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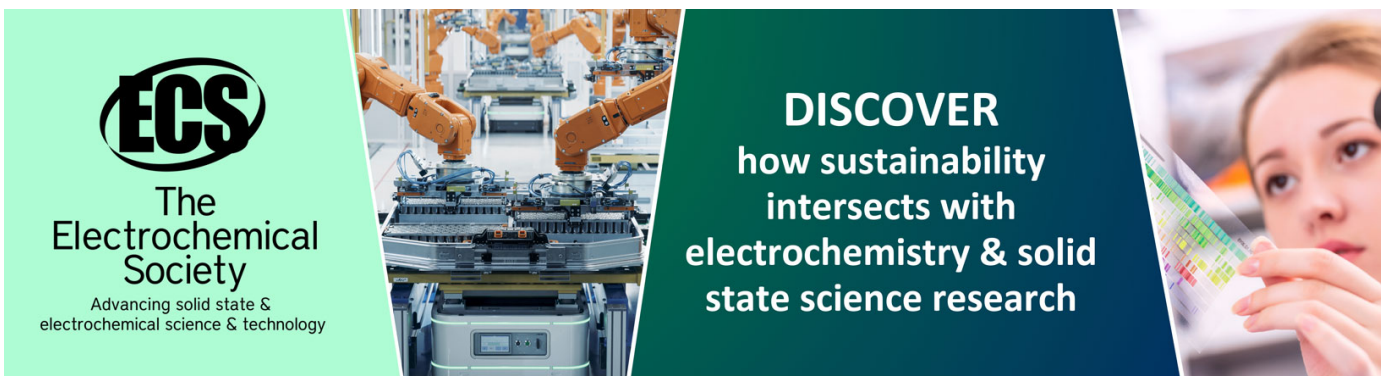
## Climate Variability and Renewable Energy Planning

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# Climate Variability and Renewable Energy Planning

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**Abstract.** The impact of climate change is a global event. Its significant role in the climate system altered meteorological parameters over geographical locations. MISR satellite data have shown that climatic variability has impact on rainfall and surface vegetation; and increased aerosol loading and solar radiation. This research comparatively compared the meteorological parameters as well as its potentially accruable energy. The dataset was obtained from the automatic weather station (AWS). The location of research is Ota, southwest region of Nigeria. The research recommends that a more sophisticated technology may be required to boost wind and solar energy generation in the area.

## 1. Introduction

The reality of climate change and its effect on rainfall, surface temperature, solar radiation, surface vegetation, aerosol retention etc. are quite alarming in recent times [1]. In the West African tropics, there is reduced thermal comfort as a result of increased solar radiation [2]. Satellite measurement has shown that renewable energy parameters (such as wind and solar activities) are significantly altered. For example, Hall and Peyrille [3] reported that there are sharp seasonal differences in low-level winds and variability in monsoon winds. In other words, climate variability has intense impact on the meteorological parameters required for renewable energy planning. Also, solar irradiance dataset have been very dynamic in recent time [1], hence solar energy budgeting is becoming difficult by the day. More worrisome is the fact that the lifespan of photovoltaic (PV) module is grossly affected in the tropical region of West Africa.

In this research, two salient meteorological parameters were considered in reviewing renewable energy planning i.e. solar radiation and wind speed. Also, the meteorological parameters and its accruable renewable energy were examined to guide energy specialist on the choice of relevant technologies - required to acquire maximum usage of natural resources in Ota, Nigeria.

Ota is located on latitude 7.9452° N and longitude 4.7888° E of southwest Nigeria. The research location is a fast growing town with a population of over 300,000 [4]. The climate in Ota is classified as Aw by the Köppen-Geiger system [5].

## 2. Methodology

The dataset was obtained from the automatic weather station (AWS) located at the Covenant University, Ota (Figure 1). The dataset coverage was for the year 2014. The solar radiation and the solar energy were obtained as primary parameters in the automatic weather station. The interpretation of the graph was done using the CERN Root open source application. The optimized version of the solar energy was calculated using parameters such as solar panel dimension (of 1.2m by 0.5m), solar panel yield (of 0.45), average solar radiation (obtained from dataset) and performance ratio of 0.75. The optimized energy from the wind was obtained-using the air density (1.225), length of the wind blade (1 m, 2 m, 3 m, 12 m, 13 m, 14m and 15 m) to calculate the swept area, and the wind speed



obtained from the dataset. The distribution plot, conventional plot and 3D plot were used to illustrate salient observation in the dataset.



Figure 1: Map of Ota

### 3. Results and Discussion

The meteorological parameter (solar radiation) obtained from the AWS is shown in Figure 2a. The magnitude of the solar radiation within the year is almost uniform as shown in Figure 2a. Hence, the effect of solar shading as described by Emetere et al. [6] can be controlled with the help of emerging materials in photovoltaic (PV) technology. The highest magnitude of the solar radiation within the year is given as 267 W/m<sup>2</sup>. The solar energy as recorded by the AWS show very scanty and low magnitude of solar energy – at the beginning of the year (Figure 2b). A comparative assessment between the solar radiation and the solar energy generated on the AWS may explicitly explain the climate variability on solar energy production. The distribution of the dataset is shown in Figure 2c & d.

The distribution plot shows a number of information. For example, it shows the spot analysis of a dataset distribution. Spot analysis show the concentration of data over a spot or it shows the mode of the dataset values on each spot. For example, the raw dataset in Figure 2b shows scanty data. However, the spot analysis shows that there is a large concentration of solar energy of magnitudes

below 0.4 J. The second information that can be drawn from a distribution plot is the continuity of the dataset. The continuity of a dataset shows the degree of consistency of a dataset. Hence, the possibility of obtaining high error margin is low when the dataset is used to perform mathematical operations or modeling. The third information that can be drawn from distribution plot is the trend features. The trend feature may either describe a mathematical function or relation. It can also describe the area of a shape. The area of the shape can be calculated and may also be used to describe the dataset either in differential or integral form.

Figure 2c show that the solar radiation over the study area is consistent with significant concentration of dataset (yellow color) below 80 W/m<sup>2</sup>. The trend of the distribution plot is almost rectangular. This further corroborates the information in Figure 2a. The distribution plot in Figure 2d obviously shows the significance of climate change on solar energy production. In other words, climate variability is one of the salient factors that must be considered during renewable energy planning. In Figure 1e, a scenario where PV panel of specific parameter described in the research methodology was applied (Figure 2e). Figure 2f, illustrates a 3D plot showing the optimized solar energy that was calculated based on the solar radiation over the study region at a given period of time. The wind analysis is shown in Figures 2a-f.

The wind speed dataset from the AWS is shown in Figure 3a while the wind energy production is shown in Figure 3b. The wind energy production dwindles as shown in Figure 3b. This observation may be worrisome based on the dataset. The wind climate over the study area has been studied exclusively by Akinyemi et al. [7]. Hence, the energy generation would be somewhat unstable. However, adequate deployment of recent technology may stabilize energy production in actual sense [8]. The distribution plot shown in Figures 3c & d corroborates the effect of climate variability on renewable energy production. In Figure 3 e, a scenario of a windmill with wind blade of 15 m was considered. Though the energy production increased (i.e. compared to Figure 3b), it is observed that the trend of the meteorological parameter (wind speed) affects the power output in the system. Also, the use of storage system may stabilize power transmission to end-users. The 3D plot shows the outcome of the optimized wind energy that is calculated from the wind speed over a period of time. Unlike the information on Figure 1g, the outcome in Figure 3g is unpredictable because of the extended influence of climate change on the wind convections.

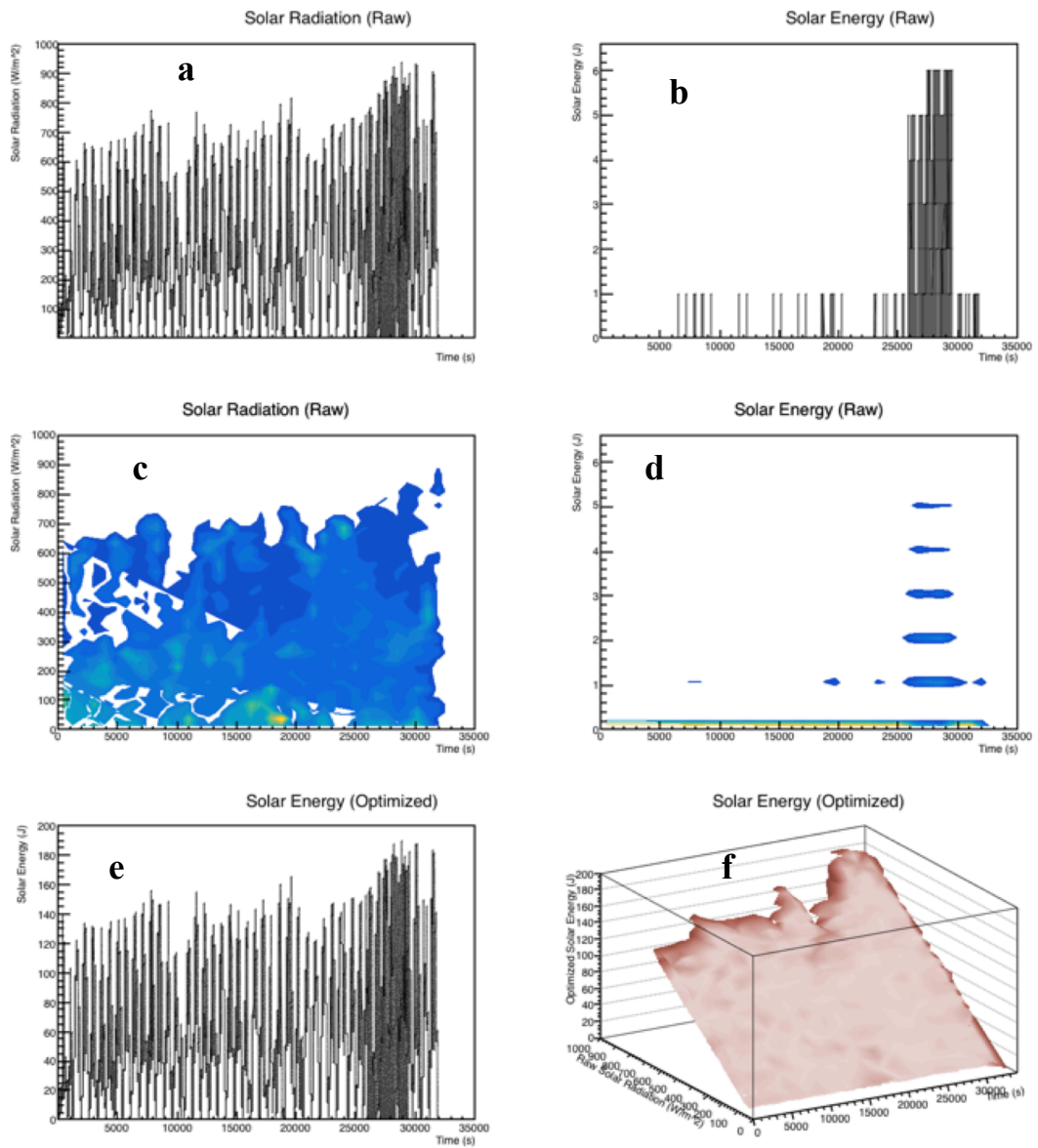


Figure 2: Comparative analysis between meteorological and solar energy parameter

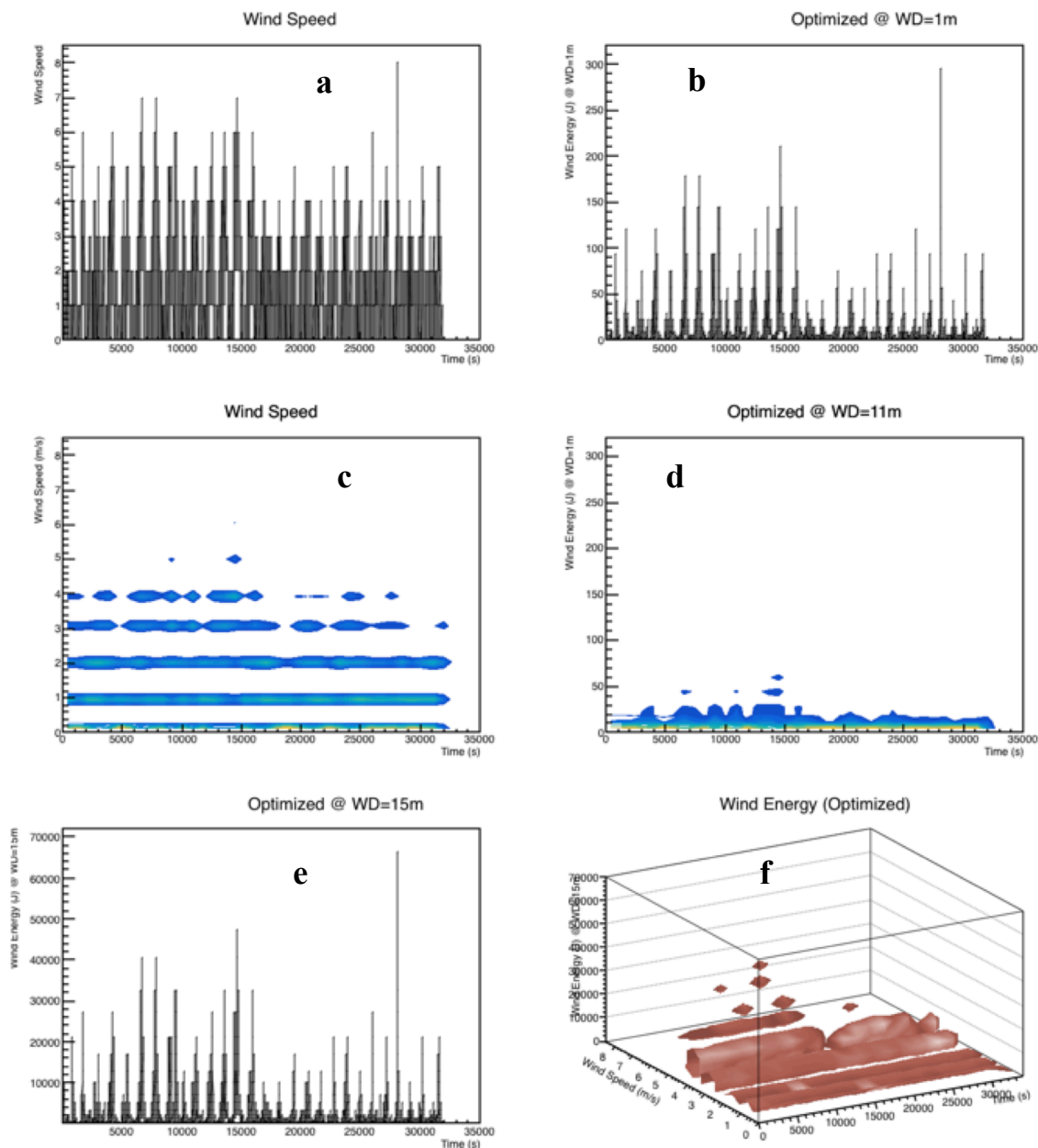


Figure 3: Comparative analysis between meteorological and wind energy parameter

**4. Conclusion**

It is observed that climate variability had significant influence on energy production i.e. considering solar and wind energy generation. However, climate variability was more significant on wind energy production. In other words, it is important for energy experts to consider the climate variability over a geographical location to understand the adequate technology to be used to acquire maximum energy production.

**Acknowledgement**

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