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Photovoltaic Modules Tilt-Angle Orientations for Optimal Solar Power Production in the Coastal Region

Efenedo Gabriel Ilori[1], Ebisine Ezekiel.Ebimene[2], Okieke Ufuoma Jeffrey[3], Aloamaka Anthony Chukwudi[4]

[1,2,3,4]Department of Electrical and Electronic Engineering, Delta State University, Abraka, Nigeria.

ABSTRACT: The coastal region in Nigeria where Delta State University Abraka, Oleh campus is located in Southern part of the Country that is faced with yearly heavy amount of rainfall. The consistence rainfall hinders effective solar system workability as factors such as humidity, daisy cloud, thunder storm, heavy wind and extreme low temperature tilt-angles of solar panels etc affect solar photovoltaic cells efficiency. This study focuses on investigating the effect of tilt-angle and orientation of the installed solar photovoltaic (PV) modules known solar panels. Experimental tools were employed which include a constructed manual rotating stand, a multimeter and a 100Watt panel to ascertain the various tilt-angles for the given location. The experiment was performed for thirty days over a period of three months (September 2024 to November 2924). Manual rotating the panel for very tilt-angle, the corresponding short-circuit current (SCC) and open-circuit voltage (OSV) were taken on hourly basis. This was employed in the determination of the panel average output power delivery for the period. Finding shows that a $+10^0$ tilt-angle of panel orientation, covers 457.065 square-meters with a maximum accumulated average output power of power of about 130Watt while a tilt-angle of -40^0 covers 264.35 square-meters with a maximum accumulated average output power of of about 60Watt at noon on daily basis. Based on this observation, it is recommended that in Faculty of Engineering, Delta State University Abraka, Oleh Campus, solar panels installations should be positioned at a tilt-angle angle of $+10^0$ to maximize solar energy harvesting and utilization.

KEYWORDS: Tilt-angle, photovoltaic (PV), orientation, simulation

1. INTRODUCTION

Globally, solar power energy demand has gained popularity among the renewable energy sources [1]. One of the components of the solar system is the photovoltaic (PV) panel, invented from semiconductor materials that directly convert sun rays to electrical energy. PV panels are position to form a tilt angle with the horizontal plane in order to extract maximum power from the sun. It is estimated globally that 47% of solar energy gets converted to heat, leading to a lot of energy wastage [2]. The amount of solar radiation on the panels is dependent on the location coordinates. Therefore, the tilt angle of the panels varies in different regions and changes monthly, seasonally and annually [3]. Nigeria has average solar radiation intensity of $5kWh/m^2/day$ and for proper installation of PV panels, an average of 192000MW of solar energy could be produced on daily basis. On In addition, the solar radiation in the coastal region of Nigeria fluctuates around $3.5kWh/m^2/day$ for an average sunshine of about nine hours per day in the dry season and five hours per day in the rainy season [4]. Improper installation of solar panels in compliance to tilt-angle orientations, affect key sector of every Nation economy using solar energy. This include the rapid growth in Information and Communication Technologies (ICTs) that has strong impact on human activities globally including service delivery models of many organizations with respect to healthcare, businesses, education and governance [5]. A case is the role of power supply to e-library equipment most especially as it affects internet connectivity for effective library utilization in Delta State University E-libraries [6].

Following increase awareness of green energy sweeping across developing countries, it is important to calculate the optimum tilt angle of photovoltaic panels for maximum solar power delivery for coastal region such as Oleh Community in Delta State, Nigeria. The daily average solar radiation in Oleh Community is put as 3.87 kWh/m² and the yearly average solar radiation is 1412 kWh/m² [7].

This as a result of drastic dropped in conventional power generation in the Country from 8,000MW with only 4,000MW operational of which only about 1,500MW is available [8]. Hence the need from renewable solar energy alternative.

2.1 Related Works

Researchers all over the world have carried out much work on tilt-angle orientation of solar PV modules for effective solar energy delivery.

In Greece, a study was performed to evaluate PV panel performance for various tilt-angles during summer period in Athens and the optimum result was 15º (±2.5º) as verified theoretically [9].

In Kerala, India, an estimate of installed PV modules tilt-angle was carried out using clearness index and declination angle factors which were compared with experimental results [10].

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In Sanliurfa, Turkey, a mathematical model was employed in the determination
of PV panel tilt-ange using two-axis solar tracker with comparison to fixed PV panel [11].

. In Perlis, Northern Malaysia, tilt angle and global solar irradiance models were formulated while the determination of optimum tilt-angle and orientation for the solar irradiance was performed in Syrian zones using the mathematical model [12, 13].

In Madinah, Saudi Arabia a study based on measured values of daily global and diffuse solar radiation to determine the optimal tilt angle of the solar panel was conducted
and was found that annual optimum tilt angle was nearly equal to the latitude of the city [14].

In Belgrade, yearly, biannual, seasonal, monthly, fortnightly and daily optimum tilt angles of solar searched for the values for which the solar radiation on the collector surface is maximum for a particular day or a specific period [15].

Gunerhan and Hepbasli (Sado et al., 2021) determined the optimum values of tilt angles for solar collectors installed in Izmir, Nigeria and they used the experimental data to apply the model.

Rouholamini et al. According to Skeiker it was estimated the total solar radiation on a tilted angle and calculated the output energy of PV panels using a mathematical model.

. Yadav and Chandel (2013) examined the various methods used for determining the tilt angles of PV panels.

It is seen that the experimental studies in literature focused on the global and diffuse solar radiation calculation to determine the optimum tilt angle. In the study, the monthly optimum tilt angle was determined by examining the energy amount of PV panels placed at 10º, 20º, 30º, 40º, 50º and 60º tilt angles.

Raspberry Pi was used for the store, backup, analysis of the data in the computer environment and to transfer the data to a web page. The some electrical data such as voltage, current and power of PV panels are watched alive from 05:00 to 21:00 every day by the web server set up on Raspberry Pi. The experimental data obtained for summer period was compared with the mathematical analysis results.

3. MATERIALS AND METHODS

The research was carried out in a real-world setting at the Faculty of Engineering, Delata State University Abraka, Oleh campus located within latitude 6° 11' 35'' E and Longitude 5° 26'47''N due East. Figure 1 presents the google map of Oleh Community while Figures 2, 3 and were the experimental setting which include a constructed manually rotating stand, 100Watt PV module and experimental circuit connectivity.

Figure 1. Map of Oleh Community

Figure 2. Constructed manually rotating stand

The manually rotated solar panel stand is a mounting system for solar panels that allows adjustment of the tilt or orientation of the solar panels. It typically consists of a frame or support structure on which the solar panels are mounted. This adjustment helps maximize the solar panels' efficiency in capturing sunlight and its energy generation.

Figure 3. 100Watt PV module

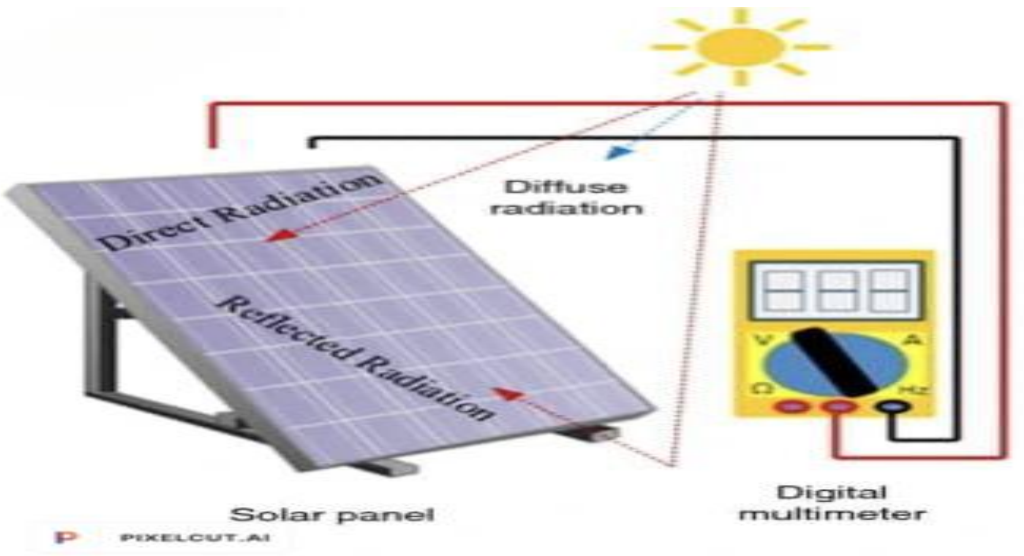

Figure 4. Experimental circuit connectivity

2.1 Data Collection

Data was collected through systematic observations and measurements for detailed analysis of energy production. Data collection were carried out for a duration of 9:00 am to 3:00 pm to capture daily variations in solar energy for period of three months of September-November, 2024. Measurements of solar panel output at various angles, ranging from -40 degrees to 40 degrees, for each hour for thirty days in three months were performed. The produced power output from the panel involve measured short-circuit current (ISC) in amperes (A) and open-circuit output voltage (V). The average daily power output per hour for the three months were performed as programmed in Excel and results for the first ten days out of the thirty days data are presented in Tables 1-10.

Table 1. Average Current Output and Voltage in Day 1

Current /Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	
9:00-9:30am	0.30	0.37	0.47	0.50	0.50	0.53	0.54	0.51	0.50	21
10:00-10:30am	0.50	0.60	0.69	0.77	0.80	0.92	0.91	0.90	0.89	21
11:00-11:30am	1.60	1.90	2.20	2.60	2.90	3.11	3.20	3.20	2.90	21
12:00-12:30pm	2.10	2.25	2.70	3.15	3.00	3.19	3.15	2.90	2.85	21
1:00-1:30pm	1.90	2.10	2.30	2.40	2.60	2.82	2.00	1.80	1.70	21
2:00-2:30pm	0.70	0.70	0.80	0.90	0.90	0.91	0.90	0.89	0.70	21
3:00-3:30pm	0.30	0.40	0.40	0.45	0.46	0.49	0.45	0.40	0.40	21

Table 2. Average Current Output and Voltage in Day 2

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	

9:00-9:30am	**0.60**	**0.75**	**0.85**	**0.90**	**0.95**	**0.96**	**0.90**	**0.85**	**0.80**	**21**
10:00-10:30am	**0.30**	**0.40**	**0.42**	**0.50**	**0.60**	**0.71**	**0.80**	**0.80**	**0.80**	**21**
11:00-11:30am	**1.60**	**1.85**	**2.00**	**2.20**	**2.30**	**2.21**	**2.10**	**2.10**	**2.00**	**21**
12:00-12:30pm	**1.20**	**1.70**	**2.50**	**3.20**	**4.00**	**3.81**	**3.60**	**3.40**	**3.20**	**21**
1:00-1:30pm	**1.30**	**1.60**	**1.85**	**2.10**	**2.10**	**2.01**	**1.90**	**1.70**	**1.60**	**21**
2:00-2:30pm	**1.15**	**1.35**	**1.55**	**1.70**	**1.85**	**1.91**	**1.85**	**1.70**	**1.60**	**21**
3:00-3:30pm	**0.60**	**0.60**	**0.65**	**0.70**	**0.70**	**0.71**	**0.75**	**0.75**	**0.70**	**21**

Table 3. Average Current Output and Voltage in Day 3

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	**-40.00**	**-30.00**	**-20.00**	**-10.00**	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	
9:00-9:30am	**0.55**	**0.65**	**0.75**	**0.90**	**0.95**	**1.05**	**1.00**	**1.00**	**0.90**	**21**
10:00-10:30am	**1.20**	**1.90**	**2.50**	**3.00**	**3.50**	**4.05**	**4.00**	**3.50**	**3.40**	**21**
11:00-11:30am	**1.70**	**1.80**	**1.90**	**2.00**	**2.20**	**2.43**	**2.50**	**2.20**	**2.20**	**21**
12:00-12:30pm	**2.73**	**2.93**	**3.51**	**4.10**	**3.90**	**4.15**	**4.10**	**3.77**	**3.71**	**21**
1:00-1:30pm	**2.47**	**2.73**	**2.99**	**3.12**	**3.38**	**3.67**	**2.60**	**2.34**	**2.21**	**21**
2:00-2:30pm	**0.91**	**0.91**	**1.04**	**1.17**	**1.17**	**1.18**	**1.17**	**1.16**	**0.91**	**21**
3:00-3:30pm	**0.39**	**0.52**	**0.52**	**0.59**	**0.60**	**0.64**	**0.59**	**0.52**	**0.52**	**21**

Table 4. Average Current Output and Voltage in Day 4

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	**-40.00**	**-30.00**	**-20.00**	**-10.00**	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	
9:00-9:30am	**0.55**	**0.65**	**0.75**	**0.90**	**0.95**	**1.05**	**1.00**	**1.00**	**0.90**	**21**
10:00-10:30am	**0.65**	**0.78**	**0.90**	**1.00**	**1.04**	**1.20**	**1.18**	**1.17**	**1.16**	**21**
11:00-11:30am	**2.08**	**2.47**	**2.86**	**3.38**	**3.77**	**4.04**	**4.16**	**4.16**	**3.77**	**21**
12:00-12:30pm	**2.73**	**2.93**	**3.51**	**4.10**	**3.90**	**4.15**	**4.10**	**3.77**	**3.71**	**21**
1:00-1:30pm	**2.47**	**2.73**	**2.99**	**3.12**	**3.38**	**3.67**	**2.60**	**2.34**	**2.21**	**21**
2:00-2:30pm	**0.91**	**0.91**	**1.04**	**1.17**	**1.17**	**1.18**	**1.17**	**1.16**	**0.91**	**21**
3:00-3:30pm	**0.39**	**0.52**	**0.52**	**0.59**	**0.60**	**0.64**	**0.59**	**0.52**	**0.52**	**21**

Table 5. Average Current Output and Voltage in Day 5

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	**-40.00**	**-30.00**	**-20.00**	**-10.00**	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	
9:00-9:30am	**0.45**	**0.56**	**0.71**	**0.75**	**0.75**	**0.80**	**0.81**	**0.77**	**0.75**	**21**
10:00-10:30am	**0.75**	**0.90**	**1.04**	**1.16**	**1.20**	**1.38**	**1.37**	**1.35**	**1.34**	**21**
11:00-11:30am	**2.40**	**2.85**	**3.30**	**3.90**	**4.35**	**4.67**	**4.80**	**4.80**	**4.35**	**21**
12:00-12:30pm	**3.15**	**3.38**	**4.05**	**4.73**	**4.50**	**4.79**	**4.73**	**4.35**	**4.28**	**21**
1:00-1:30pm	**2.85**	**3.15**	**3.45**	**3.60**	**3.90**	**4.23**	**3.00**	**2.70**	**2.55**	**21**
2:00-2:30pm	**1.05**	**1.05**	**1.20**	**1.35**	**1.35**	**1.37**	**1.35**	**1.34**	**1.05**	**21**
3:00-3:30pm	**0.45**	**0.60**	**0.60**	**0.68**	**0.69**	**0.74**	**0.68**	**0.60**	**0.60**	**21**

Table 6. Average Current Output and Voltage in Day 6

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	**-40.00**	**-30.00**	**-20.00**	**-10.00**	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	
9:00-9:30am	**0.51**	**0.63**	**0.80**	**0.85**	**0.85**	**0.90**	**0.92**	**0.87**	**0.85**	**21**
10:00-10:30am	**0.85**	**1.02**	**1.17**	**1.31**	**1.36**	**1.56**	**1.55**	**1.53**	**1.51**	**21**
11:00-11:30am	**2.72**	**3.23**	**3.74**	**4.42**	**4.93**	**5.29**	**5.44**	**5.44**	**4.93**	**21**

12:00-12:30pm	3.57	3.83	4.59	5.36	5.10	5.42	5.36	4.93	4.85	21
1:00-1:30pm	3.23	3.57	3.91	4.08	4.42	4.79	3.40	3.06	2.89	21
2:00-2:30pm	1.19	1.19	1.36	1.53	1.53	1.55	1.53	1.51	1.19	21
3:00-3:30pm	0.51	0.68	0.68	0.77	0.78	0.83	0.77	0.68	0.68	21

Table 7. Average Current Output and Voltage in Day 7

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	
9:00-9:30am	0.36	0.44	0.56	0.60	0.60	0.64	0.65	0.61	0.60	21
10:00-10:30am	0.60	0.72	0.83	0.92	0.96	1.10	1.09	1.08	1.07	21
11:00-11:30am	1.92	2.28	2.64	3.12	3.48	3.73	3.84	3.84	3.48	21
12:00-12:30pm	2.52	2.70	3.24	3.78	3.60	3.83	3.78	3.48	3.42	21
1:00-1:30pm	2.28	2.52	2.76	2.88	3.12	3.38	2.40	2.16	2.04	21
2:00-2:30pm	0.84	0.84	0.96	1.08	1.08	1.09	1.08	1.07	0.84	21
3:00-3:30pm	0.36	0.48	0.48	0.54	0.55	0.59	0.54	0.48	0.48	21

Table 8. Average Current Output and Voltage in Day 8

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	
9:00-9:30am	0.60	0.74	0.94	1.00	1.00	1.06	1.08	1.02	1.00	21
10:00-10:30am	1.00	1.20	1.38	1.54	1.60	1.84	1.82	1.80	1.78	21
11:00-11:30am	3.20	3.80	4.40	5.20	5.80	6.22	6.40	6.40	5.80	21
12:00-12:30pm	4.20	4.50	5.40	6.30	6.00	6.38	6.30	5.80	5.70	21
1:00-1:30pm	3.80	4.20	4.60	4.80	5.20	5.64	4.00	3.60	3.40	21
2:00-2:30pm	1.40	1.40	1.60	1.80	1.80	1.82	1.80	1.78	1.40	21
3:00-3:30pm	0.60	0.80	0.80	0.90	0.92	0.98	0.90	0.80	0.80	21

Table 9. Average Current Output and Voltage in Day 9

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	
9:00-9:30am	0.75	0.93	1.18	1.25	1.25	1.33	1.35	1.28	1.25	21
10:00-10:30am	1.25	1.50	1.73	1.93	2.00	2.30	2.28	2.25	2.23	21
11:00-11:30am	4.00	4.75	5.50	6.50	7.25	7.78	8.00	8.00	7.25	21
12:00-12:30pm	5.25	5.63	6.75	7.88	7.50	7.98	7.88	7.25	7.13	21
1:00-1:30pm	4.75	5.25	5.75	6.00	6.50	7.05	5.00	4.50	4.25	21
2:00-2:30pm	1.75	1.75	2.00	2.25	2.25	2.28	2.25	2.23	1.75	21
3:00-3:30pm	0.75	1.00	1.00	1.13	1.15	1.23	1.13	1.00	1.00	21

Table 10. Average Current Output and Voltage in Day 10

Current/Voltage	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	V(v)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	
9:00-9:30am	0.45	0.56	0.71	0.75	0.75	0.80	0.81	0.77	0.75	21
10:00-10:30am	0.75	0.90	1.04	1.16	1.20	1.38	1.37	1.35	1.34	21
11:00-11:30am	2.40	2.85	3.30	3.90	4.35	4.67	4.80	4.80	4.35	21
12:00-12:30pm	3.15	3.38	4.05	4.73	4.50	4.79	4.73	4.35	4.28	21
1:00-1:30pm	2.85	3.15	3.45	3.60	3.90	4.23	3.00	2.70	2.55	21
2:00-2:30pm	1.05	1.05	1.20	1.35	1.35	1.37	1.35	1.34	1.05	21
3:00-3:30pm	0.45	0.60	0.60	0.68	0.69	0.74	0.68	0.60	0.60	21

Furthermore, the PV average monthly current/hour and the average power/hour for the three months for the three months were and results presented in Tables 11 and 12 respectively.

Table 11. Average monthly current generated per hour

Current	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00
9:00-9:30am	0.81	0.99	1.15	1.28	1.34	1.41	1.36	1.31	1.22
10:00-10:30am	1.11	1.60	2.00	2.36	2.71	3.14	3.16	2.88	2.82
11:00-11:30am	2.72	3.08	3.38	3.77	4.10	4.29	4.31	4.15	3.93
12:00-12:30pm	3.33	3.80	4.83	5.79	6.05	6.19	6.02	5.59	5.41
1:00-1:30pm	3.14	3.56	3.95	4.22	4.47	4.70	3.60	3.24	3.05
2:00-2:30pm	1.54	1.65	1.89	2.10	2.18	2.23	2.18	2.09	1.79
3:00-3:30pm	0.72	0.85	0.87	0.96	0.98	1.02	0.99	0.93	0.90

Table 12. Average monthly power output per hour

Power	W	W	W	W	W	W	W	W	W
Time/Angle	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00
9:00-9:30am	16.95	20.70	24.19	26.87	28.05	29.67	28.49	27.55	25.68
10:00-10:30am	23.22	33.68	41.92	49.60	56.94	66.01	66.38	60.46	59.18
11:00-11:30am	57.05	64.61	70.98	79.09	86.02	90.02	90.55	87.07	82.45
12:00-12:30pm	69.96	79.89	101.34	121.61	127.15	129.93	126.37	117.36	113.65
1:00-1:30pm	65.85	74.72	83.00	88.63	93.93	98.69	75.64	67.96	64.12
2:00-2:30pm	32.25	34.63	39.66	44.09	45.88	46.86	45.88	43.83	37.60
3:00-3:30pm	15.09	17.75	18.34	20.26	20.53	21.44	20.86	19.53	18.94

2.2 Analysis and Simulation

The resulting data were subject to analysis in MATLAB 6.2.0 environment by adopting an algorithm based on MATLAB software (m-file) for solar tilt-angle to optimization for solar power generation. Muslim, H. N. et. al (2019). Shown below is the adopted MATLAB code for simulation.

```
% Your data
angles = [-40.00, -30.00, -20.00, -10.00, 0.00, 10.00, 20.00, 30.00, 40.00];
time = [9, 10, 11, 12, 13, 14, 15];
data = [ 16.95, 20.70, 24.19, 26.87, 28.05, 29.67, 28.49, 27.55, 25.68;
 23.22, 33.68, 41.92, 49.60, 56.94, 66.01, 66.38, 60.46, 59.18;
 57.05, 64.61, 70.98, 79.09, 86.02, 90.02, 90.55, 87.07, 82.45;
 69.96, 79.89, 101.34, 121.61, 127.15, 129.93, 126.37, 117.36, 113.65;
 65.85, 74.72, 83.00, 88.63, 93.93, 98.69, 75.64, 67.96, 64.12;
 32.25, 34.63, 39.66, 44.09, 45.88, 46.86, 45.88, 43.83, 37.60;
 15.09, 17.75, 18.34, 20.26, 20.53, 21.44, 20.86, 19.53, 18.94];
% Create a figure
figure; % Initialize legend entries and area storage
legendEntries = cell(length(angles), 1);
areas = zeros(length(angles), 1);
% Plot all lines on the same graph with labeled entries and thicker lines
for i = 1:length(angles)
x = time; y = data(:, i);
 % Calculate the area under the curve using trapezoidal integration areas(i) = trapz(x, y); % Plot the curve plot(x, y, '-o', 'LineWidth', 2); hold on; % Keep the current plot % Create legend entry including the angle and area legendEntries{i} = ['Angle: ', num2str(angles(i)), ' (Area: ', num2str(areas(i)), ')'];end% Add labels and legend
xlabel('Time (Hour)');
ylabel('Wattage');
title('Solar Panel Data for Different Angles');
grid on; % Display the legend with angle and area information
legend (legendEntries, 'Location', 'Northwest'); %
```

3. RESULTS AND DISCUSSIONS

The result from the MATLAB code is shown in Figure 13, which indicated the plot of various solar tilt-angles (the area under each curve) using trapezoidal integration, annotating the curves and area information for various average power output of the PV module..

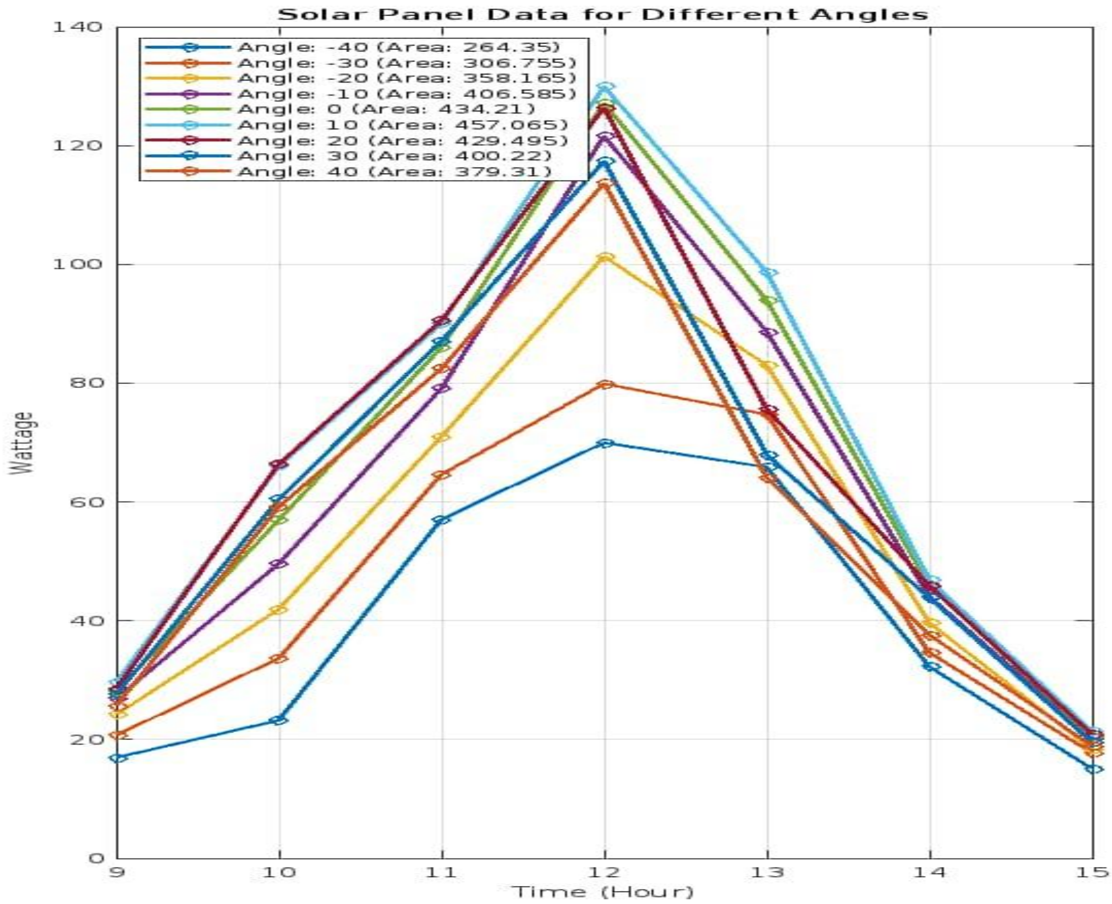

Figure 13. Tilt-angle for various power output/hour

The size of each plot corresponds to the power output, and this information is indicated by the line color. Notably, the plot area directly represents the power generated at each angle. Consequently, the plot shows that a $+10^0$ tilt-angle of panel orientation, covers 457.065 square-meters with a maximum accumulated average output power of power of about 130Watt while a tilt-angle of -40^0 covers 264.35 square-meters with a maximum accumulated average output power of of about 60Watt at noon on daily basis.

4. CONCLUSION

This paper addresses the important of proper positioning of PV module tilt-angle for maximum solar energy harvesting in tropical region with emphasis on Faculty of Engineering, Delta State University Abraka, Oleh Campus. The analysis of PV tilt-angles for the Faculty in particular and the tropical region in general, has provided valuable insights for optimizing solar energy generation. . The analysis found that the ideal tilt angle was 10° due east and at the defined location, can harvest the desired daily energy production. In regions closer to the equator, a lower tilt angle may be more suitable to capture maximum sunlight throughout the year, while at higher latitudes, a steeper tilt angle may be preferable to maximize energy generation. Generally,, selecting the appropriate tilt angle is very important for improving the efficiency and performance of solar PV modules for solar systems operations.

CONFLICTS OF INTEREST

The research is expected to generate income to Engineers in the Communities on the Coastal Regions if adopted in practice.

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