SOLAR PHOTOVOLTAIC GENERATED ELECTRICITY IN NIGERIA TODAY AND IN THE NEAR-TIME

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Abstract - The country is blessed with vast resources required to make her energy secured. However, despite these huge resources, electricity supplies to the populace is still epileptic. Factors responsible for this has continued to be gas supply shortages to thermal power plants, under-utilization of plants, transmission and distribution challenges. In a bid to provide electricity for needed use, individuals and corporations have had to depend on self-generation using internal combustion engine generators fueled with petroleum products. However, the exorbitant cost and pollution effects are forcing many to a rethink. Technological advancement in Solar photovoltaics has made it more affordable and coupled with the timespan of sunshine, it is now receiving immerse attention. Electricity generation capacity from Solar Photovoltaics installation in the country that exist in literature has been stated as a bulk value, however, this study has gone further to state the capacity of different installations and also stating the aggregate. The aggregate figures for undocumented generations tends to be appalling. The next 3-5 years is posed to witness a great leap in solar photovoltaic installations in the country. The projected generation capacity based on ongoing projects by the year 2030 has also been provided and it is expected that it will account for about 39% of the total, a very great leap from the present fraction of about 2%. Routing Solar Photovoltaics generated electricity through mini-grids or utilizing it in off-grid mode will put it in a better stead to solving the country power challenges.

Keywords: capacity, grid, installations, project, solar pv.

1. INTRODUCTION

The availability of uninterrupted Electricity is critical for the economic growth of a Nation. There is a direct nexus between electricity per capita consumption and living standards [1]. Major parts of Nigeria do experience frequent blackout due to the inadequate supply of grid powered electricity. Installed grid generated electricity stands at about 12 GW [1-3] for an estimated population of over 200 million. The precarious situation however, is that the available grid generated electricity hovers between 3 – 5 GW making the average per capita consumption to be about 150 kWh [1]. This is grossly insufficient, and a far cry from that of South Africa; 3,377 kWh and USA; 11,695 kWh [4]. There seems to be no early solution in sight, and this have forced many manufacturing and production outfits out of operation in the country [1]. In a bid to change the narrative, government at several times had come up with different policy frameworks and creation of agencies which it believed will be beneficial like the Electric Power Sector Reform (ESPR) enacted in 2005, the Transmission Electricity Market in 2015, the Power Sector Recovery Programme (PSRP) in 2017, and the recently enacted Electricity Act Amendment (EEA) bill of 2024 to mention a few [1,5,6]. While these policies have at one time or the other generated a euphoria within the populace, the impact have remained yet to be felt, a case was the issuing of licenses to would-be investors to the tune of 26 GW but with no commensurate installed capacity not to talk of available capacity [1,7].

The country is vastly blessed with resources for the generation of electricity from Hydro, Gas, Wind, and Solar [2], and ramping up generation from these sources will be environmentally friendly as it will have little effect on climate change arising from greenhouse gas emissions [8-9].

The return on investment on hydroelectricity is superb [8], and data shows that electricity generation from this source in the country is Twenty-Seven percent of the total. However, it is highly capital intensive [9-10], and with the present financial state of the country [11], it may be out of reach to envisage new plants of this mode to quickly meet the electricity demand of the populace.

Nigeria is blessed with vast deposits of Natural gas; proven reserve values is in excess of 200 trillion cubic feet [12-14]. Gas security should never be a problem, and a testament to this is the generation quota of about Seventy percent of the total from gas plants [11]. The existing licenses awarded to investors for the construction of electricity power plants that have failed to materialize are also to be gas powered. Electricity generation from gas is said to be non-green, its level of emission is however, very low in comparison to other fossil sources [9]. While electricity generation can be quickly ramped-up to the installed capacity of about 12 GW with adequate gas supplies, the challenge of the transmission grid capacity [1-2] might be a hindrance to a quick fix.

Wind generated electricity is presently uncommon in Nigeria, although it is a very good cost effective means of electricity generation [9, 15], its adoption will surely lead to an increase in capacity of generation, although matching it to the grid might be a cog in the wheel. And while it can be looked-at for a long term solution especially because of its many advantages like minimal harm to climate and habitats [8,16] to the perennial electricity blackout, it might

not bring the quick fix that is drastically needed. Its adoption will also require adequate planning in order to be able to optimize its usage while reducing the challenges attached to its utilization especially intermittency.

Exorbitant cost has hitherto, being the challenge to the usage of Solar energy generated electricity; this referring to solar panels and storage batteries cost. However, improved technology has helped in mitigating this challenge, although the issue of low value of energy return on investment still continues to rear its ugly head [10]. Solar energy and wind energy are the most sought-after electricity generation means after hydropower in the global renewable energy mix [9]. While solar farms can be set-up for the generation of bulk electricity, on-roof top installations are also very common, each having its merit and demerits [8]. The on-roof solar energy generator installation is common in Nigeria and it is proving to have the potential of having a quick fix to solving her electricity crises.

The electricity generation figures of Nigeria have always been centered on the central grid value. This figure represents generation from hydro and thermal sources are with the exemption of generated values from internal combustion engines stand-by generators. This study seeks to aggregate generation from solar photovoltaics in the country based on individual documented figures as against a bulk value that exists in literature, its potential of bridging the gap based on ongoing projects, and to also suggest ways to better harness it to reduce the challenge of frequent electricity blackout.

2. ELECTRICITY GENERATION FROM SOLAR PHOTOVOLTAIC (PV) INSTALLATIONS – THE PRESENT AND THE FUTURE

Data for solar energy capacity of Nigeria as at the year 2022 was put at 37 MW, which represents just about 3% of the capacity for Africa at the period [17], and its fraction of the installed electricity generation capacity in Nigeria is shown in Fig 1.

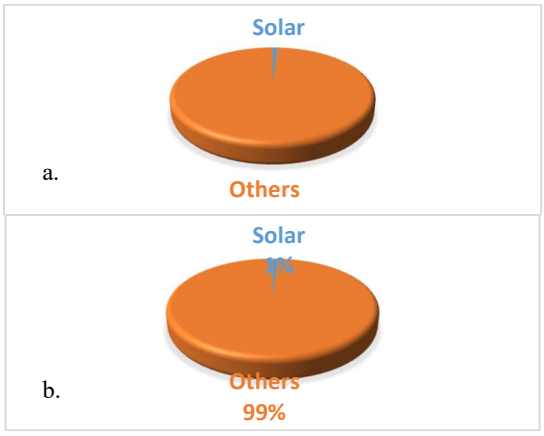

Fig. 1. Solar PV Generated Electricity Fraction of (a.) Installed Electricity Generation, (b.) Available Generation Capacity of Nigeria for the year 2022.

The percentage of Solar PV generated electricity to the installed capacity for the year considered can be said to be negligible; it only accounts for about 0.03% of the total. Power generation from solar seems to be on the increase in Nigeria, while it is difficult to assign a specific value to it, due to the numerous uncaptured installations at residential and commercial centres. Conducting an extensive search of available data in literature, Table 1 shows values of generated electricity from Solar PVs installations in the country.

Table 1. Commissioned Solar PV Plants in Nigeria with capacity above 0.5 MWp

Establishment	Generated Power (MWp)	Connection Type
Nigerian Bottling Company	10.3 [18]	Off-grid
Challawa Industrial Estate	10 [19]	On-grid
Federal University of Agriculture, Markudi	3.5 [20,21]	Off-grid
Bayero University, Kano	3.5 [20]	Off-grid
Tulip Cocoa Processing Ltd, Ogun State	2.35 [20]	Off-grid
Seven-Up Bottling Company, Nigeria	1.5 [22]	Off-grid
British American Tobacco Nigeria, Ibadan	1.4 [23]	On-grid
Federal University of Petroleum Resources, Effurun	1.35 [24]	Off-grid
Usman Dam Water Treatment Plant, Abuja	1.2 [20]	Off-grid
Alex Ekwueme University, Ebonyi	1.155 [20,21]	Off-grid
Big Bottling Company	0.95 [25]	Off-grid
UAC, Nigeria	0.8 [26]	Off-grid
Nigerian Breweries	0.664 [20]	Off-grid
Jabi Lake Mall, Abuja	0.61 [20]	Off-grid
Lagos Solar Power Project (Schools/Hospitals)	5 [27]	Off-grid
Kaduna State Health Care Centres	1.7 [28]	Off-grid
Nile University of Nigeria	0.846 [29]	Off-grid
Nationwide Health Centres (REA)	5(0.05 x 100) [30]	Off-grid
Bauchi REA Project	0.5 [21]	Off-grid

The stated solar PV installations are for those exceeding 0.5 MWp except for the nationwide health centres Rural Electrification Agency (REA) because its aggregate is in excess of this value. Some other mini-scale sized solar energy installations for communities/establishments includes Oloibiri and Akipelai communities in Ogbia local government area of

Bayelsa state plants each with a 67.32 KWp capacity, and the Egbeke community of Rivers State 55 kWp plant [31].

A 91 kWp installation recently executed by SAF-AGA renewable energy limited in Okpokunou community of Delta state [32], a 96.3 kWp installation in American University of Nigeria, Yola, and the 30 kWp solar system for an Imo State hospital executed by the Niger Delta Development Commission (NDDC) [33] to mention just a few that are documented in literature.

The volume of generated electricity from the Solar PVs sums up to about 53 MWp and connotes an increment of over Forty percent of the figure reported in literature for the year 2022. However, several installations do not appear in literature especially for the tens of thousands of such below 10 kWp which are common for private use in residences and small enterprises.

A good instance of unreported installations in literature is that in the Faculty of Technology of a Federal and State owned Universities in the Southwestern part of the country that houses ten departments and five departments respectively. The individual solar PVs installations there sums up to 80 kWp and 7.5 kWp respectively. The figures were arrived at after conducting a personal evaluation of the installations in the different departments that made up the faculties. This also applies in other faculties of the institutions and other institutions as self-devised means of solving the epileptic power supply to the citadels of learning.

This is still a far cry from the projected generation target of 3500 MWp by the year 2025 and 5000 MWp by the year 2030 [34], however, going by announced/ongoing projects, the possibilities of surpassing the 2030 target of 5000 MWp is great. Table 2 depicts different ongoing Solar PVs electricity generation project and their stage of work.

Table 2: Announced/ongoing Solar PV Electricity Generation Projects in Nigeria

Project	Power (MWP)	Expected Completion Date/Stage
Argungu Solar PV Park	5,600 [35]	2027/Announced
Jigawa Solar PV Park	1000 [35]	2026/Permit
Gezhouba Lagos Solar PV park	360 [35]	2026/Construction
Lafia Solar PV Park	350 [35]	2026/Permit
Gombe Solar PV Park	270 [35]	2026/Permit
Ashama Solar Power Plant	200 [36,37]	2026/Permit
Gwagalada Solar PV Park	143 [38]	2026/Permit
Tingo Foods Nigeria	110 [39,40]	2024/Construction
Yabo Solar PV Park	55 [41]	2026/Permit
Kwali Solar PV Power Plant	20 [42]	2026/Permit
Nigerian Breweries Plc	10.6 [43,44]	Construction
Seven-Up Bottling Company	10.5 [22]	Construction
Baze University, Abuja	5 [45]	Construction
Federal University of Technology, Akure	4.5 [46]	Construction

Going by the different highlighted ongoing projects, more than 8.1 GWp of solar PVs generated electricity is expected to be added, and this is asides the hundreds of thousands of small scale residential and commercial centres installations that continues to spring up daily.

As earlier stated, many installations in the country are not documented especially for residential and commercial use. Many houses in urban areas now have roof top installations. The challenge of conducting an audit of the installations is partly due to the variety in installed capacities and the practical impossibility of reaching every installation site.

Based on available data, the solar power plants installation capacity in Nigeria stood at 27.96 MWp in 2019 [49], this has increased by almost a hundred percent to the present installation capacity of over 53 MWp. Growth in installation capacity over the previous 5-year period; 2014 – 2019 was about 12.36 MWp [47] which amounted to less than half of the increment recorded over the last 5-year span; 2019 – 2014. New photovoltaic installations in the country over the last five years have been used to provide about 274 GWh of energy based on a conservative 6-hour period of daily sunlight.

The increased cost of fuel and increasing grid energy price seems to be a pushing force to adopting solar photovoltaics to meeting the energy needs in Nigeria especially by individuals and businesses. It is thus, expected that over the next 3-5 years, installed capacity will surpass the current trend of around a hundred percent increment over a five-year span. And based on the number of ongoing projects which are in different phases, the installed capacity of photovoltaics in the country should be in thousands of Megawatts. However, based on past experiences of cancelled/abandoned projects in the country, conservative figures for new photovoltaic installations in the next 3-5 years can be put at about 500 MWp. This figure is premised on ongoing big and mini-sized projects that have reached advanced stage and are being executed by reputable business concerns.

Completion of the various solar PV projects will in no small way increase the electricity generation capacity of the country, however, having to rely on the central grid for its transmission without a commensurate improvement in the grid transmission capacity will lead to little or no impact. This is not coming from the blues, because current installed generation capacity from all sources stands around 12 GW but the installed transmission capacity is about 8.1 GW [48] a feat which was achieved not long ago.

Having the ongoing solar PV projects come as off-grid or mini-grid will in no small way help in boosting electricity supplies [1]. This will help in by-passing the central grid which has been one of the contributing factor to the epileptic power supply. It is, however, to be noted that the transmission capacity is also currently undergoing an expansion to take it to 25 GW [49] and will definitely be subjected to losses. This will however, be insufficient to wheel the country generated electricity if all where to pass through the grid; generating at installed capacity of about 12 GW, adding on about 8.1 GW of ongoing solar PVs, and the ongoing hydroelectricity projects of about 5.4 GW.

It is expected that by the year 2030, if things go according to plan, the percentage of solar PVs generated electricity of the total will take a giant leap from where it

is presently, and the contribution of renewable generated electricity to the total in the country will also be boosted. These are depicted in Fig. 2.

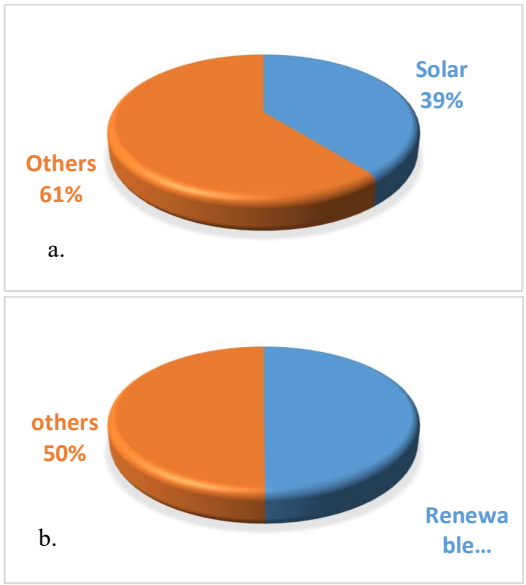

Figure 2. (a.) Expected Solar PV Generated Electricity Fraction of Expected Installed Electricity Generation Capacity, (b.) Expected Renewable Energy Generation Capacity Fraction of Expected Installed Electricity Generation Capacity by year 2030.

3. CONCLUSION

It is very difficult to state the exact current figures of solar PV installations for electricity generation in Nigeria due to the absence of data for most residential and commercial centres installations and an indication of many of the uncaptured generated figures is the generation to the tune of 80 kWp from a Faculty of Technology in a Southwestern Federal Government owned University. It was however, deduced that;

- The current installed capacity of Solar PVs for electricity generation in Nigeria is in excess of 53 MWp.
- The installed capacity increased by almost a hundred percent over the figures for the year 2019 which represent a 5-year span
- The next 3-5 years will usher in great increment in photovoltaic plants installations due to the increasing cost of alternative energies in the country
- By the year 2030, electricity generation from solar PVs will form about 39% of the country's total installed generation capacity
- Having the solar PVs generation routed through mini-grids/off grids will be a better method to solving the power crises than to route it through the central grid.

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