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Comparative Evaluation of Photovoltaic Energy Potential Of Five beaches in Nigeria

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***Abstract*— In this paper, comparative evaluation of photovoltaic energy potential of five different beaches in Nigeria is presented. The Nigerian beaches considered are Ibeno Beach in Akwa Ibom State, Otuogu Beach in Asaba Delta state, Nkonmo-Oyenghe Beach in Cross River state, Lagos Bar Beach in Lagos state and Port Harcourt Tourist Beach in Rivers state. The metrological data for the five beaches are obtained from NASA SSE website based on the latitude and longitude data of each site. Analytical expressions are used to determine the actual yearly energy yield, performance ratio and specific energy yield for each of the sites. The results showed that Nkonmo-Oyenghe Beach has the highest ideal yearly energy yield of 1861.5 kWh , the highest actual yearly energy yield of 1475.387 kWh and the highest specific energy yield of 1475.387 kWh/k W_p and the lowest performance ratio of 79.2579 %. Also, the actual energy yield at Nkonmo-Oyenghe Beach is about 18% above that at Port Harcourt Tourist Beach which had the lowest yearly energy yield buts highest performance ratio of 80.778 %. The high energy yield at Nkonmo-Oyenghe Beach can be attributed to the high annual average insolation which is about 20 higher than that at Port Harcourt Tourist Beach. In all, the ranking of PV energy potential of the five beaches is as follows; Nkonmo-Oyenghe Beach, Cross Rivers State (1st), Otuogu Beach Asaba , Delta State (2nd), Lagos Bar Beach, Lagos State (3rd) , Eket Ibeno Beach, Akwa Ibom State(4th) and Port Harcourt Tourist Beach, Rivers State (5th).**

Keywords— Photovoltaic, Solar Energy Potential, Performance Ratio ,Specific Energy Yield , Yearly Energy Yield, Peak Sun Hours, Cell Temperature

I. INTRODUCTION

As the world clamor for green and renewable energy, researchers seek for ways to make such energy production systems more affordable, more efficient and hence, more economically viable for diverse applications [1, 2, 3, 4, 5, 6]. Among the numerous clean and renewable energy systems, photovoltaic (PV) systems have been found to be the fasted growing and most widely adopted option [7, 8, 9, 10, 11]. Particularly, in the developing countries of Africa with adequate solar radiation in most part of the countries, PV power plants becomes the system of choice for powering remote sites that are far away from the grid [12, 13]. Most often, recreational facilities at sea shores (beaches) in such developing countries like Nigeria are powered by off grid power systems. Again, in such case, PV systems becomes the most viable option given the fact that lower ambient temperature at the sea shore and high wind speed are particularly suitable for high PV power harvesting [14, 15, 16, 17, 18, 19, 20].

According studies, PV power plants' performance depends on numerous parameters that amount to many loss mechanisms [21, 22, 23, 24, 25]. In view of the site dependent PV power system loss, in this paper, the focus is to determine the solar energy potential of five different beaches across Nigeria. This gives insight into the economic viability of such power systems among the different beach sites in Nigeria. First, the comparison is based on the actual average yearly energy yield for PV installation in each of the five beaches studied. In addition to the average yearly energy yield, some site-specific PV module performance meters such as performance ratio (PR) and specific energy yield (SEY) are considered in the comparative analysis of the solar energy potential of the different offshore sites studied in the paper.

The performance ratio, often called "Quality Factor", is the ratio of the electricity generated to the electricity that would have been generated if the plant consistently converted sunlight to electricity at the level expected from the DC nameplate rating [26, 27, 28, 29, 30]. PR is, again, a function of both the PV system efficiency and the weather. PR is independent of the irradiation and installation size and therefore it is a useful metric for comparing PV systems and sites.

It takes into account all pre-conversion losses, inverter losses, thermal losses and conduction losses. PR metric helps designers to understand which locations will provide the most productive PV plants. For example, a colder site will provide a higher PR, implying more electricity generation if everything else is equal [29, 31].

Specific energy yield (SEY) refers to how much energy (in kWh) is produced for every kWp of module capacity over the course of a typical or actual year [7, 32, 33, 34, 35]. SEY relates the installed capacity of PV systems to the amount of PV generated electricity [36]. It is a practical way to calculate the amount of generated electricity based on the installed capacity. SEY is dependent on the irradiation but independent of installation size. SEY can be used to give an indication of the efficiency and feasibility of a PV system , to compare PV energy potential of different locations, to analyze different PV system designs as well as to assess the health of an array [37] . Finally, based on the presented performance parameters, namely; actual average yearly energy yield , performance ratio and specific energy yield the five different beach sites will be ranked according to their ability to support efficient production of solar energy to the end users.

II. METHODOLOGY

A. The Meteorological Data For The Case Study Sites

In this study five different beaches across Nigeria are considered. The beaches are Ibeno Beach in Akwa Ibom State, Otuogu Beach in Asaba Delta, Nkonmo-Oyenghe Beach in Cross River State, Lagos Bar Beach in Lagos state and Port Harcourt Tourist Beach in Rivers State. The study data location for Ibeno Beach is at latitude of 4.540457 and longitude of 8.002922. The study data for Otuogu Beach is based on the meteorological data extracted at latitude of 6.204612 and longitude of 6.735343; for Nkonmo-Oyenghe Beach the location is at latitude of 6.054546 and longitude of 8.522118; for Lagos Bar Beach it is at latitude of 6.422637 and longitude of 3.411714 ; for Port Harcourt Tourist Beach it is at latitude of 4.758625 and longitude of , 7.044082.

The metrological data for the five study sites are obtained from NASA SSE website based on the latitude and longitude data of each site. Meanwhile, for any given location latitude denoted as $\emptyset$, the optimal PV module tilt angle denoted as β_{opt} can be calculated as:

$$\beta_{opt} = 3.7 + 0.69|\emptyset| \quad (1)$$

where $\beta(^0)$ is the tilt angle, and β_{opt} is the tilt angle, where β, β_{opt} and $\emptyset$ are in degrees.

When global irradiation on a PV module is given as $G(\beta)$ and β is the tilt angle of the PV module then the irradiation on the tilted plane is given as [38]

$$\frac{G(\beta)}{G(\beta_{opt})} = 1 + 4.46 * (10^{-4})(\beta - \beta_{opt}) - 1.19 * (10^{-4})(\beta - \beta_{opt})^2 \quad (2)$$

For any given $G(\beta)$ and β_{opt}, the global irradiation on the optimally tilted PV module is given as $G(\beta_{opt})$ where;

$$G(\beta_{opt}) = \frac{G(\beta)}{\left(1 + 4.46 * (10^{-4})(\beta - \beta_{opt}) - 1.19 * (10^{-4})(\beta - \beta_{opt})^2\right)} \quad (3)$$

So, for the given five beach locations, the optimal tilt angle and optimal global irradiation are computed and the values are shown in Table 1 and figure 1. Particularly, Table 1 shows the latitude, $\emptyset$; optimal tilt angle , β_{opt} $(^0)$; annual averaged insolation incident on a horizontal surface , $G(\beta)$ (kWh/m^2/day) and annual average insolation incident on optimally inclined surface , $G(\beta_{opt})$ (Kwh/m2/Day) for the five beaches considered in the study. The data showed that Port Harcourt Tourist Beach in Rivers state has the lowest annual average insolation incident on optimally inclined surface whereas the highest value is obtained at Nkonmo-Oyenghe Beach in Cross Rivers state.

Table 1 The Latitude, $\emptyset$; Optimal Tilt Angle , β_{opt} (^{0}); annual averaged insolation incident on a horizontal surface , $G(\beta)$(kWh/m^2/day) and annual average insolation incident on optimally inclined surface , $G(\beta_{opt})$(Kwh/m2/Day) for the five beaches considered in the study

Site Name	Latitude	Optimal Tilt Angle (^{0})	Annual Average Insolation Incident On A Horizontal Surface, $G(\beta)$(Kwh/m2/Day)	Annual Average Insolation Incident On Optimally Inclined Surface , $G(\beta_{opt})$(Kwh/m2/ Day)
Lagos Bar Beach, Lagos State	6.422637	8.13162	4.73	4.79
Eket Ibeno Beach, Akwa Ibom State	4.540457	6.832915	4.26	4.30
Otuogu Beach Asaba , Delta State	6.204612	7.981182	4.8	4.85
Nkonmo-Oyenghe Beach, Cross Rivers State	6.054546	7.877637	5.04	5.10
Port Harcourt Tourist Beach, Rivers State	4.758938	6.983667	4.2	4.24

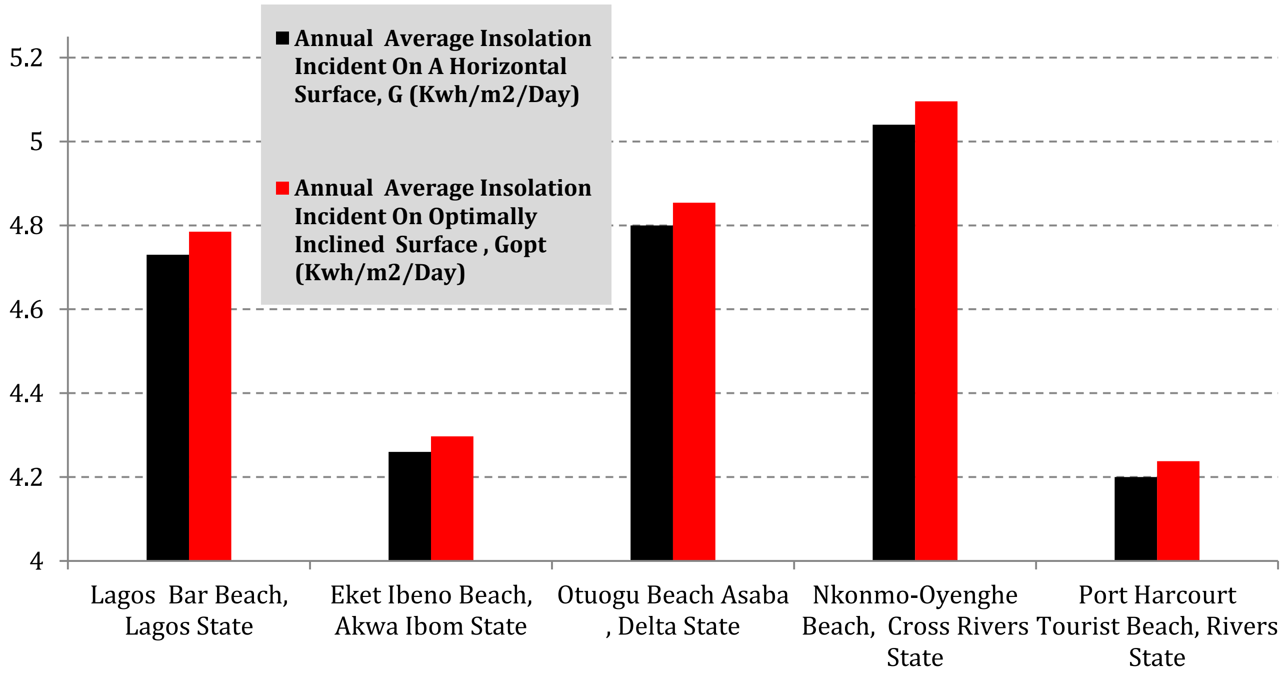

Figure 1: The Annual Averaged Insolation Incident On A Horizontal Surface , $G(\beta)$(kWh/m^2/day) and Annual Average Insolation Incident On Optimally Inclined Surface , $G(\beta_{opt})$(Kwh/m2/Day) for the five beaches considered in the study

For offshore PV installation the equivalent offshore ambient temperature are determined from the onshore data as follows [39, 40];

$$T_{aS} = 5.0 + 0.75(T_a) \qquad (4)$$

Where T_{aS} is sea (or offshore) temperature in °C and T_a is air temperature on land (or onshore air temperature) in °C.

Also, for offshore PV installation the equivalent offshore wind speed are determined from the onshore data as follows [39, 41,42];

$$V_{ws} = 1.62 + 1.17\ (V_w) \quad (5)$$

Where V_{ws} = is sea (or offshore) wind speed in m/s and V_w is wind speed on land (or onshore wind speed) in m/s.

The offshore PV cell temperature $T_{cs}(°C)$ is given as [39, 43]:

$$T_{cs}(°C) = (0.943[T_{as}(°C)] + 0.095[G(W/m^2)] - 1.528[V_{ws}(m/s)] + 0.3529 \quad (6)$$

Where $T_{as}(°C)$ is ambient temperature in ℃ ; $G(W/m^2)$ is solar irradiance in W/m^2 and $V_{ws}(m/s)$ is wind speed in m/s . Conversion of insolation value from Kw$\mathbf{h/m^2/day}$ to $\mathbf{W/m^2}$ is given as;

$$G(\mathbf{W/m^2}) = \frac{G(\mathbf{Kwh/m^2}/day)1000}{24} = G(\mathbf{Kwh/m^2}/day)(41.67) \quad (7)$$

So, for the given five beach locations, the annual average air temperature on land , Ta (°C) and on sea, Tas (°C) and the annual average cell temperature , Tcs (°C) on Sea are shown in Table 2 and figure 2.

Table 2 : The annual average air temperature on land , Ta (°C) and on sea, Tas (°C)and the annual average cell temperature , Tcs (°C) on Sea

Site Name	Annual Average Air Temperature , Ta (°C) on Land	Annual Average Air Temperature , Tas (°C) on Sea	Annual Average Cell Temperature , Tcs (°C) on Sea
Lagos Bar Beach, Lagos State	25.70	24.28	33.36
Eket Ibeno Beach, Akwa Ibom State	24.60	23.45	32.08
Otuogu Beach Asaba , Delta State	25.30	23.98	34.87
Nkonmo-Oyenghe Beach, Cross Rivers State	24.70	23.53	35.53
Port Harcourt Tourist Beach, Rivers State	25.30	23.98	31.47

The data in Table 2 and figure 2 showed that Eket Ibeno Beach, Akwa Ibom state has the lowest Tas (°C) whereas the highest value of Tas (°C) is obtained at Lagos Bar Beach in Lagos state. However, the highest value of cell temperature, Tcs (°C) is obtained at Nkonmo-Oyenghe Beach, Cross Rivers state whereas the lowest value of cell temperature, Tcs (°C) is obtained at Port Harcourt Tourist Beach, Rivers state.

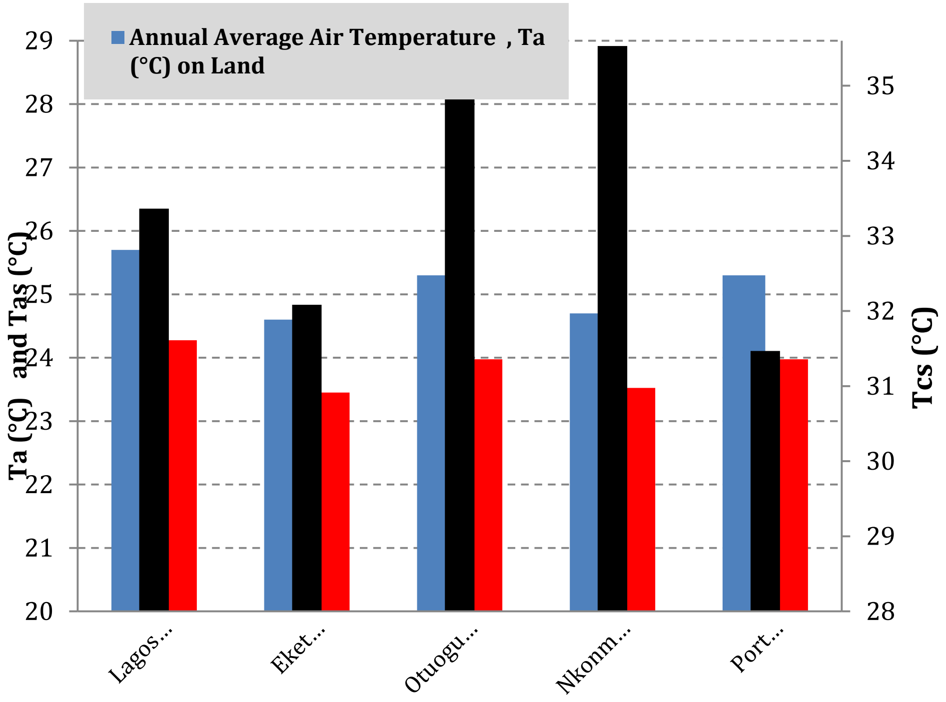

Figure 2 The annual average air temperature on land , Ta (°C) and on sea, Tas (°C)and the annual average cell temperature , Tcs (°C) on Sea

For offshore PV installation the equivalent offshore ambient wind speed are determined from the onshore data as [41,42, 43];

$$V_{ww} = 1.62 + 1.17(V_{Wa}) \quad (8)$$

So, for the given five beach locations, the onshore wind speed ,V_w (m/s)on land and wind speed on sea , V_{ws} (m/s) are shown in Table 3 and figure 3. The highest wind speed on land and on sea are obtained at Lagos Bar Beach in Lagos state whereas the lowest wind speed on land and on sea are obtained at Nkonmo-Oyenghe Beach, Cross Rivers state.

Table 3 the onshore wind speed ,V_w (m/s)on land and wind speed on sea , V_{ws} (m/s)

Site Name	Onshore Annual Averaged Wind Speed At 10 m Above The Sea Level, Vw (m/s)	Offshore Annual Averaged Wind Speed At 10 m Above The Sea Level, Vws (m/s)
Lagos Bar Beach, Lagos State	3.55	5.7735
Eket Ibeno Beach, Akwa Ibom State	2.75	4.8375
Otuogu Beach Asaba , Delta State	2.7	4.779
Nkonmo-Oyenghe Beach, Cross Rivers State	2.63	4.6971
Port Harcourt Tourist Beach, Rivers State	3.24	5.4108

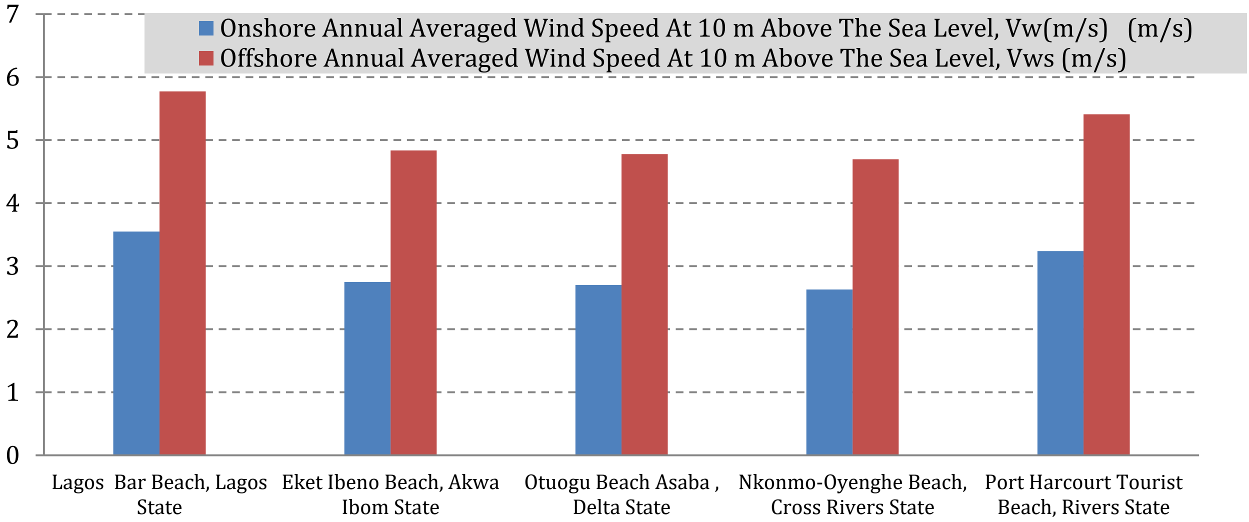

Figure 3the onshore wind speed , V_w (m/s)on land and wind speed on sea , V_{ws} (m/s)

B. Data On The Selected The Selected PV Module

In this paper, the PV module selected is the Canadian Solar CS5P-200 (200W) Polycrystalline silicon PV module manufactured by Canadian Solar with nominal power of 200Wp at STC, nominal voltage of 24V, manufacturers tolerance of ± 3%, efficiency of 11.8%, absorption coefficient of 0.9, temperature coefficient of -0.45%/°C and cell area of 1.609 m^2.

D. Energy Yield of a PV Array

The AC energy output of a PV array is the electrical AC energy delivered to the to the load at the point of connection of the inverter to the load. For solar array with a given peak power rating (kWp) the average yearly energy yield (E_{sys}) can be determined as:

$$\mathbf{E_{sys}} = (\mathbf{P_{TPVSTC}})(\mathbf{f_{man}})(\mathbf{f_{temp}})(\mathbf{f_{dirt}})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(\mathbf{G_{tilt}}) \quad (9)$$

Where:

E_{sys} = average yearly energy output of the PV array, in watthours

P_{TPVSTC}= total rated PV output power of the array under standard test conditions, in watts

f_{man} =de-rating factor for manufacturing tolerance, dimensionless (refer next section)

f_{temp} = temperature de-rating factor, dimensionless (refer next section)

f_{dirt} =de-rating factor for dirt, dimensionless (refer next section)

G_{tilt} = yearly irradiation value (kWh/m^2) for the selected site (allowing for tilt, orientation and shading)

η_{Inv}= efficiency of the inverter dimensionless

η_{PvInv} =efficiency of the subsystem (cables) between the PV array and the inverter

η_{InvSb} =efficiency of the subsystem (cables) between the inverter and the switchboard

PV absorption coefficient =0.9

The Rated Output Power of The PV Array : Now, let N_{PV}be the number of PV modules in the array and let P_{PVSTC}be the rated PV output power of each of the PV module in the array, then total rated PV output power of all the PV modules in the array denoted as $P_{TPVSTC}$is given as ;

$$P_{TPVSTC} = (N_{PV})(P_{PVSTC}) \quad (10)$$

In this analysis, five (5) of the Canadian Solar CS5P-200 (200W) Polycrystalline silicon PV module is used. Each of the five modules has a rated power of 200 W. Then, P_{TPVSTC} = (N_{PV}) (P_{PVSTC}) = (5)(200W) = 1000W.

Manufacturers Tolerance De-Rating Factor (f_{man}) : For the given manufacturers PV percentage tolerance value, the manufacturers tolerance de-rating factor (f_{man}) is given as ;

$$f_{man} = \frac{100 - \text{Manufacturers PV Percentage Tolerance}}{100} \quad (11)$$

Hence, for the given manufacturers PV percentage tolerance of $\pm 3\%$, $f_{man} = \frac{100-3}{100} = 0.97$.

Temperature De-Rating Factor (f_{temp}): For a given temperature coefficient (β), cell temperature (T_{cs}) and standard test condition temperature (T_{STC}) the temperature de-rating factor, dimensionless, f_{temp} is given as follows;

$$f_{temp} = 1 - \left(\left|\frac{\beta\%}{100}\right| (T_{cs} - T_{STC})\right) \quad (12)$$

In this paper, β = -0.45%/°C and $T_{STC} = 25^0C$, hence;

$$f_{temp} = 1 - \left(\left|\frac{-0.45\%}{100}\right| (T_{cs} - 25)\right) = 1 - 0.0045(T_{cs} - 25) \quad (13)$$

Dirt De-Rating Factor (f_{dirt}): The output of a PV module can be reduced as a result of a build-up of dirt on the surface of the module. Given that the power loss due to dirt is 5%, then;

$$f_{dirt} = \frac{100 - \text{power loss due to dirt}}{100} \quad (14)$$

Hence, $f_{dirt} = \frac{100-5}{100} = 0.95$

DC cable Loss Factor or DC Cable Efficiency(η_{PvInv}): The DC energy output of the solar array will be further reduced by the power loss in the DC cable connecting the solar array to the inverter. Given that cable losses for the DC cables is 3% , then;

$$\eta_{PvInv} = \frac{100 - \text{cable losses for the DC cables}}{100} \quad (15)$$

Hence, $\eta_{PvInv} = \frac{100-3}{100} = 0.97$.

Inverter Efficiency(η_{PvInv}): Inverter efficiency is 96% gives η_{Inv}= 0.96

DC cable Loss Factor or DC Cable Efficiency(η_{InvSb}): The AC energy output of the inverter will be further reduced by the power loss in the AC cable connecting the inverter to the load. Given the cable losses for the AC cables are 1%, then;

$$\eta_{InvSb} = \frac{100 - \text{cable losses for the AC cables}}{100} \quad (16)$$

Hence, $\eta_{InvSb} = \frac{100 - \text{cable losses for the AC cables}}{100} = \frac{100-1}{100} = 0.99$.

E. Performance Ratio (PR) Of PV Array Installation

The performance ratio (PR) of PV array installation is calculated as follows:

$$PR = \frac{E_{sys}}{E_{ideal}} \quad (17)$$

Where E_{sys} = Actual Yearly Energy Yield from the system.

E_{ideal} =the ideal yearly energy output of the array. E_{ideal} is determined as follows;

$$E_{ideal} = (P_{TPVSTC})(G_{tilt})$$

Where G_{tilt} = yearly irradiation value (kWh/m^2) for the selected site (allowing for tilt, orientation and shading) and ;

$$G_{tilt} = (PSH)(365) \quad (18)$$

Where PSH is the daily Peak Sun Hours (PSH) which is the average daily solar insolation in units of kWh/m^2 per day. Hence,

$$E_{ideal} = (P_{TPVSTC})(PSH)(365) = (N_{PV})(P_{STC})(PSH)(365) \quad (19)$$

$$E_{sys} = (P_{TPVSTC})(f_{man})(f_{temp})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(PSH)(365) \quad (20)$$

$$E_{sys} = (E_{ideal})\{(f_{man})(f_{temp})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})\} \quad (21)$$

$$PR = \frac{E_{sys}}{E_{ideal}} = \frac{(P_{TPVSTC})(f_{man})(f_{temp})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(PSH)(365)}{(P_{TPVSTC})((PSH)(365))} \quad (22)$$

$$PR = (f_{man})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(f_{temp}) \quad (23)$$

F. Specific Energy Yield of PV Array Installation

The specific energy yield (S_{SYE}) of PV array installation is expressed in kWh per kWp and it calculated as follows:

$$S_{SYE} = \frac{E_{sys}}{P_{TPVSTC}} \quad (22)$$

Where E_{sys} = average yearly energy yield in kWh/year and P_{TPVSTC} = total rated PV output power of the array under standard test condition in kWp.

$$S_{SYE} = \frac{E_{sys}}{P_{TPVSTC}} = \frac{(P_{TPVSTC})(f_{man})(f_{temp})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(PSH)(365)}{(P_{TPVSTC})} \quad (23)$$

$$S_{SYE} = (365)(f_{man})(f_{dirt})(\eta_{Inv})(\eta_{PvInv})(\eta_{InvSb})(PSH)(f_{temp}) \quad (24)$$

$$S_{SYE} = (PR)(PSH)(365) \quad (25)$$

III. RESULTS AND DISCUSSIONS

Table 4 Actual Yearly Energy Yield , (kWh) and Normalised Actual Yearly Energy Yield (%) With Respect To The Lowest Energy Yield

	Actual Yearly Energy Yield , (kWh)	Normalised Actual Yearly Energy Yield , (%) With Respect To The Lowest Energy Yield
Nkonmo-Oyenghe Beach, Cross Rivers State	1475.387	118.02
Otuogu Beach Asaba , Delta State	1407.438	112.58
Lagos Bar Beach, Lagos State	1399.911	111.98
Eket Ibeno Beach, Akwa Ibom State	1264.226	101.13
Port Harcourt Tourist Beach, Rivers State	1250.121	100.00

Table 4 and figure 4 show that Port Harcourt Tourist Beach in Rivers state has the lowest actual yearly energy yield of 1250.121 kWh whereas the highest actual yearly energy yield of 1475.387 kWh occurred at Nkonmo-Oyenghe Beach in Cross Rivers state. The normalized values in Table 4 showed that the yearly energy yield at Nkonmo-Oyenghe Beach in Cross Rivers state is about 18 % more than that at Port Harcourt Tourist Beach in Rivers state.

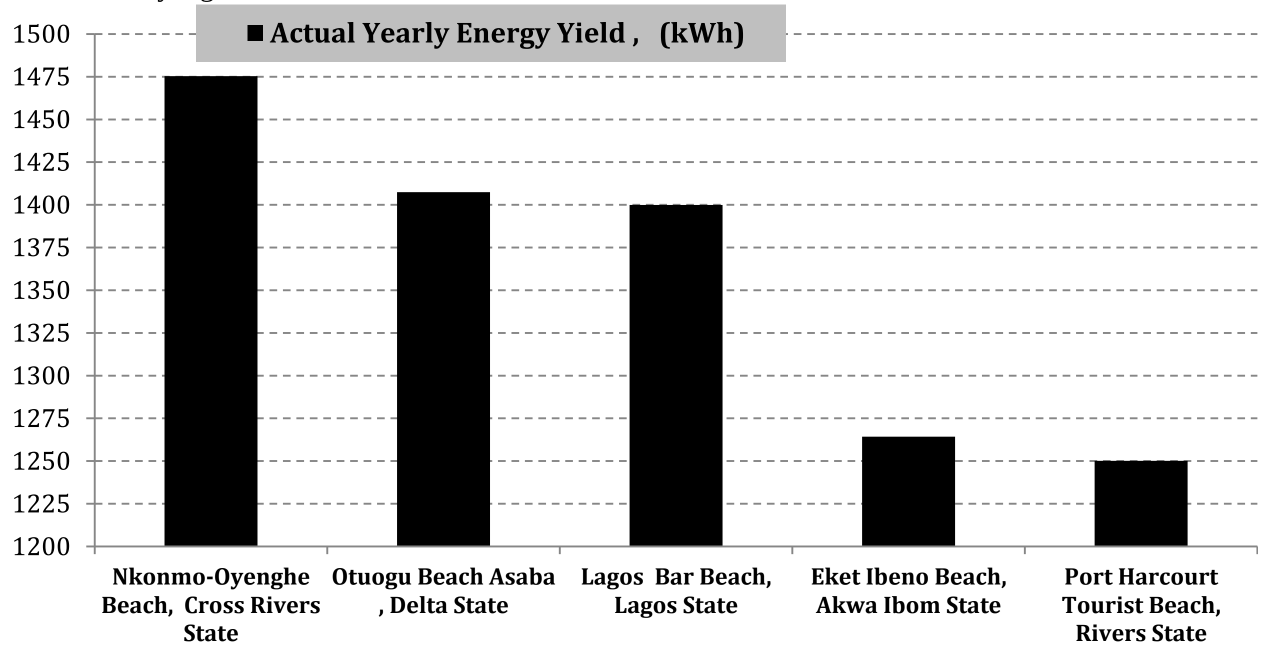

Figure 4Actual Yearly Energy Yield For The Five Beach Sites

Table 5 shows the total rated PV output power at STC (kW_p), ideal yearly energy, E_{ideal} (kWh), actual yearly energy yield ,E_{sys} (kWh), performance ratio , PR (%) and specific energy yield, S_{SYE} (kWh/kW_p).

The results in Table 5 show that Port Harcourt Tourist Beach in Rivers state has the highest performance ratio of 80.778 % whereas Nkonmo-Oyenghe Beach in Cross Rivers state has the lowest performance ratio of 79.2579 %. It means that that the total loss at Nkonmo-Oyenghe Beach is the highest among the five beaches studied. This can be attributed to the highest cell temperature witnessed at the Nkonmo-Oyenghe Beach in Table 2 and figure 2. On the other hand, Table 5 shows that Nkonmo-Oyenghe Beach has the highest ideal yearly energy yield, E_{ideal} (of 1861.5 kWh) , the highest actual yearly energy yield , E_{sys} (of 1475.387 kWh) and the highest specific energy yield, S_{SYE} (of 1475.387 kWh/kW_p). Table 4 showed that the actual energy yield at Nkonmo-Oyenghe Beach is about 18% above that at Port Harcourt Tourist Beach whereas in Table 5 and figure 5 the Port Harcourt Tourist Beach has only about 1% improvement in performance ratio over the at Nkonmo-Oyenghe Beach. The high energy yield at Nkonmo-Oyenghe Beach can be attributed to the high annual average insolation incident on optimally inclined PV module, $G(\beta_{opt})$ in (Table 1 and Figure); in this case, the $G(\beta_{opt})$ at Nkonmo-Oyenghe Beach is about 20 higher than that at Port Harcourt Tourist Beach.

Table 5 Total Rated PV Output Power At STC (kW_p), Ideal Yearly Energy, E_{ideal} (kWh), Actual Yearly Energy Yield , E_{sys} (kWh), Performance Ratio , PR (%) and Specific Energy Yield, S_{SYE} (kWh/kW_p)

	Total Rated PV Output Power At STC (kW_p)	Ideal Yearly Energy, E_{ideal} (kWh)	Actual Yearly Energy Yield , E_{sys} (kWh)	Performance Ratio, PR (%)	Specific Energy Yield, S_{SYE} (kWh/kW_p)	Rank
Nkonmo-Oyenghe Beach, Cross Rivers State	1	1861.5	1475.387	79.2579	1475.387	1
Otuogu Beach Asaba , Delta State	1	1770.25	1407.438	79.505	1407.438	2
Lagos Bar Beach, Lagos State	1	1748.35	1399.911	80.0704	1399.911	3
Eket Ibeno Beach, Akwa Ibom State	1	1569.5	1264.226	80.5496	1264.226	4
Port Harcourt Tourist Beach, Rivers State	1	1547.6	1250.121	80.778	1250.121	5

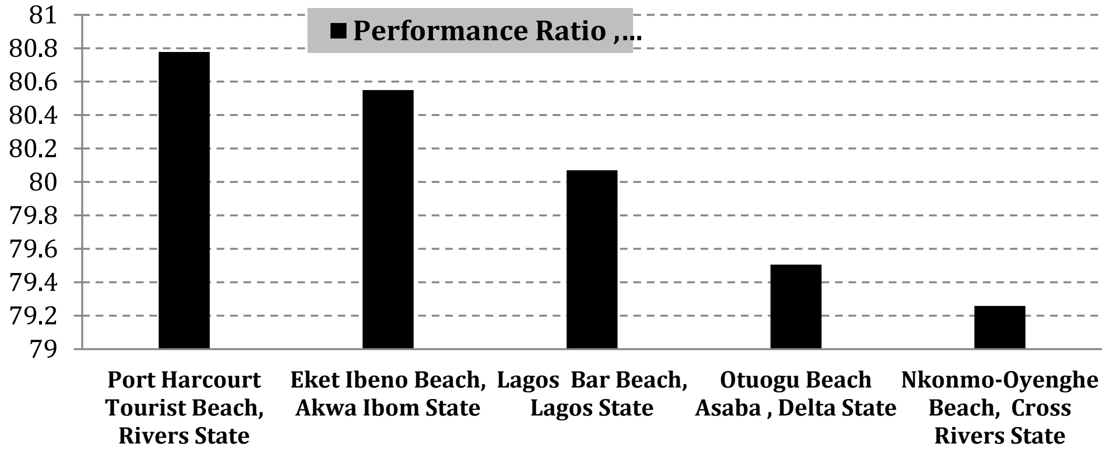

Figure 5 Performance Ratio, PR (%) For The Five Beach Sites

IV. CONCLUSION

Solar energy potential of five different beaches in Nigeria are determined and compared based on actual yearly energy yield, performance ratio and specific energy yield for each of the sites. The metrological data for the five beaches are obtained from NASA SSE website based on the latitude and longitude data of each site. The five beaches considered are Ibeno Beach in Akwa Ibom state, Otuogu Beach in Asaba Delta state, Nkonmo-Oyenghe Beach in Cross River state, Lagos Bar Beach in Lagos state and Port Harcourt Tourist Beach in Rivers state. The results showed that Nkonmo-Oyenghe Beach has the highest yearly energy yield and the lowest performance ratio . The high energy yield at Nkonmo-Oyenghe Beach can be attributed to the high annual average insolation whereas the low performance ratio can be attributed to the high cell temperature at the site. In all, the much higher value of annual average insolation compared to the other sites made the Nkonmo-Oyenghe Beach to still retain the best site for PV system installation.

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