Analysis of Power Plan Capabilities in Nigeria's Electric Grid System for Energy Security

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ABSTRACT

The total installed capacity of power plants in Nigeria's electric grid system varied from 8,910.40 MW in 2011 through 10,915.40 MW in 2013 to 12,132.40 MW in 2015. These values, though meagre enough for the nation's very large population and developmental stage, were not completely utilized. Some of the generating units in the various power stations across the country are not functional and therefore have been decommissioned. Thus in 2011, the average annual available capacity was 4,479.32 MW (a reduction of 50.3%), while in 2015, it was 6,401.20MW (52.8%). These unfortunate developments have had a catastrophic impact on the nation's economy. This paper analyzes Nigeria's power plant capabilities over the past ten years using frequency counts, tables, and graphical illustrations to prove that there is a wide gap between actual peak generation and forecast values over the years. Credible solutions were proffered to mitigate the challenges of power generation in Nigeria.

(Keywords: forecast values, installed capacity, peak generation, available capacity)

INTRODUCTION

Electrical power is one of the major drivers of the economy of any nation. Unfortunately, its supply is grossly inadequate especially in a developing economy such as Nigeria. The African Development Bank (AFDB, 2014) discloses that 57% of the people of West Africa do not have access to electricity. Ghana is outstanding in that it is said to have an access rate of 70%. Unfortunately, only about 48% of Nigerians have access to electricity.

It is well known that over 150 multi-national industries such as Michelin, Dunlop, Glaxo, and Pfizer (among others) have since quit doing business in Nigeria because of poor electricity supply which invariably implies rise in cost of doing business (Adinuba, 2015).

These scenarios would not have been sordid as such if enough power plants (power stations) were built, operated, and effectively managed over the years. More specifically, for two consecutive days (February 23 – 24, 2015), the peak generation (MW) on February 23, 2015 was 3,866.80 MW with corresponding energy value of 88,781.55 MWH while on February 24, 2015, the peak generation (MW) was 3,830.80 or 83,812.86 MWH (NCC, 2015).

There is therefore need to build more power plants, maintain the existing ones to improve plant efficiency and availability, and reinforce the entire Generation–Transmission–Distribution chain. This is because investment on only one aspect of power system, such generation without improvement on other transmission and distribution subsystems would endanger the much-desired energy security. However, the thrust of this work is on the generation capabilities of Nigeria in the face of the current energy crisis.

LITERATURE REVIEW

The history of electricity generation in Nigeria dates back to 1898 with the installation of two, 3 KW generating sets at Marina, Lagos under the control of the then Public Works Department (Oyebola, 1992). Since then, the construction of power plants in Nigeria has been very slow. For instance, according to Sambo (2008) and Iwayemi (2008) for over 20 years prior to 1999, there was no remarkable investment in the power sector. In fact, between 1990 and 1999, no new power stations (power plants) were built. Besides,

there was no major turn-around-maintenance (TAM) carried out (Anoruo, 2015). As of December 2004 (NCC, 2004), total installed generating capacity (including the Independence Power Plants) was only 6,240.40 MW and that is over 100 years since 1898 and 44 years after independence!

Even in just 2015, the total installed capacity was 12,132.40 MW but the average annual available capacity was only 6401.20 MW or 52.8% of the total installed capacity (TCN, 2015). The implication of all this is that power made available for Nigeria with a population of over 170 million people lies between 3000 MW and 3500 MW (on average) over time. This impacts negatively on socio – economic life of Nigeria in the way of collapse of many industries, rising unemployment rate and criminal activities in the country. A lot of literature abounds which expresses further the debilitating effect of inadequate generation capacity and power supply in Nigeria (Adejumobi and Okoye, 2016; Ezennaya, et al., 2014; UNDP, 2014; AFDB, 2014).

Table 1 shows electricity generation (MW) and population of selected countries relative to Nigeria. The relative poor status of Nigeria is obvious.

Table 1: Electricity Generation (MW) and Population of Selected Countries.

Country	Population in millions	Electricity Generation (MW)
Nigeria	170	4,500
South Africa	45	46,000
Ghana	23	1,800
South Korea	68	168,000
Egypt	44.3	33,000
Zambia	11	2,000
Cuba	10.54	4,000
Iraq	47	562,000

Source: Synthesized from Zenith Quarterly and related sources

As at December 2015, Nigeria had 25 power stations consisting of three hydropower stations, and twenty-two thermal power stations (including eight Independent Power Producer, IPPs).

The hydro power contributed 1938.40 MW (16%) of the total grid installed capacity of 12,132.40 MW while all the thermal stations contributed 10,194 MW (84%). The IPPs accounted for only 2119.00 MW (17.5%) of the total grid installed capacity.

There is no contribution to national grid by the renewable energy (apart from hydro). Worse still, coal resources are not being utilized to generate electricity at present. The coal-powered station at Oji, Enugu state has been abandoned long ago.

MATERIALS AND METHODS

Trips were made to the National Control Centre, (NCC) at Osogbo, Nigeria for data collection which also harbors the Transmission Company of Nigeria (TCN). A single National Integrated Electric Grid system is operated in Nigeria by the TCN through the NCC. The Centre is equipped with necessary electrical / electronic instruments for data acquisition and measurement / recording.

The data were supplied to the NCC by the various generation companies (GENCOs), distribution companies (DISCOs) and internally by the departments of TCN. Data were also collected from the records of the Power Holding Company of Nigeria (PHCN) and various literature.

- The main data collected span ten years (2006 - 2015). They include:
- Installed capacities of all power stations in Nigeria (2006 - 2015), MW
- The average annual available capacity (MW), 2006 – 2015 of all power stations.
- Peak generations (MW), 2006 – 2015.
- Generation peak load (forecast and actual), January – December for 2013, 2014 and 2015, respectively.

The data were analysed by using descriptive statistics to further derive the needed information from them.

RESULTS AND DISCUSSION

Table 2: Nigeria's Power Plant Capabilities in MW (2006 - 2015).

Year	Installed capacity (MW)	Average Annual Available capacity (MW)	Peak Generation(MW)	Availability factor
2006	7017.7	3889.36	3682.3	0.55
2007	8138	4156.19	3599.6	0.51
2008	8469.5	4232.61	3596.9	0.57
2009	8702.25	4825.17	3710	0.55
2010	8425.4	4212.7	3804.3	0.5
2011	8910.4	4479.32	4089.3	0.5
2012	9955.4	4479.32	4517.6	0.55
2013	10915.4	5050.99	4458.2	0.46
2014	11165.4	6317.7	4486.7	0.57
2015	12132.4	6401.2	4883.9	0.53

Availability factor = $\dfrac{\text{Annual availability}}{\text{Installed Capacity}}$

Source: Synthesized from Power Holding Company of Nigeria (PHCN), National Control Centre (NCC), Transmission Company of Nigeria (2006 - 2015)

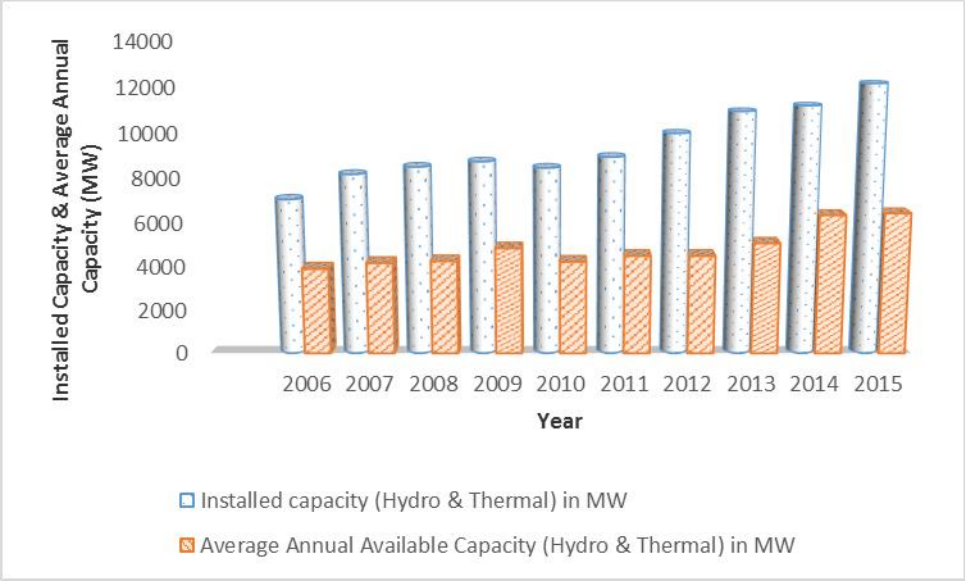

Figure 1: Power Stations in Nigeria: Installed Capacity and Available Capacity, 2016 -2015 (from Table 1).

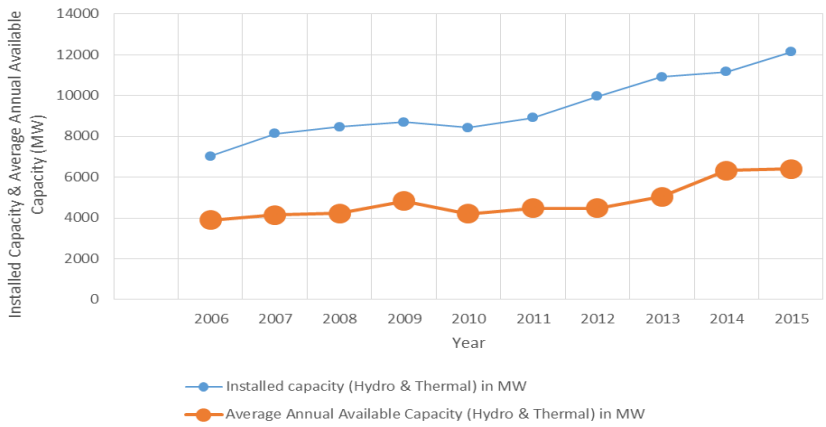

Figure 2: Power Stations in Nigeria: Installed Capacity and Available Capacity (2006 – 2015).

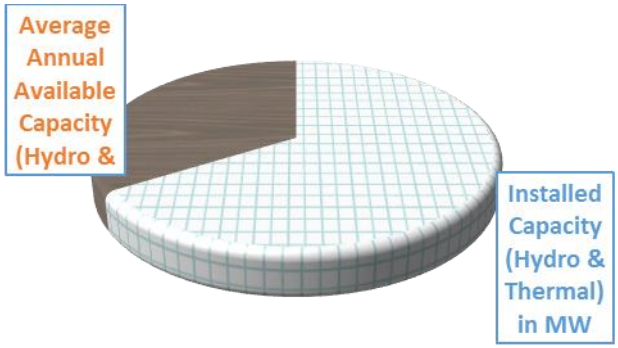

Figure 3: Total Installed Capacity and Available Capacity.

Table 3: Generation Peak load (forecast and actual), January – December 2013.

Monthly Peak Load		
Month	**Forecast (MW)**	**Actual (MW)**
January	11660	4362
February	12140	4458
March	12620	4388
April	13070	4214
May	12930	4223
June	12800	4037
July	12670	4021
August	12800	3758
September	12870	3846
October	12930	3910
November	13000	3726
December	13050	3827

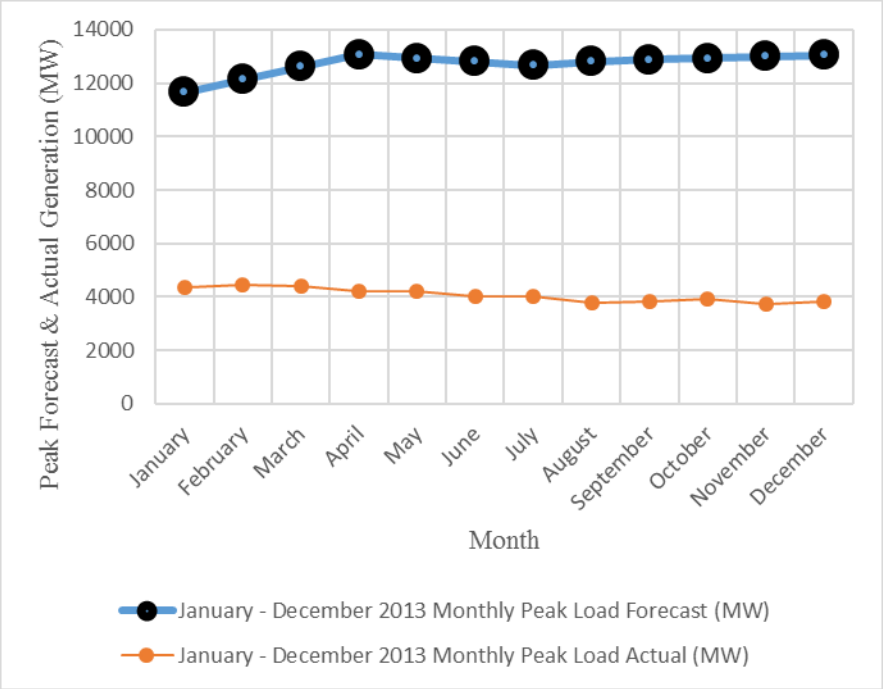

Figure 4: Monthly Peak Forecast and Actual Generation in 2013.

Table 4: Generation Peak load (forecast and actual), January – December 2014.

Monthly Peak Load		
Month	**Forecast (MW)**	**Actual (MW)**
January	13060	3799
February	13600	4249
March	14130	4180
April	14630	4106
May	14480	4248
June	14330	3977
July	14190	3620
August	14330	4300
September	14410	4324
October	14480	4487
November	14560	4378
December	14620	4390

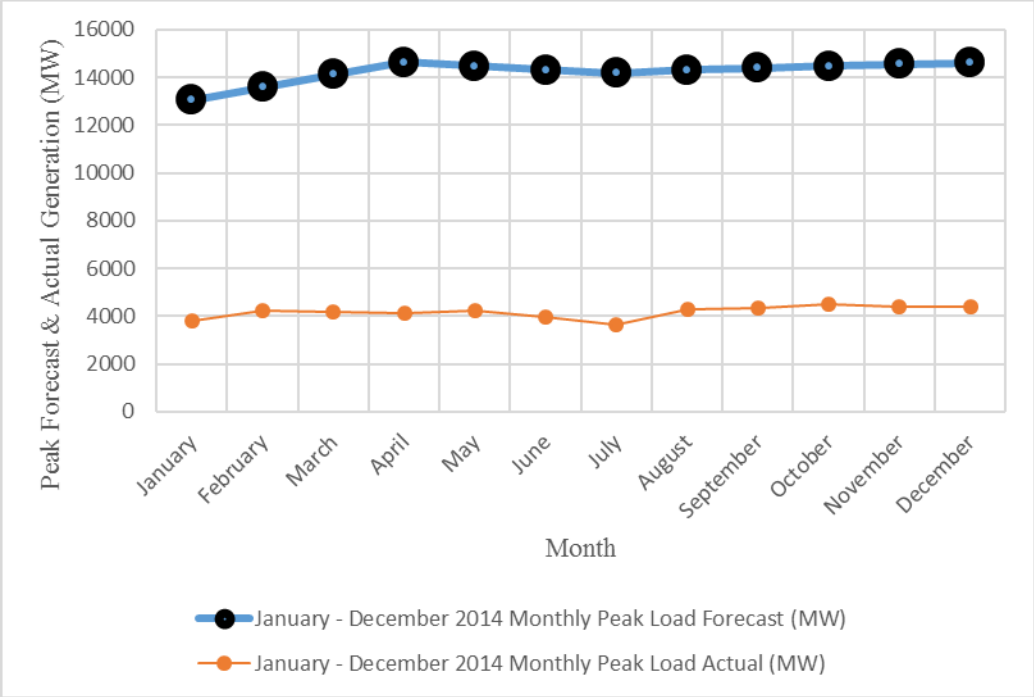

Figure 5: Monthly Peak Forecast and Actual Generation in 2014

Table 5: Generation Peak Load (forecast and actual), January – December 2015.

Monthly Peak Load		
Month	**Forecast (MW)**	**Actual (MW)**
January	13060	4406
February	13600	4202
March	14130	4336
April	14630	3890
May	14480	3685
June	14330	4357
July	14190	4656
August	14330	4811
September	14410	4783
October	14480	4688
November	14560	4884
December	14620	4635

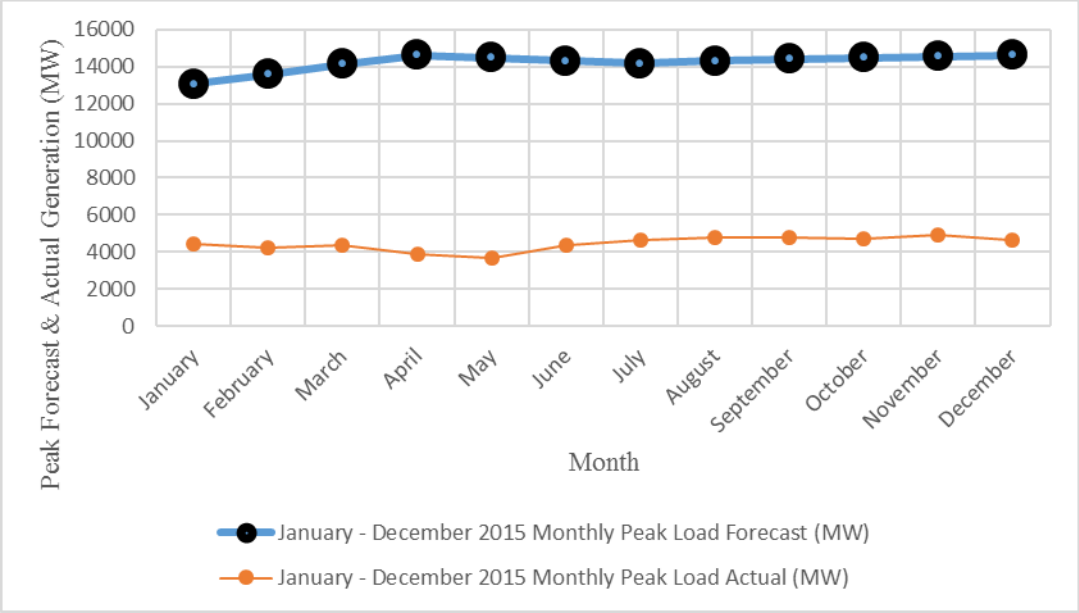

Figure 6: Monthly Peak Forecast and Actual Generation in 2015.

Table 2 depicts Nigeria's power plant capability spanning 10 years. It can be seen that there is a clear gap between the installed capacity of all the 25 power stations and the capacity actually available (Figures 1, 2, and 3). This has contributed to reduced electricity generation over the period.

Tables 3, 4, and 5 show the monthly peak load forecast and actual values in MW from January to December for three consecutive years. The very wide gap between the forecast and actual values have been demonstrated graphically (Figures 4, 5, and 6). Again, the huge deficit between forecast and actual values (as in the case of installed capacity and available capacity) may be due to some constraints such as:

- Low water level
- Lack of enough spares
- Shortage of gas supply
- Ageing of generating equipment
- Generation and transmission system faults
- Inadequate maintenance of power plants
- Power evacuation difficulties encountered by distribution companies (DISCOs)

Nigeria has only 25 power plants (power stations), including the Independent Power Producers and total installed capacity of only 12132 MW as at December 2015. Yet only about half (50%) of all installed capacity were available. This trend could be observed over the ten years under study as shown by availability factor in Table 2.

Comparatively, the US electric grid (Hicks, 2012) comprises over 5000 power plants, over 200,000 miles of high voltage transmission lines and over 5.5 million miles of distribution lines. Besides, it is said (Modern Power System, 2012) that India plans to construct 1200kV transmission system which would operate at the highest AC voltage level in the world. This would also be matched with high – level operational generating facilities.

Furthermore, it could be observed that there is no contribution from renewable energy systems to the grid. The plan throughout the world is to go green, especially in the face of our rapidly depleting ozone layer and the concomitant negative environmental impact (RECP, 2015; Alamau, 2016; IEA, 2014).

CONCLUSION

A study of power generating capabilities of Nigeria's power stations (power plants) spanning to ten years was carried out and analyzed using relevant descriptive statistics. Out of the total installed capacity of 12132.40 MW as at

December 2015, only 6401.20 MW (52.8%) was available for generating the much-needed power for national development.

Similarly, the analysis of the various generation peak load (forecast and actual) shows a wide gap between the forecast values and actual values in three consecutive years. Several constraints were identified as contributing to the low capacity utilization of power plants and inability of generation to meet forecast values. Major among them are: low water levels especially during the dry season, inadequate gas supply, insufficient spares to carryout maintenance, and challenges associated with evacuating power by distribution companies (among others). Also, there is no renewable energy contribution to the grid electricity and no coal-powered generation despite Nigeria's rich coal resources.

RECOMMENDATION

In order to enhance energy security in Nigeria, the following actions are recommended:

(i) Some of the power plants (hydro and thermal) are very old and should be rehabilitated completely.

(ii) Gas supply to thermal power plants should be increased and gas pipelines inspected and maintained periodically.

(iii) Distribution companies (DISCOs) should be encouraged to evacuate power generated to make way for more power generation.

(iv) Many transformers are overloaded far above their technical ratings and this should be discouraged.

(v) There is need to retain staff involved in power operations especially in this age of information and communication technology.

(vi) Funding of power infrastructures should never be relegated to the background by the power plant owners. It is even better to plough back much of their profits in order to reap bigger harvest in the future.

(vii) A good maintenance culture should be observed at all times and spares should be provided in quality and quantity needed.

(viii) Many countries of the world are going green in the face of deteriorating environment. So, renewable energy should be exploited to, besides, boost energy availability.

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SUGGESTED CITATION

Okoye, C.U. 2019. “Analysis of Power Plan Capabilities in Nigeria’s Electric Grid System for Energy Security”. *Pacific Journal of Science and Technology*. 20(1):66-74.