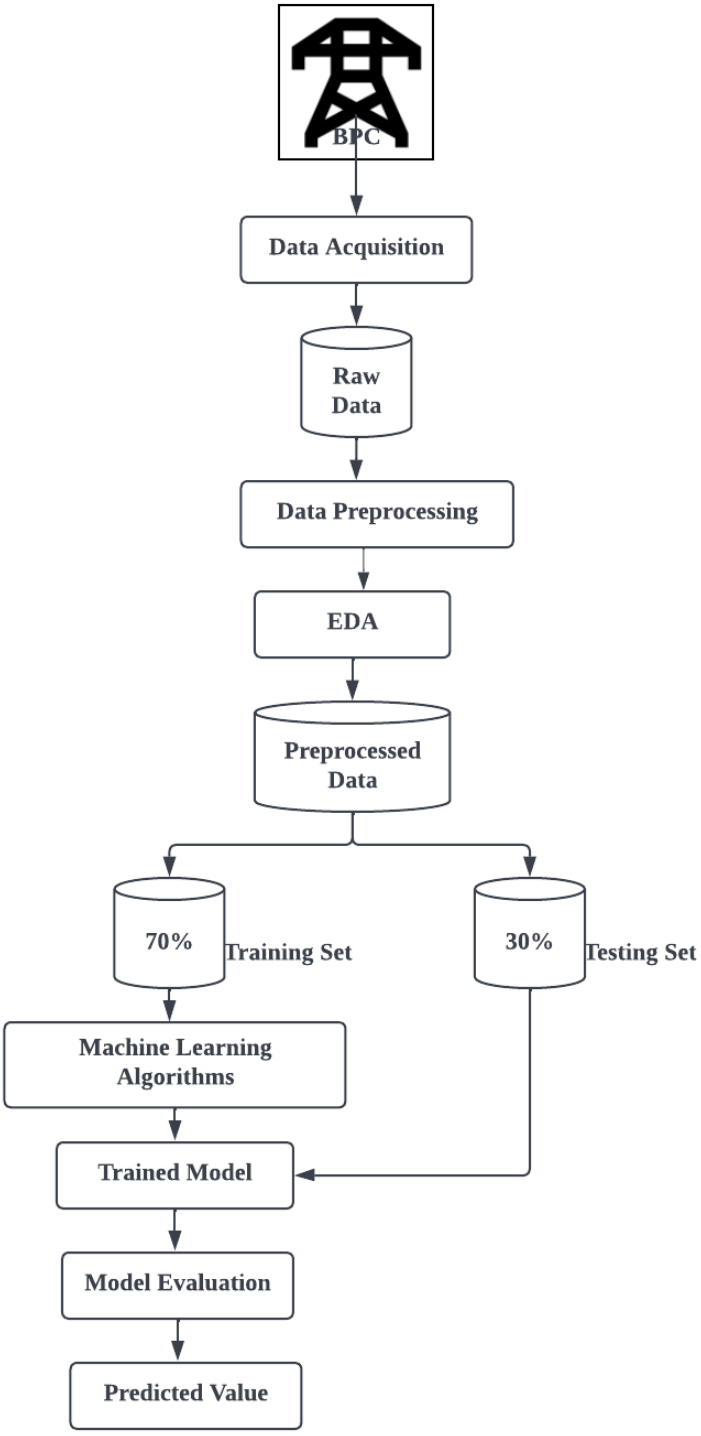


*Figure 11.1: Steps in building ML model*

## 11.2 USE CASE DIAGRAM

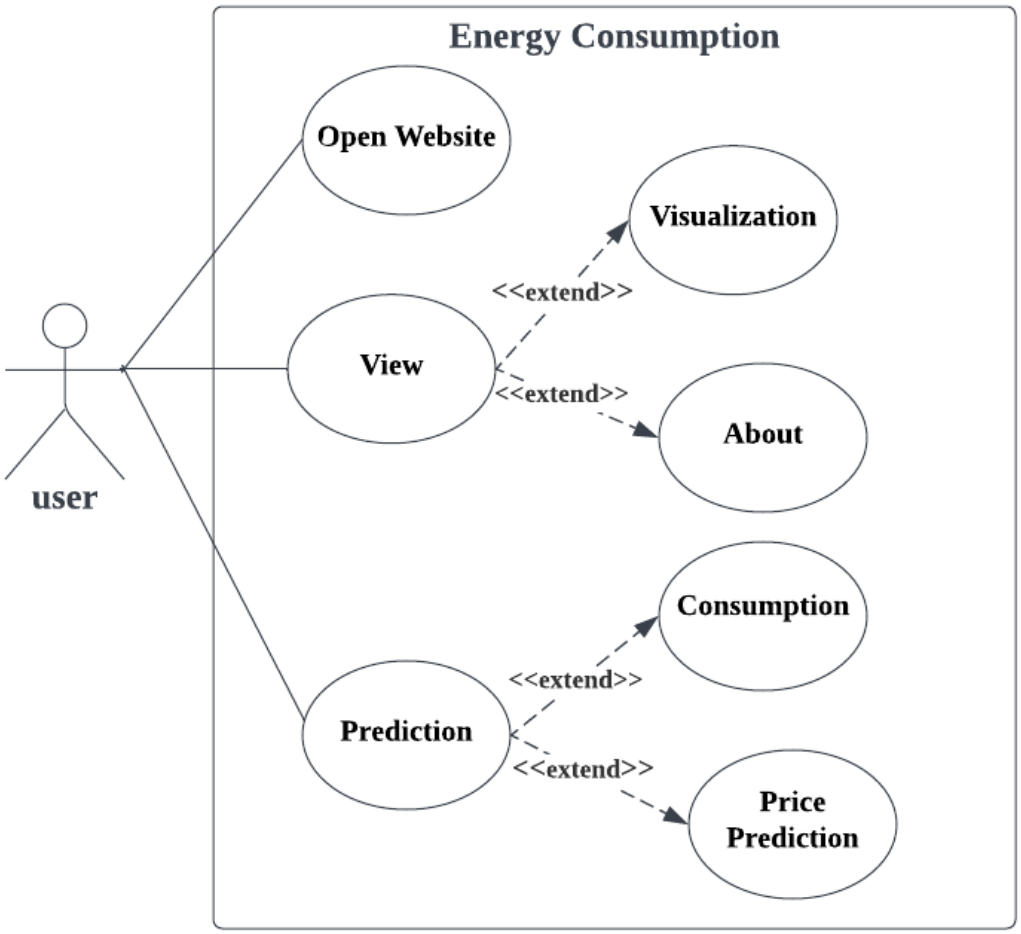


*Figure 11.2: Use Case Diagram*

The system will consist of only one actor(primary actor); users. The users of this system will be the Gyalpozhing power supplier(Gyalpozhing BPC) and the customers(residents of Gyalpozhing). The system users will be able to go to this project website, view the analysis of the past energy consumption and make predictions such as the energy consumption prediction and price prediction.

### 11.2.1 USE CASE DESCRIPTION

| | |
|---|---|
| **Use Case** | View |
| **Actor** | Users(Primary Actor) |
| **Goal in context** | To view the analysis(graphs) and about page of the website |
| **Scenario** | The viewers/users will click on the specific button which they want to view and the respective page will be displayed. |

*Table 11.2: View Use Case*

| | |
|---|---|
| **Use Case** | Prediction |
| **Actor** | Users(Primary Actor) |
| **Goal in context** | To predict the energy consumption and price. |
| **Scenario** | 1. The viewers/users will click on the specific prediction button and the respective page will be displayed.<br>2. Then, the user can fill out the required form and click the prediction button.<br>3. The predicted value will be displayed |

*Table 11.3: Predict Use Case*

## 11.3 SEQUENCE DIAGRAM

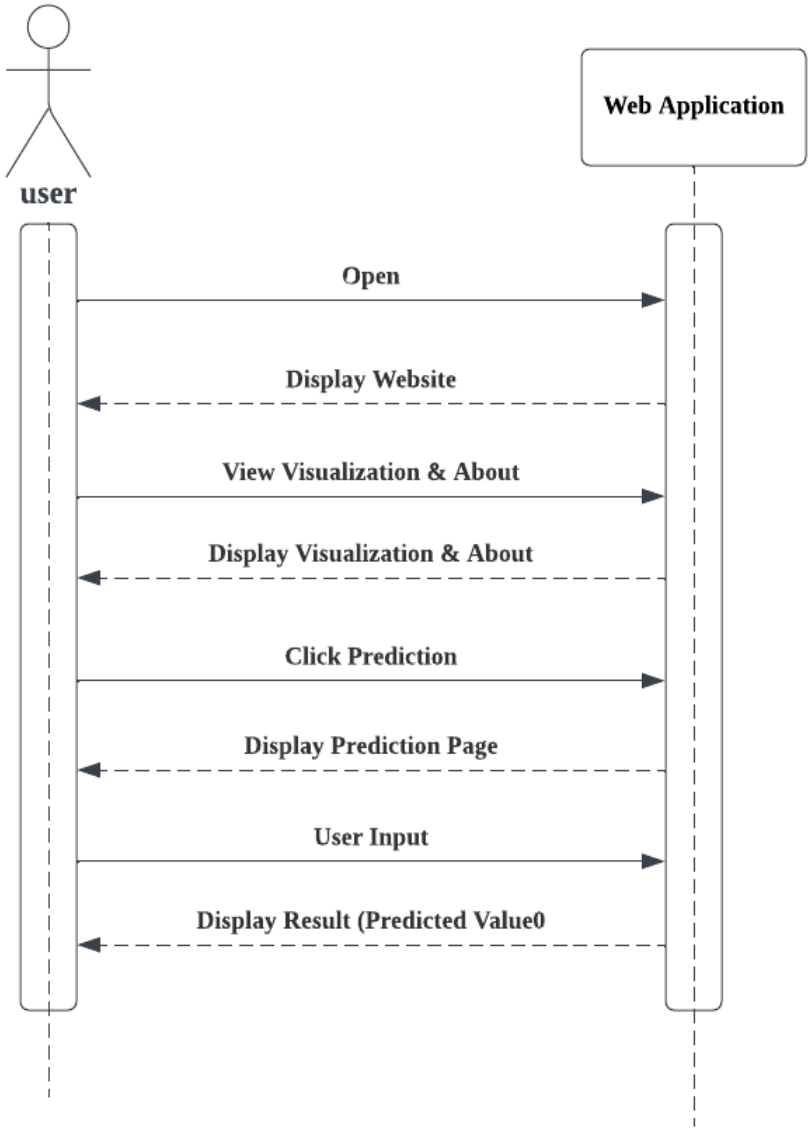


*Figure 11.3: Sequence Diagram*

The users will be directed to the homepage of the website when accessing the website. If they want to view the visualization and About page, they just have to click the visualization button and the About link and they will be able to view their required choice. The users will also be able to make predictions such as the energy consumption prediction and price prediction separately. Inoder to do so, they have to fill in the required information and click on the prediction button which will display the predicted value.

## 11.4 SYSTEM ARCHITECTURE

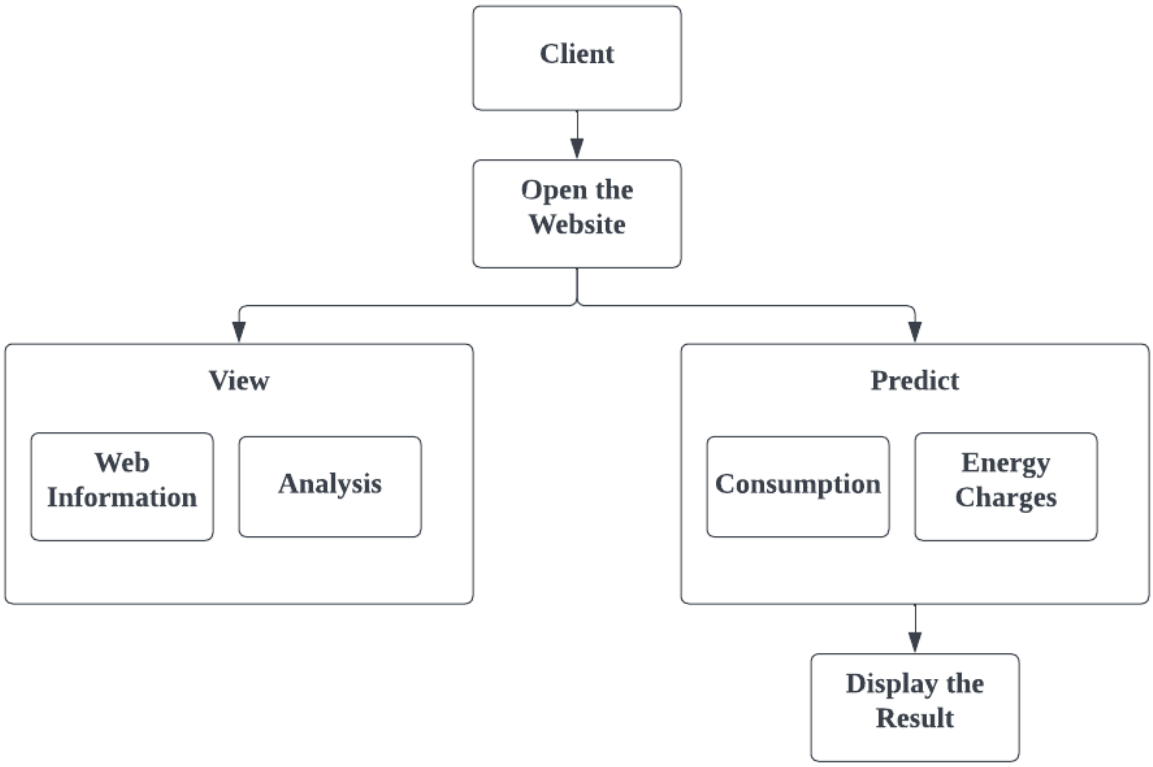


*Figure 11.4: System Architecture*

## 11.5 PROTOTYPE / WIREFRAME

After the completion of the data collection, the interface design of this web application was made/designed using an online collaborative interface design tool, 'Figma'.

### 11.5.1 HOME PAGE


*Figure 11.3.1: Home Page*

The home page of the website consists of the following buttons:

- **About:** About the web application and the team members.
- **Analysis:** Graphical representation of the past 3 years of energy consumption data of Gyalpozhing.
- **Consumption Prediction**
- **Price Prediction**

### 11.5.2 ABOUT PAGE

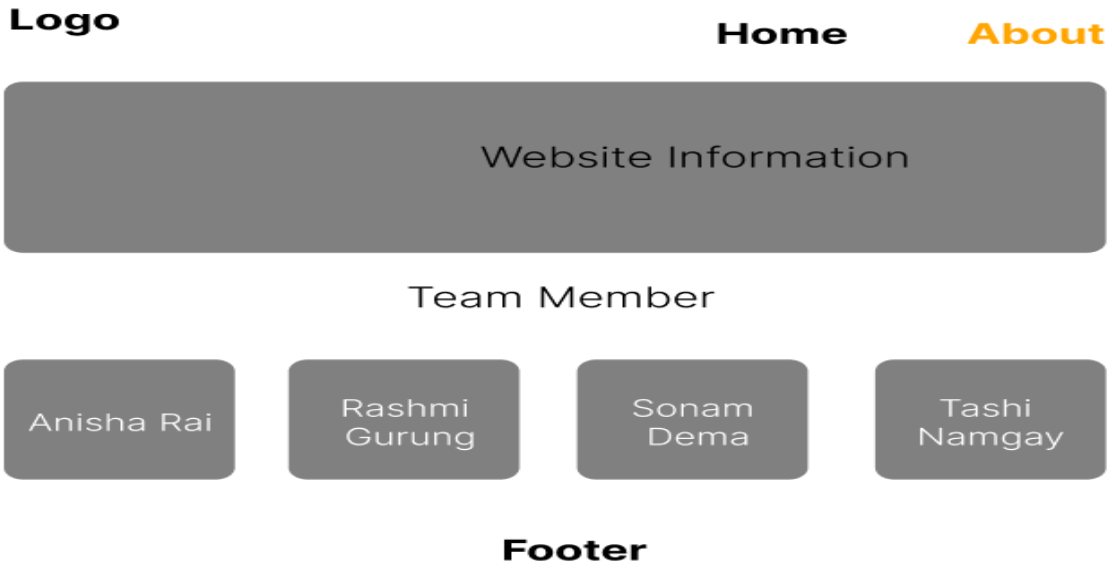


*Figure 11.3.2: About Page*

This webpage contains a short information about the web application and the contacts of the team members. The users will be able to contact the members through the given Gmail, Gitlab and Github links.

### 11.5.3 ANALYSIS PAGE


*Figure 11.3.3: Analysis Page*

This page will display the patterns and amount of energy consumption of Gyalpozhing Community through graphs.

### 11.5.4 ENERGY CONSUMPTION PREDICTION PAGE

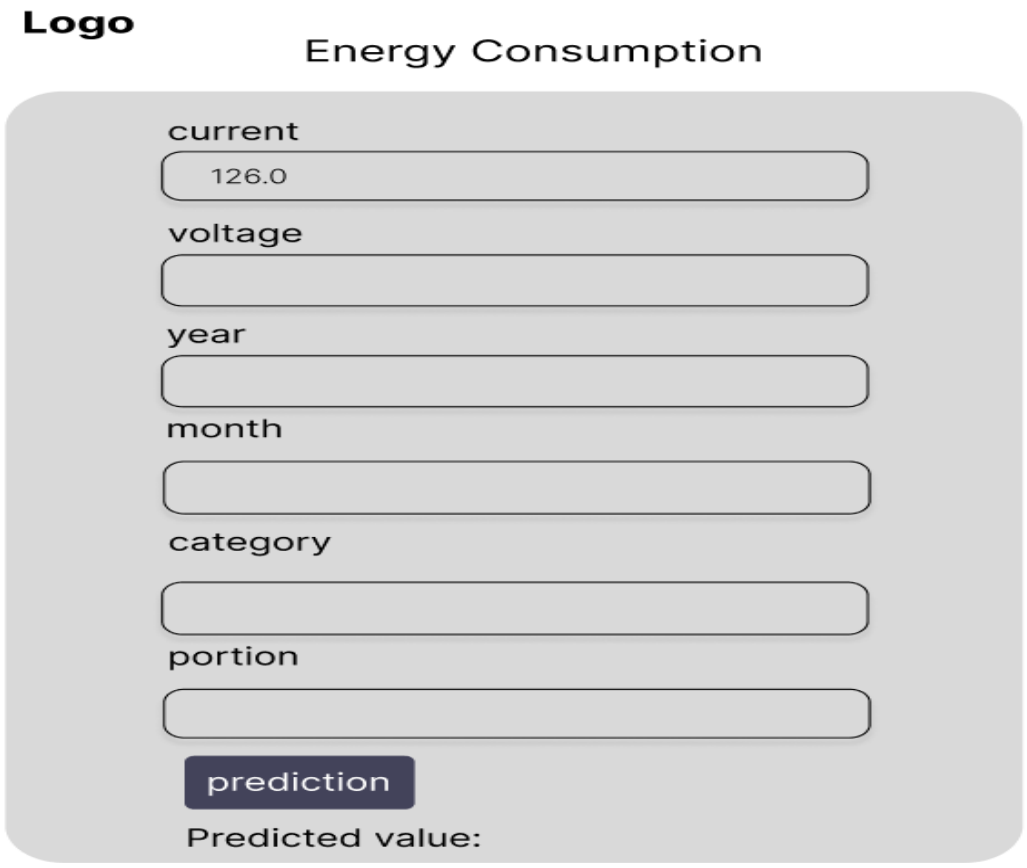


*Figure 11.3.4: Energy Consumption Prediction*

This webpage will display a form where the users are required to fill all the fields and when clicking the prediction button, the predicted value will be displayed.

### 11.5.5 ENERGY CHARGES PREDICTION PAGE

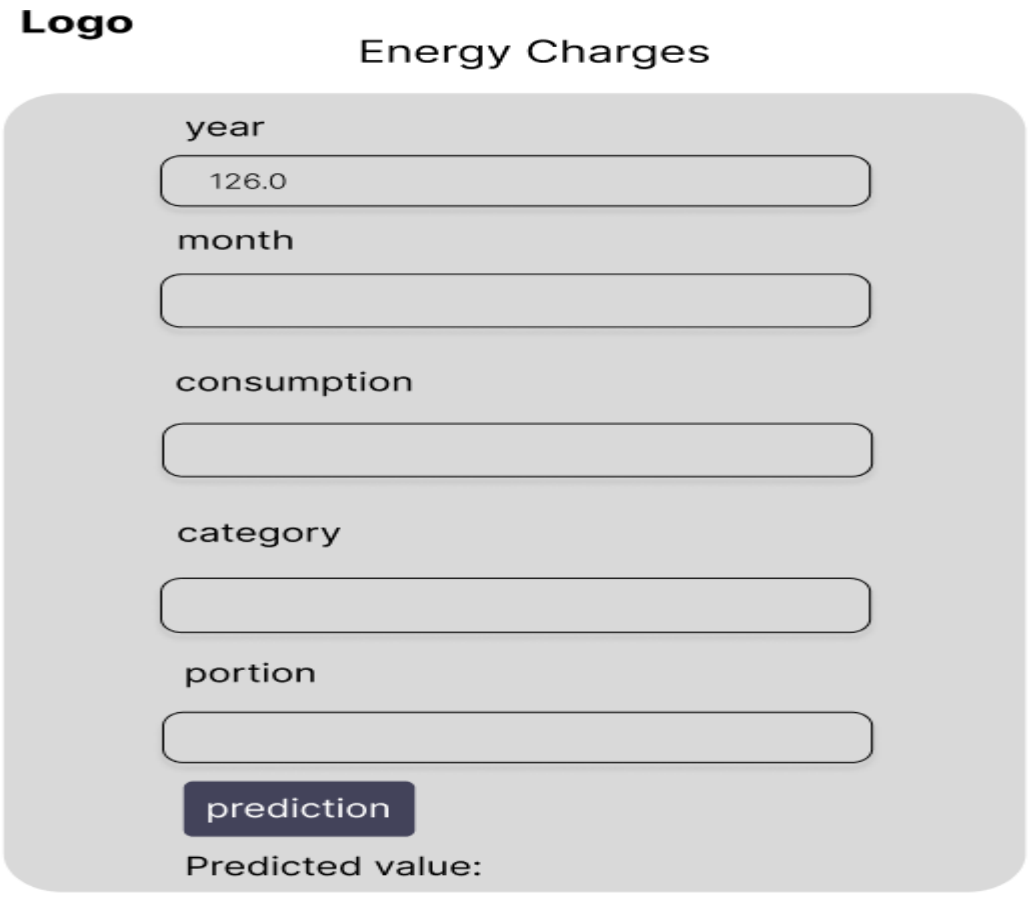


*Figure 11.3.5: Price Prediction*

This webpage will also display a form but with different fields to fill up. The users have to fill all the fields and the predicted price will be displayed when the prediction button is clicked.

### 11.5.6 RESPONSIVENESS OF THE WEBSITE

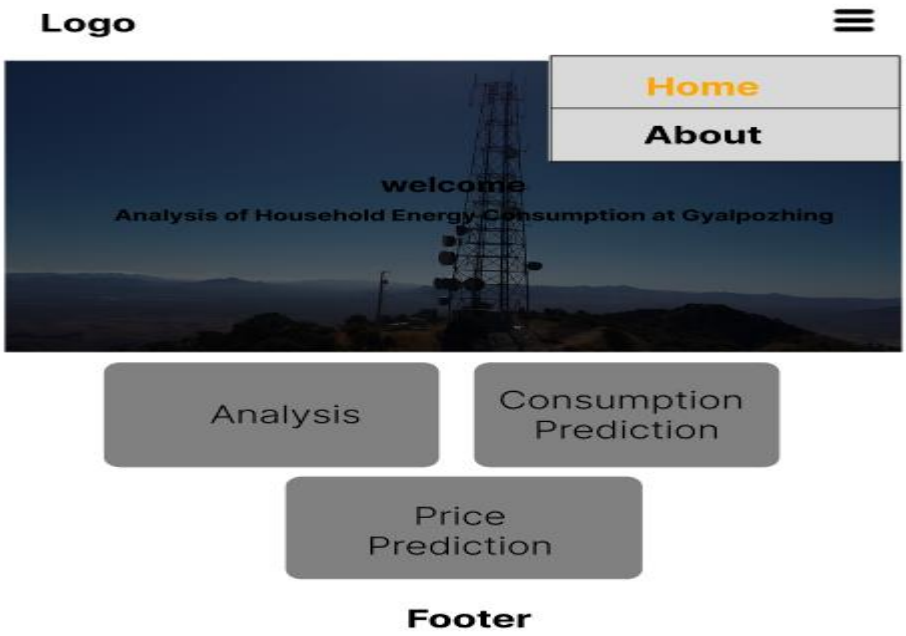


*Figure 11.3.6: Hamburger Menu*

The website will be accessible, presentable and user friendly on different platforms. Bootstrap will be used for making the website responsive. Changes such as the navigation bar changing into a hamburger bar when viewing in smaller device screens will be applied for the responsive purpose.

# 12 CHAPTER 6 RESULT

This chapter contains screenshots and a brief explanation of the final working web application which is already deployed in Heroku. It contains a brief introduction of this web application "Analysis of Household Energy Consumption at Gyalpozhing" and the features provided by this website with the corresponding screenshots respectively.

## 12.1 INTRODUCTION OF THE WEB APPLICATION

**Website Logo :** The logo of the website is a picture of a house and an electric bulb. The house represents the Gyalpozhing household and the bulb represents the electricity/ energy consumption.

*Figure 12.1: Website Logo*

## 12.2 WEB APPLICATION

### 12.2.1 HOME PAGE

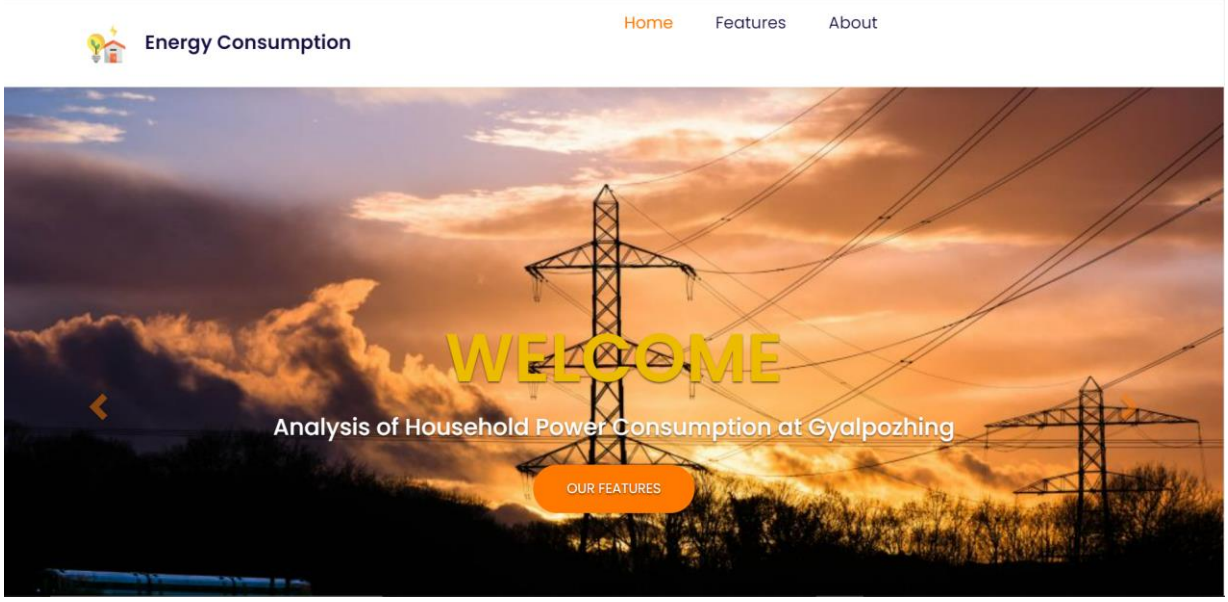


*Figure 12.2: Home Page, Slider Image*

The first thing that the users will see when accessing this website will be the homepage with a big slider of images related to the projects in order to grab their attention.

The Home Page consists of the followings:

- **Navigation bar:** The navigation bar consists of the website's logo, Home, Features and About links. When clicking on them, it will navigate the users to the respective web pages.
- **Image Slider:** The image slider consists of two images, the topic of our project and a 'OUR FEATURES' button which serves the same purpose as the Feature link.

When clicking on either the Feature link or the OUR FEATURES button, both will navigate the user to the features section of the same web page. Here, we have three features; Analysis, Consumption and Price. A single click will navigate the website to the respective clicked web page.

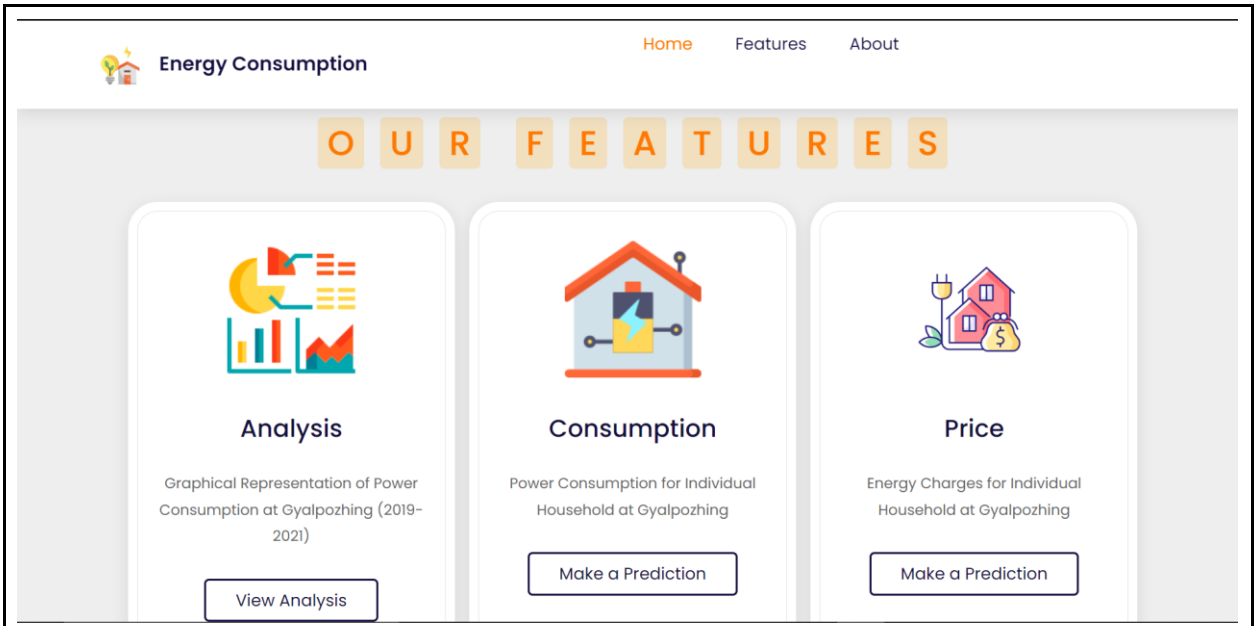


*Figure 12.3: Home Page, Features*

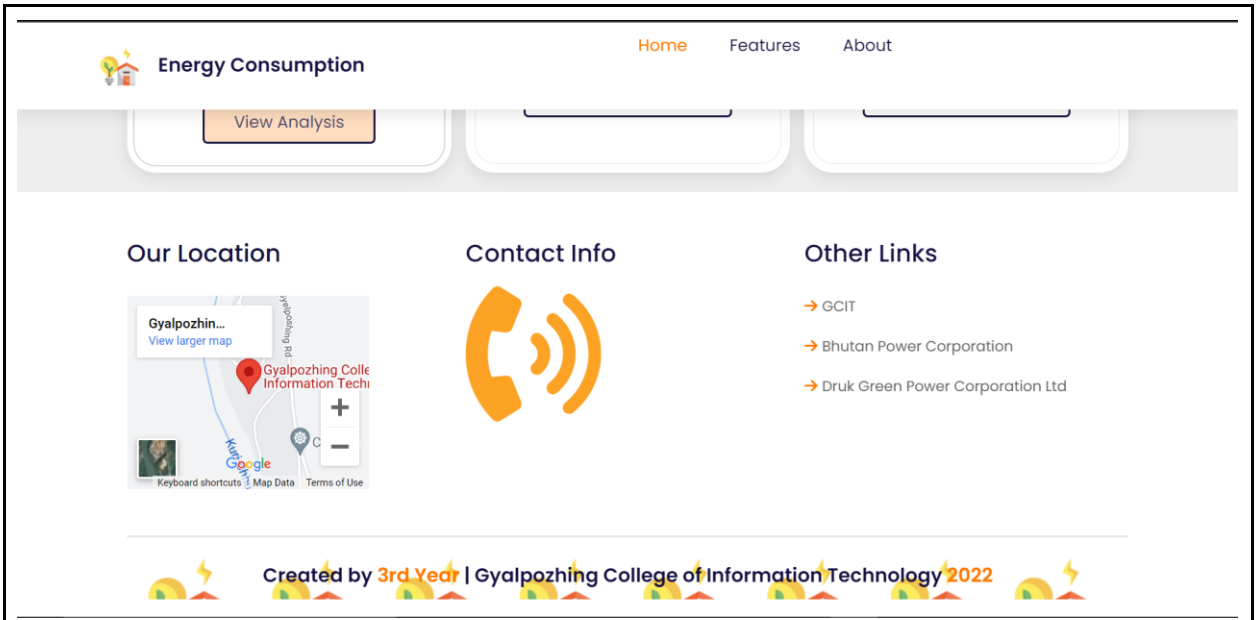


*Figure 12.4: Home Page, Footer*

Footer: The Home Page also consists of a footer which contains basic information and links related to the website. It contains an interactive map of Gyalpozhing College of Information Technology which can be zoomed in and out. The contact info in the footer when clicked will navigate the website to the About page of the website.

### 12.2.2 ABOUT PAGE

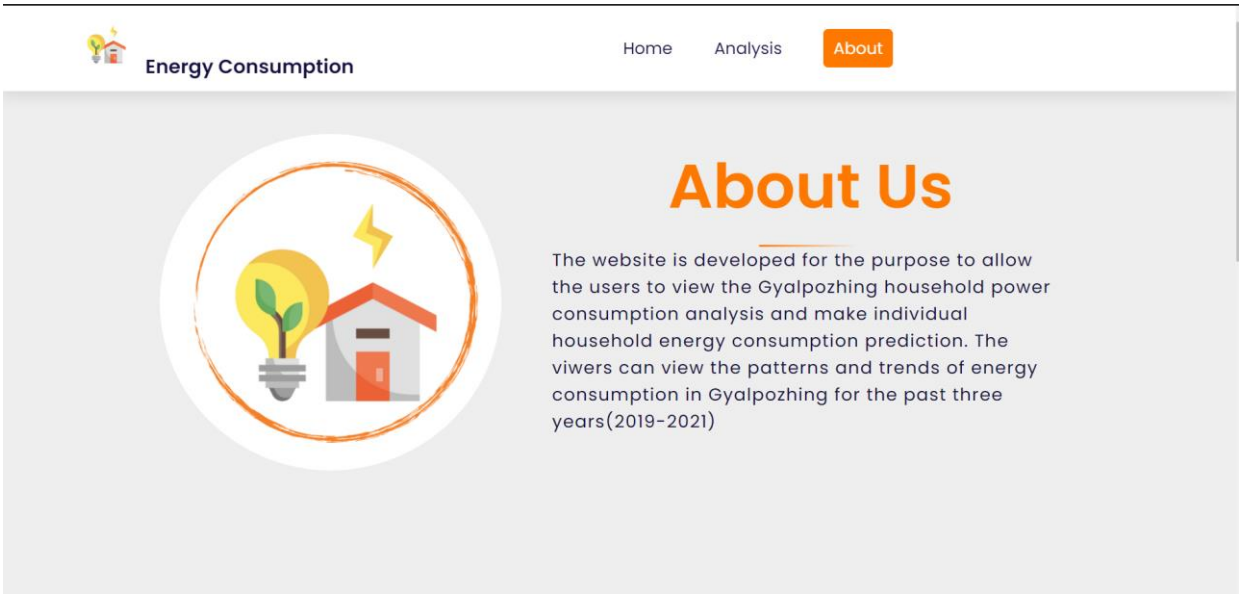


*Figure 12.5: About Page*

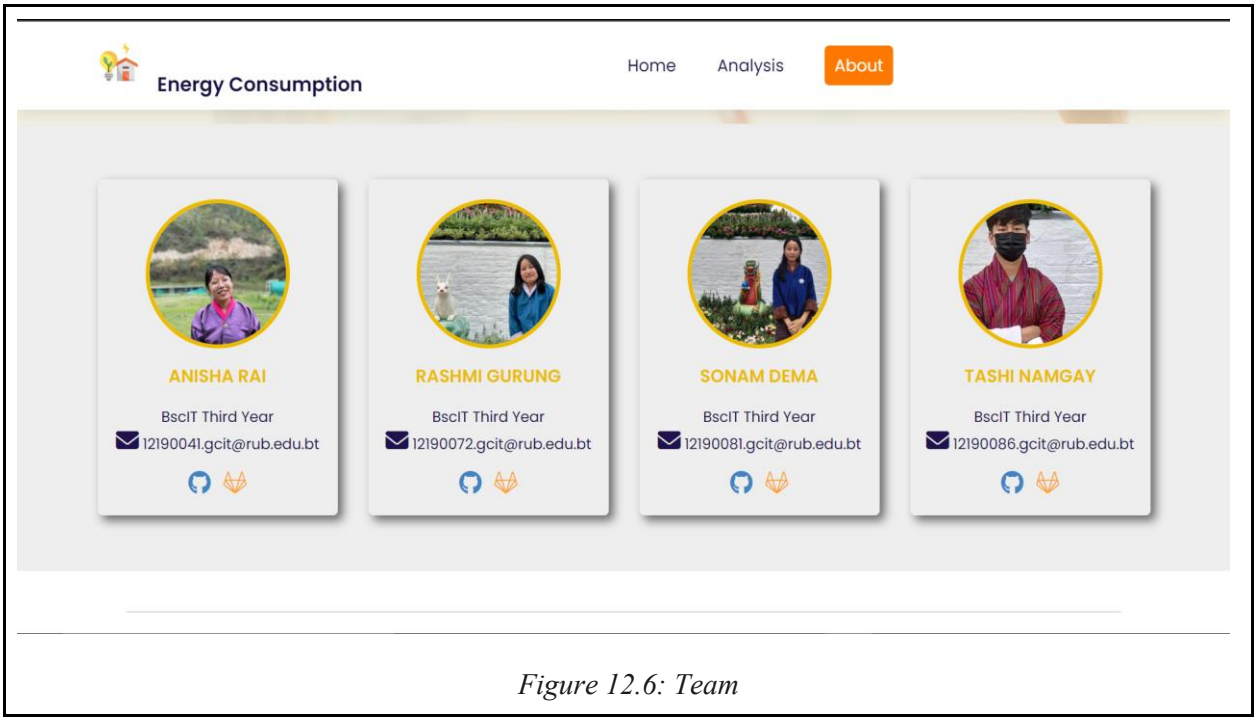


*Figure 12.6: Team*

When clicking on either 'About' from the navigation bar or the 'Contact info' from the footer will navigate the website to the About page. The About page consists of a brief description about the website along with a picture of the website's logo. At the bottom, the names of the team members along with their pictures and Gmail, Github and Gitlab links are provided.

### 12.2.3 ENERGY CONSUMPTION PREDICTION PAGE

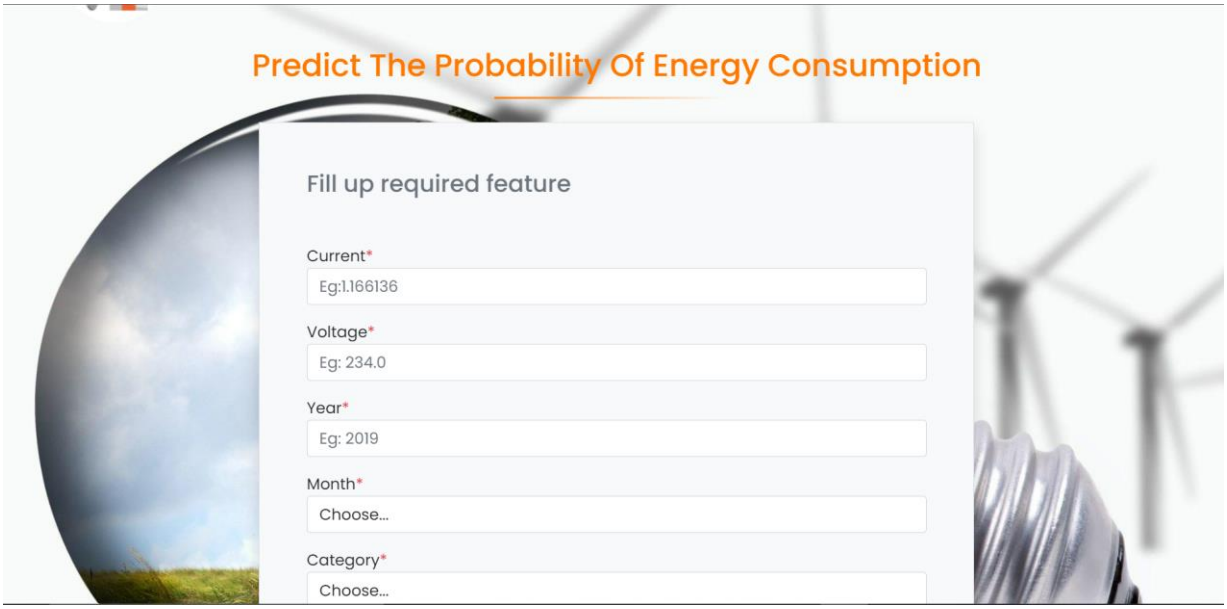


*Figure 12.7: Energy Consumption Prediction Page*

The energy consumption page consists of a form which has six fields which requires the user input to make the prediction. The fields are as follows:

- **Current:** This field only accepts the numeric values, no special characters or text input will be accepted as the current is numeric in nature.
- **Voltage:** This field also only accepts the numeric values like the current field.
- **Year:** This field accepts the only whole numbers, no float or text input will be accepted in this field.
- **Month**
- **Category**
- **Portion**

For the Month, Category and Portion fields, it has a drop down option to choose from.

After filling all the fields, the user has to click on the 'Prediction' button which will give a predicted power consumption.

### 12.2.4 PRICE PREDICTION PAGE

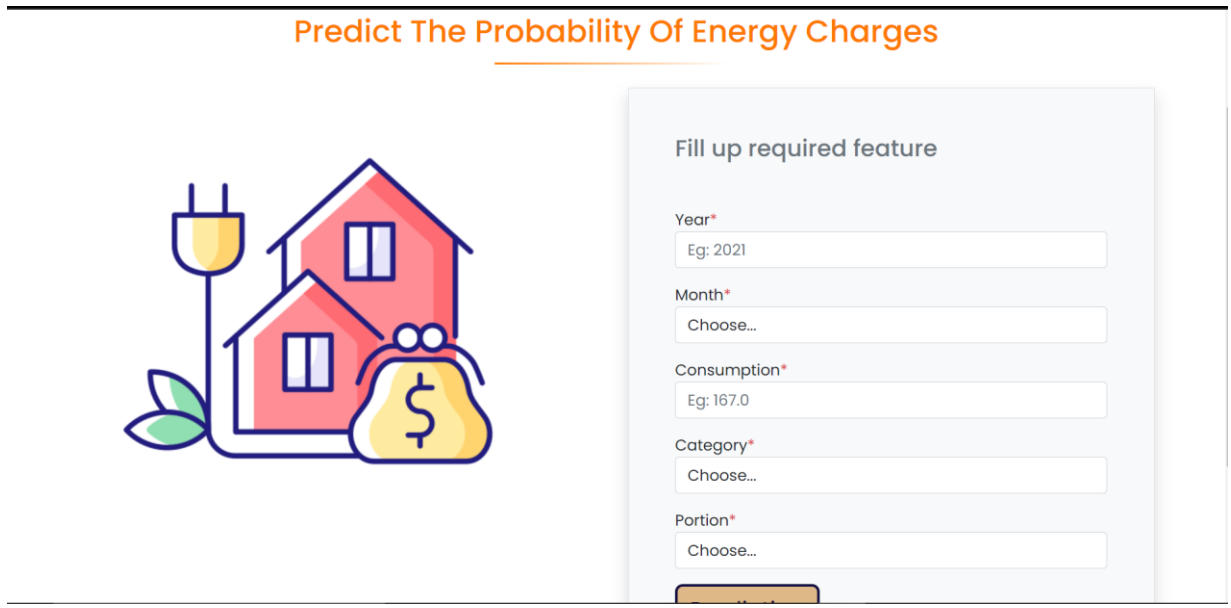


*Figure 12.7: Price Prediction Page*

The price prediction page consists of a form which has five fields which requires the user input to make the prediction. The fields are as follows:

- **Year:** This field accepts the only whole numbers, no float or text input will be accepted in this field.
- **Consumption:** This field only accepts the numeric values, no special characters or text input will be accepted.
- **Month**
- **Category**
- **Portion**

For the Month, Category and Portion fields, it has a drop down option to choose from.

After filling all the fields, the user has to click on the 'Prediction' button which will give the predicted price.

# 13 CONCLUSION

There has been no software, application and website created to predict the power consumption in Bhutan or Gyelpozhing Community. People are using power without any prior knowledge of how much they are consuming in a month or in a year. Only through research or analysis of the past power consumption of a community gives a vague idea about it, however it doesn't give any idea based on the future power consumption. The project we are working on has features that can predict the future power consumption of Gyalpozhing community. It can predict the consumption of power for households too. It is a web application developed to predict in an easy, effective and efficient manner. It is an easy to use and efficient website specifically designed for the purpose of predicting power consumption of Gyalpozhing community.

This website is also proven to be beneficiary. It has shown that it is advantageous for both users as well as the organization and institution who is organizing and supplying electricity to the whole community. It is built using Machine learning, Django (framework/design) and Python(programming language). The system is incorporated with features that help to give accurate predictions. The main motive of this web application is to predict easily, efficiently, accurately and without much effort. In addition, using this application is cost efficient and it gives a clear idea for the power consumption for the future. The result generation is very fast and accurate. The system is easily accessible and less time consuming.

# 14 ACHIEVEMENT

This web application is not a final product and needs many improvements but the result achieved so far is enough to conduct a decent energy consumption and price prediction. And the achievements so far are as follows:

- Machine learning models with high accuracy and low MSE basically give a good energy consumption prediction.
- User friendly, interactive, efficient and portable web application.
- Successful integration of the machine learning model.
- Successful integration of the Django plotly dash for visualization purposes.
- Successfully deployed in Heroku.

# 15 FUTURE WORKS

The development of this web application is not a final one as more additional features can be added and changes can be made to make this web application more effective and useful. Some of the additional works to be implemented in this application in the near future are as follows:

- Increase the scope: The scope of the project is limited to future Gyalpozhing community but in the future, we can increase the scope to Mongar Dzongkhag or even Bhutan as a whole. This will require more time and resources but is doable.

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