

**MASTER OF SCIENCE IN ELECTRICAL AND COMPUTER ENGINEERING**

**[MSECE]**

**COURSE: 18865: PHOTOVOLTAIC SYSTEMS ENGINEERING**

**HOMEWORK 1: EFFECT OF PANEL TILT AND SEASONAL VARIATION ON SOLAR RADIATION IN SIERRA LEONE**

**MOHAMED ALPHA**

[**malpha@andrew.cmu.edu**](mailto:malpha@andrew.cmu.edu)

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# **1. Executive Summary**

This report presents an analysis of hourly extraterrestrial and clear sky radiation for Sierra Leone, focusing on an equator-facing surface with latitude tilt. The study compares radiation patterns for October 1st and November 1st and examines the effect of panel tilt on radiation reception. Key findings include significant seasonal variations in radiation patterns and the potential benefits of optimizing panel tilt for improved solar energy capture in Sierra Leone.

**2. Introduction**

Sierra Leone, located on the west coast of Africa, has considerable potential for solar energy utilization. This study aims to quantify the solar radiation available in the country by calculating hourly extraterrestrial and clear sky radiation. The analysis focuses on two specific dates ***(October 1st and November 1st)*** and explores the impact of panel tilt on radiation reception.

# **3. Methodology**

## **3.1 Location Parameters**

* Country: Sierra Leone
* Latitude: 8.460555° N
* Longitude: 11.779889° W

## **3.2 Calculation Methods**

Extraterrestrial radiation (G₀) was calculated using the following equation:

**Rb**​ Where:

* G\_sc is the solar constant (1367 W/m²)
* n is the day number of the year
* φ is latitude
* δ is solar declination
* ω is hour angle
* R\_b is the ratio of beam radiation on tilted surface to that on horizontal surface

Clear sky radiation was estimated using a simple model:

## 

## **3.3 Assumptions**

* Albedo: 0.2
* GHI composition: 90% direct, 10% diffuse radiation
* Panel orientation: Equator-facing (south)
* Panel tilt: Equal to latitude (8.460555°) and 20° for comparison

# **4. Results and Analysis**

## **4.1 Hourly Radiation Patterns**

Figure shows the hourly extraterrestrial and clear sky radiation patterns for October 1st and November 1st.

Key Observations:

* **Extraterrestrial Radiation**: Represents solar energy at the top of the atmosphere.
* **Clear Sky Radiation**: Accounts for atmospheric effects reducing surface radiation.
* **Seasonal Impact**: October receives more solar energy than November.

## A graph of a graph Description automatically generated**4.2 Effect of Panel Tilt on Radiation**

Figure illustrates the effect of changing panel tilt from latitude tilt (8.460555°) to 20°.

Key observations :

* A 20° tilt increases radiation received in the morning and evening hours.
* The effect is more pronounced for November 1st compared to October 1st.
* The 20° tilt slightly decreases radiation around solar noon.

## **4.3 Comparison of October 1st and November 1st**

The analysis reveals distinct differences between the two dates:

* October 1st shows higher peak radiation values compared to November 1st.
* The duration of daylight is slightly longer on October 1st.
* Peak extraterrestrial radiation on October 1st: approximately 1150 W/m²
* Peak extraterrestrial radiation on November 1st: approximately 1050 W/m²

*Table 1 shows the comparison between October 1st and November 1st*

|  |  |  |
| --- | --- | --- |
| Graph | Description | Key Observations |
| Graph 1: Effect of Tilt on Clear Sky Radiation | This graph compares the clear sky radiation for October 1st and November 1st with two tilt angles: **Latitude tilt (8.46°)** and **20° tilt**. | * A higher tilt (20°) increases radiation in the morning and evening but slightly reduces peak radiation at noon. * October has higher radiation than November due to more direct sunlight. |
| Graph 2: Hourly Radiation for Sierra Leone (Latitude Tilt) | This graph shows the hourly extraterrestrial and clear sky radiation for October 1st and November 1st with a panel tilted at the latitude (8.46°). | * Extraterrestrial radiation is higher than clear sky radiation due to atmospheric attenuation. * Peak radiation is higher in October (~1400 W/m²) than in November (~1300 W/m²). * Clear sky radiation peaks at ~1000 W/m² in October and ~900 W/m² in November. |

# **5. Discussion**

# **5.1 Seasonal Variations**

The observed differences between October 1st and November 1st reflect the seasonal changes in solar declination. As Sierra Leone moves from October to November, the sun's position in the sky becomes lower, resulting in reduced radiation intensity and shorter daylight hours.

## **5.2 Implications for Solar Energy in Sierra Leone**

The high levels of radiation, even in November, suggest that Sierra Leone has significant potential for solar energy utilization throughout the year. The analysis of panel tilt effects indicates that optimizing tilt angles can enhance energy capture, especially during non-summer months.

## **5.3 Limitations of the Study**

This study has several limitations:

* The analysis is based on clear sky models and does not account for local weather patterns or atmospheric conditions.
* Only two specific dates were analyzed, which may not fully represent annual variations.
* The simple clear sky model used (70% of extraterrestrial radiation) may not accurately reflect all atmospheric conditions in Sierra Leone.

# **6. Conclusion**

The analysis of hourly extraterrestrial and clear sky radiation in Sierra Leone reveals promising potential for solar energy utilization. The country receives substantial solar radiation even as it approaches the winter months, with peak values exceeding 1000 W/m² on clear days. Optimizing panel tilt can further enhance energy capture, particularly during periods when the sun's position is lower in the sky. Future studies should incorporate local weather data and more clear sky models to provide a more accurate assessment of Sierra Leone's solar energy potential. Additionally, analyzing data across the entire year would offer a more comprehensive understanding of seasonal variations and inform better system design strategies.