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ACHIEVING OPTIMAL SOLAR PANEL PLACEMENT WITH RESPECT TO SOLAR RADIATION AND GENERATION

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ABSTRACT:

There are various types of renewable energy, the most attention has been on solar energy since it can convert energy directly into electricity. Maximizing the efficiency of solar energy systems is crucial for harnessing the full potential of this renewable resource. This project focuses on leveraging machine learning (ML) techniques to enhance solar power generation by accurately predicting solar radiation levels. These models continuously analyse incoming data from weather stations and sensors to predict solar radiation levels for specific time intervals. Finally, its help to predict the suitable place for fixing the power panel based on the solar power generation and solar radiation.

KEYWORDS: *Machine Learning algorithms, Solar power, Solar electricity, Random-forest algorithm.*

INTRODUCTION:

The industry has taken a shift towards clean and renewable energy production instead of the age-old process. Electricity forecasting means the process of managing power systems in the dynamic climatic conditions. In operation planning, scheduling, and real-time power system balance, forecasting is crucial. In today's power systems, electricity load, pricing, and renewable energy sources are the three main forecasting concerns. The solar power industry has experienced significant growth and has assumed a leadership position among the recently developed renewable sources of energy (solar energy). Solar energy has been the most sought-after energy type of-late. Since it is considerably easy to generate solar power instead of the other various power systems. Even though it has its own negative side, Solar power is termed as an emerging trend since it is easier and more efficient in terms of renewable energy.

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LITERATURE REVIEW:

1-Rahim Zahedi, Erfan Sadeghitabar, Abolfazl Ahmadi [1] - Solar Energy Potential in South-Eastern Iran

The implemented a system to assess the solar energy eventuality for electricity generation along the south- eastern seacoast of Iran. They employed methods such as Potentiometry, GIS, site selection, and AHP. The research underscores the considerable benefits of solar energy, emphasizing its direct conversion into electricity and heat, ease of use, and endless availability.

However, the study also acknowledges challenges inherent in large-scale solar power plant implementation. Some challenges to be considered here are the climate change, ecosystem impact and land use, high initial investments, and the need for careful economic viability analysis.

The importance of sustainable energy planning and point selection for solar power shops is emphasized, particularly in the environment of the south- eastern seacoast of Iran. The overarching goal is to contribute to the region's overall growth and development through the efficient utilization of solar energy.

Factors	Weights (%)
Land scope	21
The main faults	12
Beach	26
Urban areas	11
Rural areas	7
Permanent rivers	10
Land use	13

Figure 1 – Factors and their weights percentage

The AHP method is utilized to determine the final weights assigned to each criterion in the calculation of indicators.

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2-Daning Hao et al. [2] - Solar Energy Harvesting Technologies for PV Self-Powered Applications

The perpetration of solar energy harvesting technologies for photovoltaic(PV) tone- powered operations, enforcing styles similar as Maximum Power Point Tracking(MPPT) in PV systems.

Acknowledging the potential of PV self-powered technologies, the study underscores the importance of recognizing certain disadvantages inherent in these systems. One prominent drawback highlighted is the intermittency of solar energy, leading to fluctuations in power generation. The dependence on sunlight renders these systems less reliable during adverse weather conditions or at night, necessitating supplementary energy storage solutions.

Moreover, the research points out the substantial initial costs associated with implementing PV Self-powered applications. This includes expenses related to the purchase and installation of solar panels and associated infrastructure. The efficiency of PV systems is also noted to be told by factors such as location, shading, and maintenance requirements.

The points to be considered here are the easy disposal of the boards as well as the environmental care that it provides. Despite this, sustainability challenges persist, emphasizing the need to balance these drawbacks with ongoing advancements in technology. Such a balance is deemed crucial for the widespread adoption and effectiveness of PV self-powered applications.

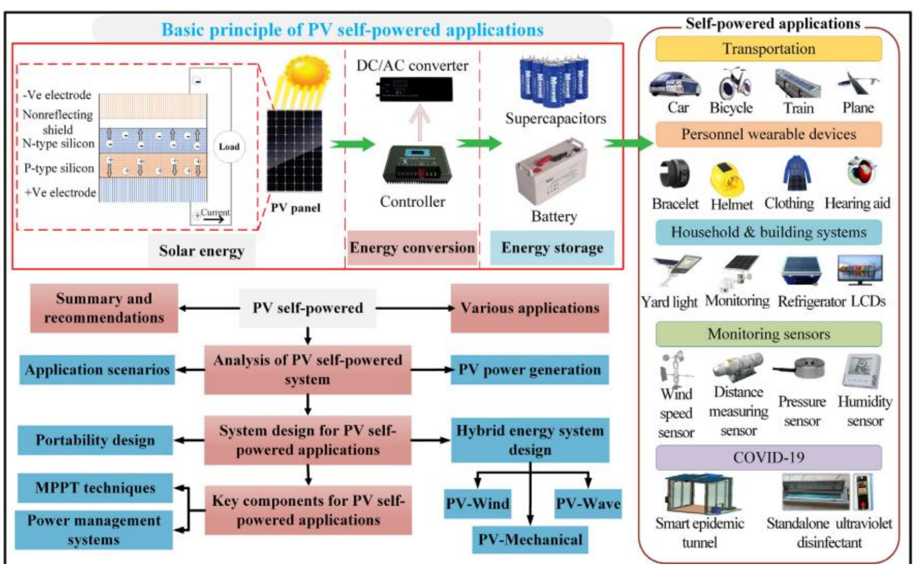

Figure 2 - Self-powered photovoltaic (PV) technologies

3-Sumedha R.G. Weliwaththage et al. [3] - Solar Energy Technology

The solar energy technology, specifically employing methods such as concentrated photovoltaic technology (CPV), which is considered novel in the field of solar power technology.

The study begins by highlighting the critical distinction between renewable and non-renewable energy resources, driven by increasing environmental concerns such as air pollution, climate change, and resource depletion. In this context, solar energy takes center stage as a pivotal and widely discussed resource within the realm of renewable energy.

Given the global population surge and escalating energy demands, the research emphasizes the pressing need for advancements in solar energy technologies. These advancements are deemed essential to enhance energy efficiency and meet the ever-growing energy demands.

A significant limitation of traditional solar cells is addressed, specifically their inability to generate electricity at night. Focused on innovation and improvements, the study explores the current state of solar energy technologies and offers a future perspective. The necessity for continuous development is underscored to align with evolving global energy requirements, positioning solar energy as a crucial resource in the sustainable energy landscape.

Voltage	Current	Power	Concentration
12.98	1.91	24.84	Without
15.02	1.92	28.838	1 mirror
15.43	1.93	29.625	Plus cooling
16.11	1.94	31.253	2 mirrors
16.50	1.94	32.011	Plus cooling
16.71	1.95	36.929	3 mirrors
16.91	2.23	37.709	Plus cooling

Figure 3 - The differences in current, voltage, and power in relation to attention and cooling are critical factors under consideration.

4 - Mohammad H. Ahmadiet.al [4]Solar power technologyfor electricity generation

Solar power technology for electricity generation, addressing the increasing recognition of detrimental environmental consequences associated with fossil fuel consumption. This awareness has led to people being interested in energy sources, with solar energy gaining considerable attention, especially in the realm of electricity generation.

The study explores various solar energy technologies, where both direct and indirect methods of generating solar power for electricity production are discussed. The approach seemingly has the use of Photovoltaic(PV) modules that are then used to convert the energy . In discrepancy, the circular system focuses on employing thermal energy through concentrated solar power(CSP) shops, similar as Linear Fresnel collectors and parabolic trough collectors.

The study discusses associated barriers and opportunities within these technologies. Additionally, a comparative analysis is conducted between modules to convert solar irradiation directly into electricity. In discrepancy, the circular system focuses on employing thermal energy through concentrated solar power(CSP) shops, similar as Linear Fresnel collectors and parabolic trough collectors.

This literature survey contributes to a nuanced understanding of the strengths, limitations, and economic implications of different solar energy technologies for electricity generation.

Total field area (m^2)	Fuel consumption (kg/h)	CO_2 emission (kg/h)
3000	615291.53	703893.51
6000	589792.76	674722.84
9000	539566.43	617264.00
120 000	448437.20	513012.16

Figure 4 - Hybrid parabolic trough collector is aimed at achieving fuel savings through an innovative approach to solar energy harnessing.

OBJECTIVE:

- The main aim of the project is to predict the suitable place for fixing the power panel based on the solar power generation and solar radiation.
- The algorithm has been proposed and compare to get the better accuracy in finding solar power generation and solar radiation.

CHALLENGES:

Solar power generation has many challenges that starts out from the intermittent and variable nature of solar power, as there may be many fluctuations in the way sunlight is being precepted in regions. This intermittency poses difficulties in meeting constant energy demands, necessitating the development of efficient energy storage solutions. Geographical limitations, such as cloudy weather or high latitudes, further impact the reliability and efficiency of solar panels. There are places where we need large amount of land for a bigger setup. Material availability, environmental impact during manufacturing and decommissioning, and the need for ongoing technological advancements also present challenges. Additionally, integrating solar power into existing energy grids and addressing regulatory frameworks for grid stability require concerted efforts. Overcoming these challenges is crucial for maximizing the potential of solar power as a sustainable and widespread energy source.

PROPOSED SYSTEM:

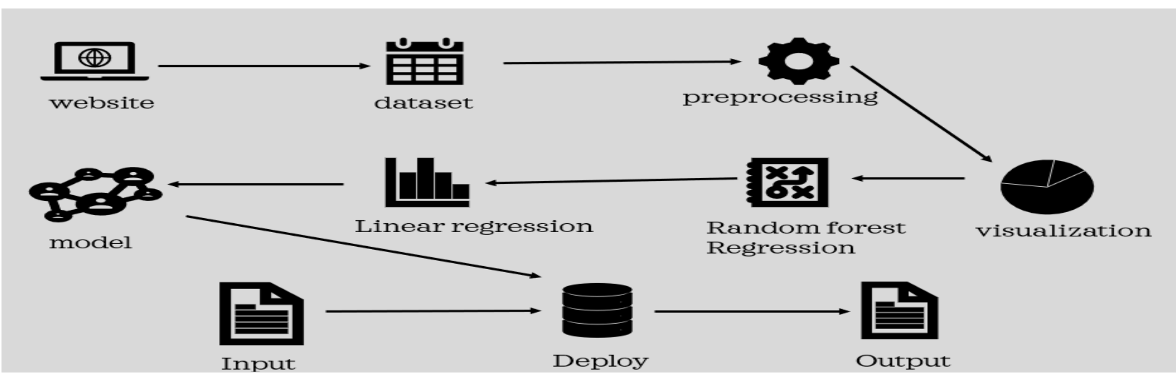

Figure 5 – Image depicting the proposed system.

DATA COLLECTION:

This Dataset contains 8760 records from various weather features which can be analyzed and used as predictors. It Contains

- System Power Generated
- Solar Speed
- Solar Direction
- Pressure
- Air Temperature

LIST OF MODULES:

- Data Pre-processing
- Data Visualization
- Random forest Regression
- Linear Regression
- Deployment

MODULE DESCRIPTION

1. DATA PRE-PROCESSING

The actual meaning of data pre-processing would be that the noise present in the data is removed. Noise in data may lead to mis-calculations when the output is generated. Hence, to avoid abnormal output or to get the clearer version of the output, noise-removal or data pre-processing needs to be done. The figure 6 gives us the sample dataset that is taken for the testing of the algorithms and predicting the outcome using both Random Forest and Linear regression methods. The figure 7 gives us the data representation as present in the dataset. This can be named as the way the data is recorded in the dataset.

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	Day of Year	Year	Month	Day	First Hour of Period	Distance to Solar Noon	Average Temperature (Day)	Average Wind Direction (Day)	Average Wind Speed (Day)	Sky Cover	Visibility
count	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000	2919.000000
mean	183.282631	2008.665982	6.524495	15.715999	11.501542	0.503327	58.468996	24.957862	10.099486	1.987667	9.559609
std	105.751253	0.471727	3.448038	8.795825	6.875714	0.298069	6.842318	6.912203	4.837128	1.412220	1.380290
min	1.000000	2008.000000	1.000000	1.000000	1.000000	0.050401	42.000000	1.000000	1.100000	0.000000	0.000000
25%	92.000000	2008.000000	4.000000	8.000000	5.500000	0.232061	53.000000	25.000000	6.600000	1.000000	10.000000
50%	183.000000	2009.000000	7.000000	16.000000	13.000000	0.479241	59.000000	27.000000	10.000000	2.000000	10.000000
75%	275.000000	2009.000000	10.000000	23.000000	17.500000	0.739559	63.000000	29.000000	13.100000	3.000000	10.000000
max	366.000000	2009.000000	12.000000	31.000000	22.000000	1.141361	78.000000	36.000000	26.600000	4.000000	10.000000

Figure 6 – Sample Dataset.

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 2919 entries, 0 to 2919
Data columns (total 16 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   Day of Year                           2919 non-null   int64
 1   Year                                  2919 non-null   int64
 2   Month                                 2919 non-null   int64
 3   Day                                   2919 non-null   int64
 4   First Hour of Period                  2919 non-null   int64
 5   Is Daylight                           2919 non-null   bool
 6   Distance to Solar Noon                2919 non-null   float64
 7   Average Temperature (Day)             2919 non-null   int64
 8   Average Wind Direction (Day)          2919 non-null   int64
 9   Average Wind Speed (Day)              2919 non-null   float64
 10  Sky Cover                             2919 non-null   int64
 11  Visibility                            2919 non-null   float64
 12  Relative Humidity                     2919 non-null   int64
 13  Average Wind Speed (Period)           2919 non-null   float64
 14  Average Barometric Pressure (Period)  2919 non-null   float64
 15  Power Generated                       2919 non-null   int64
dtypes: bool(1), float64(5), int64(10)
memory usage: 367.7 KB
```

Figure 7 – Sample data Representation

MODULE DIAGRAM

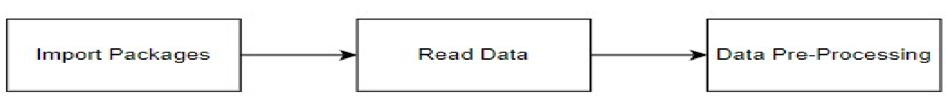

Figure 8 - Module diagram representing overall flow.

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The module diagram gives us the overall work-view as it is shown in Figure 8. Here, the packages are imported, then the data is read from those packages. Later on, the pre-processing process is done so as to get the error-less data for further research.

GIVEN INPUT EXPECTED OUTPUT

Input : data Output : removing noisy data

2. DATA VISUALIZATION

Visualization would mean how the data is represented to the user. The various modes of visualization includes graphs, charts, flow-diagrams and Smart-art features. This would enable the user to get a clear-cut view of the upcoming processes and would also help in comparison of two or more products. Here, the data is visualized with the help of bar charts to show the variations or difference with respect to their parameters as shown in Figure 9.

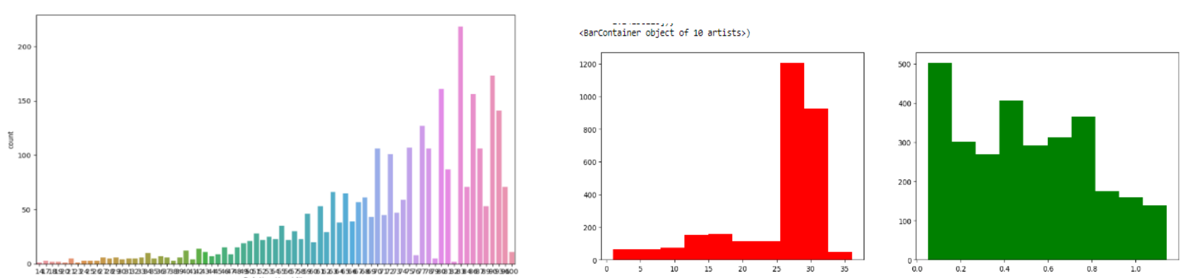

Figure 9 – Sample Visualization of data.

MODULE DIAGRAM

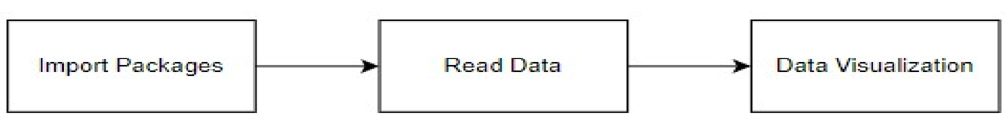

Figure 10 - Module diagram to represent data visualization process.

Here, the figure 10 shows us the process of data visualization. It is shown that the packages are imported and data is read. Later on, the data is visualized or presented in a way where the user can understand it just by going through the charts or graphs alone.

GIVEN INPUT EXPECTED OUTPUT

Input : data
Output : visualized data

3. RANDOM FOREST REGRESSION

Random Forest regression method in machine learning would mean that multiple decision trees are used and their predictions are combined. This combination's mean is then taken as the output for the whole. This would mean that the output is not dependent on one decision tree alone; instead, it covers various decisions trees. A single decision tree has high varience, but when multiple of them are combined, the varience turns out less than the whole of it. The part where the mean of all the decision trees is combined is called as Aggregation.

The figure 11 shows various functions in accordance with the Random Forest Regressor. They are inbuilt functions that give us the Accuracy score, Varience score, Mean squared error score, Mean absolute error score from the given data.

```
from sklearn.metrics import r2_score
R2 = r2_score(y_test,predicted)
print("THE R2 SCORE OF RandomForestRegressor IS :",R2*100)

THE R2 SCORE OF RandomForestRegressor IS : 90.5396819430449

from sklearn.metrics import rand_score
RAND = rand_score(y_test,predicted)
print("THE ACCURACY SCORE OF RandomForestRegressor IS :",RAND*100)

THE ACCURACY SCORE OF RandomForestRegressor IS : 90.29093281148076

from sklearn.metrics import explained_variance_score
EVS = explained_variance_score(y_test,predicted)
print("THE EXPLAINED VARIENCE SCORE OF RandomForestRegressor IS :",EVS)

THE EXPLAINED VARIENCE SCORE OF RandomForestRegressor IS : 0.9054034946192723

from sklearn.metrics import mean_squared_error
MSE = mean_squared_error(y_test,predicted)
print("THE MEAN SQUARED ERROR SCORE OF RandomForestRegressor IS :",MSE)

THE MEAN SQUARED ERROR SCORE OF RandomForestRegressor IS : 9964273.478743378

from sklearn.metrics import median_absolute_error
MAE = median_absolute_error(y_test,predicted)
print("THE MEAN ABSOLUTE ERROR SCORE OF RandomForestRegressor IS :",MAE)

THE MEAN ABSOLUTE ERROR SCORE OF RandomForestRegressor IS : 236.72500000000002
```

Figure 11–Output using Random Forest Regression

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MODULE DIAGRAM

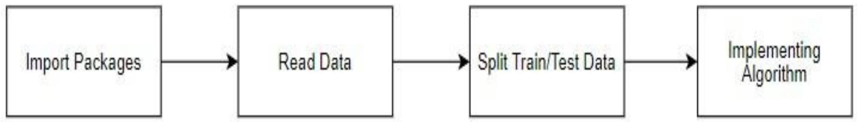

Figure 12 - Process flow shown in the means of module diagram

The figure 12 gives us the way how packages are imported and the data is got from them. Later the testing and training data is split from the dataset. At the end, the algorithm is implemented accordingly.

GIVEN INPUT EXPECTED OUTPUT

input : data output : getting accuracy

4. LINEAR REGRESSION

Linear regression is a supervised machine learning algorithm where it formulates the relation between one dependent variable and one or more independent variable. The said relationship is received using a linear equation that it formulates. When there is only one independent variable, it would be called as Simple linear regression and when there are more than one independent variable, it is termed as Multiple linear regression. In the same way, if there is only one dependent variable, it is called as Univariate linear regression and when there are more than one, it is termed as Multivariate regression.

The figure 13 describes the output received from Linear regression with the use of the dataset that was considered earlier. It gives us the Accuracy score, Varience score, Mean square error score, Mean absolute error score in the context of linear regression.

```
from sklearn.metrics import r2_score
R2 = r2_score(y_test,predicted)
print("THE R2 SCORE OF LINEAR REGRESSER IS :",R2*100)
```

```
THE R2 SCORE OF LINEAR REGRESSER IS : 55.79949826470872
```

```
from sklearn.metrics import rand_score
RAND = rand_score(y_test,predicted)
print("THE ACCURACY SCORE OF LINEAR REGRESSER IS :",RAND*100)
```

```
THE ACCURACY SCORE OF LINEAR REGRESSER IS : 97.75685414128289
```

```
from sklearn.metrics import explained_variance_score
EVS = explained_variance_score(y_test,predicted)
print("THE EXPLAINED VARIENCE SCORE OF LINEAR REGRESSER IS :",EVS)
```

```
THE EXPLAINED VARIENCE SCORE OF LINEAR REGRESSER IS : 0.5581262629005517
```

```
from sklearn.metrics import mean_squared_error
MSE = mean_squared_error(y_test,predicted)
print("THE MEAN SQUARED ERROR SCORE OF LINEAR REGRESSER IS :",MSE)
```

```
THE MEAN SQUARED ERROR SCORE OF LINEAR REGRESSER IS : 43911.78347656334
```

```
from sklearn.metrics import median_absolute_error
MAE = median_absolute_error(y_test,predicted)
print("THE MEAN ABSOLUTE ERROR SCORE OF LINEAR REGRESSER IS :",MAE)
```

```
THE MEAN ABSOLUTE ERROR SCORE OF LINEAR REGRESSER IS : 124.14957117180617
```

Figure 13 – Output using the Linear Regression method

MODULE DIAGRAM

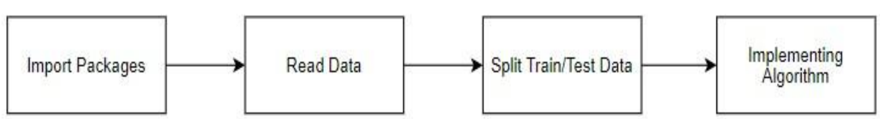

Figure 14 - Module diagram representing implementation with respect to linear regression.

The figure 14 gives us the module diagram of the implementation. It remains the same as described for the Random Forest regression, except for the change in the algorithm.

GIVEN INPUT EXPECTED OUTPUT

input : data output : getting accuracy

5. DEPLOYMENT

Solar energy, as said the earlier sections, holds a high regard in terms of renewable energy. The "Central tower Solar thermal Power plant " is created using Jarallax JS, an open-source platform. Here, as described in the figure 15, it has large number of mirrors, also known as Heliostats which are capable of changing directions. This is used to capture maximum solar radiation and concentrate that on a specific point. Then, the heat is transmitted to a thermally conductive fluid that further as its temperature increases, becomes steam and creates a thermodynamic cycle.

Here, the solar radiation and generation pages are displayed in figures 16 and 17 respectively. The solar radiation page gets the values of Temperature, Pressure, Humidity, Wind-direction and its speed from the user. Then it is directed to the Generation page, where the values such as Distance to the sun at noon, average temperature during day time, average wing speed and direction during day time, Visibility, relative humidity, Average barometric pressure period are all recorded.

Figure 15 – Homepage

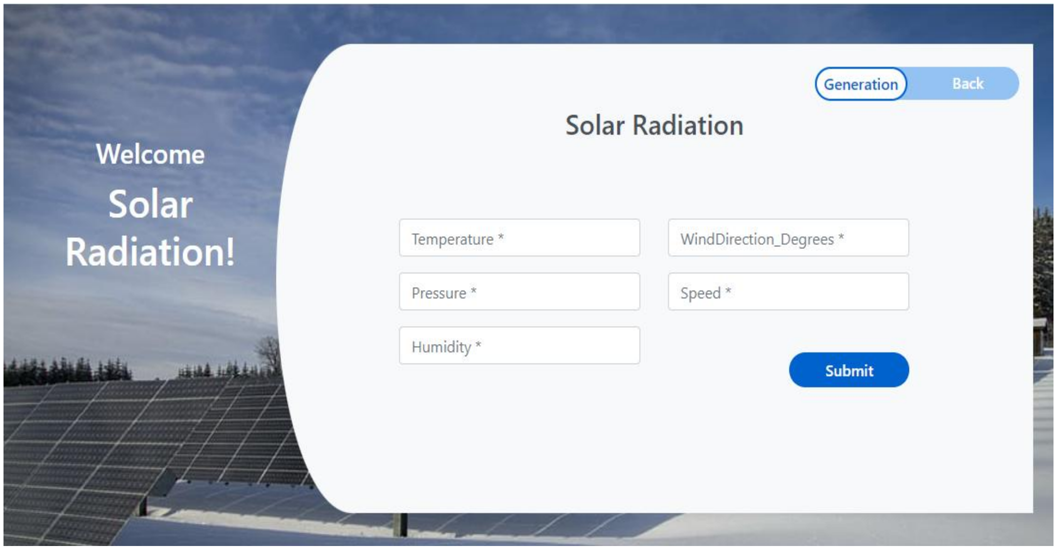

Figure 16 – Solar Radiation Page

Figure 17 – Solar Generation Page

CONCLUSION:

In this project, two algorithm such as Random Forest Regression and Linear Regression has been proposed to generate the solar power generation and solar radiation. The result of the two algorithms are verified and discussed to predict the exact place to fix the power panel based on sunlight condition.

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