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A Policy Analysis of Grid Rural Electrification in Nigeria since 1981

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Abstract: Grid-based electricity is vital for ensuring adequate electricity for meaningful development. However, a centralized grid system tends to pose some setbacks to rural electricity delivery, particularly in developing countries. Analysis was on Nigeria's rural electrification policy, since, 1981, premised on its centralized grid. Questionnaires were utilized for data collection while data analysis was done through descriptive and inferential statistic (Chi-square). Data from 894 respondents out of a sample size of 1,056 that was selected from Imo State; showed abysmal electricity situation and lack of rural development; given that the centralized grid has not effectively delivered electricity to rural areas in the country. Therefore, a decentralized grid based on localized GTD (Generation, Transmission and Distribution) was recommended, to promote electricity supply and development in rural areas.

INTRODUCTION

Electricity is the most convenient form of energy usage and a key driver of development and modernity[1]. Prevalent mass consumption fast-tracked by ICT (Information and Communication Technologies) is hinged on steady electricity supply. Electricity generation, transmission and distribution processes are highly technical, making it difficult for individuals to venture into commercial electricity production. In Nigeria, mostly public utilities constructed large-scale power plants to drive economic activities but electricity generated is routed to all parts of the country through a single gigantic centralized complex national grid. Distributed generation can create electricity in small scales at locations throughout the electricity network but this has not been the case. Grid-supplied electricity is considered suitable and cost-efficient overall in the long term but this is not reliable in Nigeria. Hence, the widespread use of electricity generating sets, despite the risks of noise and air pollution and explosion.

Rural areas are significant to economic growth as food producers and ready markets for domestic products. This agrarian economy lacks adequate electricity supply which limits productivity and living standards. Rural needs for electricity are endless including: home lighting, Small-Medium Enterprises (SME), irrigation/water pump, crop processing, storage, cooling/refrigeration (including space cooling and vaccine refrigeration at health centres), recreation, telecommunication and education. Thus, economic the justification for investments in rural electrification is significant.

Nigerian Rural Electrification Programme (NREP) was initiated in 1981 by the then Federal Ministry of Power and Steel (FMPS) with the mandate to expand the electricity infrastructure to all parts of the country[2].

The NREP had one strategy which was to extend the national grid to all the local government headquarters in the country from where electricity would be provided to every nook and cranny. This was to evolve under the market monopoly of the National Electric Power Authority (NEPA), establish in 1972 to manage the power sector and provide electricity to a rapidly increasing population[3]. All the efforts and policies have not yielded significant results as far as the electricity situation in the country is concerned. Only 45% of the entire population and only 36% of rural population are connected to the nation's electric grid resulting in massive failure of the electricity system regularly. In reality, 75% of the population lacks access to regular power probably due to the fact that grid connection is not the same thing as electricity access[4, 5]. The situation could get far worse in the rural areas as the country's population continues to grow at the fast rate of 2.6%[6].

In the bid to improve the electricity situation in the country through policy and action, a new National Electric Power Policy (NEPP) in 2001 culminated in the Electric Power Sector Reform (EPSR) Act in 2005 that would enhance power sector privatization. Subsequently, a full deregulation was implemented in November, 2013 and PHCN (Power Holding Company of Nigeria) which had earlier replaced NEPA was unbundled into 18 autonomous divisions comprising 6 Generating Companies (GENCOs), 11 Distribution Companies (DISCOs) and 1 Transmission Company (TCN) charged with generation, transmission and distribution/trading of electricity[3]. There was no specific mention of or emphasis on rural electrification as a target goal in the exercise.

At present, 18 grid-based power stations generated about 3000 mW of electricity from multiple sources: hydro, oil and gas. These grid-connected stations are owned by the Federal Government, the National Integrated Power Project (NIPP) or the Independent Power Producers (IPP), respectively. The NIPP which is run by NDPHC (Niger Delta Power Holding Company) is owned by the three tiers of government while IPP is owned by state governments and/or private companies/individuals[3, 7]. Thus, the paper enlisted the objectives below:

- To establish the ineffectiveness of the centralized grid strategy in Nigeria and its main challenges
- To advance the need to restructure the national grid for effective electricity delivery

Meanwhile, efforts by various governments on nationwide electrification to bring electricity to rural reach have been greatly impeded-a scanty 18% rural electrification rate[8, 9]. The problems are include first, Nigeria has an area of 923,769 km^2 and a population of 182 million[10]. Connecting the nooks and crannies with access roads (vital to facilitate grid rural electrification) has been a daunting task for governments due to huge costs of extending the grid against copious physical impediments. Politicians are either not keen to cough out this whopping sum or are hamstrung by myriads of conflicting interests. Second, inadequate capacities in capital and manpower lead to epileptic power supply, power theft and low revenue[11].

Third, meeting a projected generation capacity of 5.96 GW has been a mirage. Only a meager portion of this is generated; giving available electricity per capita of 25 W, instead of a projected 40 W per capita: in the same arena where Ghana and South Africa have astounding 62 and 826 W available electricity per capita, respectively. The electricity infrastructure in the country is dilapidated owing to maintenance challenges posed by the complex grid which also results in huge energy losses[11]. Inefficient metering/poor billing system create room for overestimated billing by in attempts to recoup de facto losses.

Fourth, decades of government monopoly in the electricity sub-sector severely hampered electricity generation and grid coverage in the country. Until November 1, 2013, the Federal Government was virtually responsible for electricity generation, transmission and distribution. Nigerian Electric Power Authority (NEPA) and later Power Holding Company of Nigeria (PHCN) until then provided electricity to all parts of the country through the centralized grid structure. The major problem here is not the popular idea that 'government is not a good manager of businesses. The problem is the cankerworm of corruption that has eaten up the public fabric for decades. No doubt, meaningful development can only be possible in a free market situation where government is also a key player, providing the enabling environment as a stimulus for development. What is the enabling environment that government provides? It is the Basic Social Infrastructure (BSI) policy instruments, reliable electricity, good roads etc and government has statutory responsibility to provide BSI.

Fifth, the dire lack of a clear and comprehensive energy policy was a major setback to rural electrification in Nigeria. The National Energy Policy of 2003 was the first attempt to do so. The policy objective was anchored in 'optimal utilization of the nation's energy resources for sustainable development'[12]. The policy would also safeguard energy security through energy mix and efficient utilization hinged on energy planning. Hitherto,

energy was an exclusive item: for example, the Federal Government of Nigeria had total jurisdiction on energy issues until the 2005 Power Sector Reforms[13]. ECN[12] noted that the Federal Government had "98% ownership of installed capacity in the electricity sub-sector". The ensued policies had major pitfalls. The top-down structure made them operationally inefficient. The 2003 policy in particular, only made provision for state units of the Energy Sector which were mere extension points in a trickle-down process. That was time-consuming and ineffective in addressing grassroots needs, given that state and local governments were not actively involved in the policy's formulation and implementation. Hence, the policy unwittingly placed constraints on power generation and transmission, even though it advocated for private sector participation[1]. Besides, its emphasis on foreign capital depicted the policy's neo-colonial orientation; tending to relieve government from its basic duties. Until recently, the private sector participation (especially foreign capital) advocated for in the policy was not visible. No wonder rural electrification rate was very low at 18%[9]. Uzoma[1] also observed that although the policy centred on energy security, rural electrification was not overtly stressed in its objectives. Finally, given the country's vast geography and highly plural demography, routing electricity to every section through a complex clumsy central grid is difficult. Marvel and Agvaanluvsan[14] formulated the Random Matrix Theory in Physics to explain a complex system such as the electric grid. The random matrix grid electrification in Nigeria makes electricity trickle down from the complex grid centre to consumers throughout the country. This takes time and requires a whopping budget which threatens investment in other sectors of the economy. On the other hand, ethnic sentiments and mutual suspicion turn basic infrastructure such as electric power into political weapons in the hands of ethnocentric politicians, marginalized sections of the country. Consequently, social infrastructure distribution is subjected to the same skewed federal character formula that allocates excessive numeric, power and resources to sparsely populated regions which gained an edge over the years. This dysfunctional system on which rural electrification in Nigeria is based, alluding to Marx has not been very effective in delivering electricity to the grassroots. Thus, an effective system approach to rural development should imbibe community harmony, inclusive resource mobilization and contextualization of development programmes. Arguably, the grid system is not need-based and is largely ineffective. Against this backdrop, the following hypothesis are formulated and tested:

- Rural electrification improves as the grid is more centralized
- The more centralized the grid, the more rural development improves

MATERIALS AND METHODS

A cross-sectional survey was done, taking into account time and geographical space. Data was collected in Imo State with a population of 3.9 million distributed across 27 local government areas (Table 1). A primary sample of 1056 was determined using the Z score statistical method at 95% level of significance (α) which is 1.96 of the Standard Deviation (SD) unit. Thus:

$$n = z^2(pq)/e^2$$

Where:

n = Required sample size,
z = Confidence level (95%)
p = Prevalence of event (proportion of people living in rural areas) which is about 55%, estimated by Trading Economics[15, 16]
q = Complement of p which is 100%-p
e = Expected level of accuracy or precision $(3\%)^2$

Thus, $n = 1.96^2(0.55)\ (0.45)/0.03^2$ $n = 3.8416 \times 0.2475/0.0009$ n = 1056. Sizes of the selected sample areas in the n1 are determined as follows:

$$\text{N of sample LGA}/\sum \text{N of all sample LGAs} \times n$$

The primary sample was selected by multiple probabilities sampling techniques as shown in Table 2. In addition, an auxiliary sample of 15 local leaders was purposively selected for IDI (In-Depth Interview) sessions.

Data were collected, using questionnaires and structured IDI guides; these were analyzed through both quantitative and qualitative methods.

Table 1: Summary of questionnaire and in-depth interview feedbacks (f and%)

Variables	N	Returned completed/%	Returned uncompleted/%	Unreturned or undistributed/%	IDI Feedbacks/%
Imo East	406	354/87	23/6	29/7	5
Imo North	338	269/80	17/5	52/15	5
Imo West	312	271/87	9/3	32/10	5
Total	1.056	894/85	49/5	113/10	15/100

*n = sample size; f = frequency; % = percentage

Table 2: Probability random sampling procedure

Sampling procedure	Result 1	Result 2
Clustre R. Sampling	3 Senatorial Zones (Imo East, North, West)	LGAs in each senatorial zone
Clustre R. Sampling 2		
SRS	Selected LGAs from Zones	n from selected LGAs
SRS 2		

RESULTS AND DISCUSSION

First, data distributions across the three Senatorial Zones in the State are displayed on Table 1. Over the 75% minimum requirement of responses collated was valid for analysis.

Second, gender characteristics of questionnaire respondents such as sex, education and residence are described as follows. Male respondents out-number female respondents in Table 3 living two possibilities. Either more males received the questionnaires than females or that males are more likely to respond to research questionnaires than females. However, women's traditional roles saddle them with many domestic chores that deny them time off. 'Only men can usually pass leisure time chatting, hardly women'. Apparently, men are more disposed to discuss extraneous issues than women.

The sum of the responses for age brackets '15-24' and '25-39' (72.0%) on Table 4 is significantly high. A possibility here is the fact that Nigeria has vast youth populations.

According to Table 5, most of the respondents have some form of education with the majority falling within secondary and tertiary levels 37 and 44.5%, respectively. Moreover, the sum of the scores for primary, secondary and tertiary is 93% of all the scores. This supports the views of a high literacy rate and education being a huge industry. Hence, the crucial need for adequate and reliable electric power supply in the country.

Table 6 shows that most of the respondents (74%) are indigenes which may simply point to the fact that rural electrification through the national grid has not been very effective. This is because electricity attracts migration and thus these communities do not host a large migrant population.

Similarly, a description of the in-depth interview data on Table 7 shows that 80% are males, 73% are 40 years and above, 40% have just primary education, a remarkable 53% attained tertiary education while only 7% has secondary education. Occupational distribution is as follows: 40% farmers, 27% civil servants, 13% traders and housewives a piece and 7% artisan. It is no surprise that the respondents are married; albeit, 1 individual 7% is widowed. Besides, many communities had populations of ten thousand and above which pointed to huge human resources to propel rural economies.

Third, specific issues bordering the study are hereby analyzed. More than half of the respondents (63%) in Table 8 classify their community as 'rural' while 24% refer to their community as 'semi-urban'. To juxtapose, Table 8 and Table 6 suggest that scores for urban and semi-urban may have been recorded in communities with high numbers of immigrants. This is because the sum of 79 and 215 (294) for urban and semi-urban in Table 8 is in the same range with 235 for 'immigrant' in Table 6. For example, many respondents viewed electricity and migration as strong indicators of urban development.

Table 3: Distribution according to sex

Gender	Score	Percentage
Female	387	43
Male	507	57
Total	894	100

Table 4: Distribution according to age

Age	Score	Percentage
15-24	278	31.0
25-39	365	41
40 and above	251	28.0
Total	894	100

Table 5: Distribution according to education

Variables	Primary	Secondary	Tertiary	None	Total
Score	103	330	398	63	894
Percentage	11.5	37	44.5	7	100

Table 6: Residential status of respondents

Variables	Indigene	Immigrant	Total
Score	659	235	894
Percentage	74	26	100

Table 7: Frequency and percentage distributions of in-depth interview data

Variables	Frequency	Percentage
Gender		
Female	3	20
Male	12	80
Age		
25-39	4	27
40-above	11	73
Education		
Primary	6	40
Secondary	1	7
Tertiary	8	53
Occupation		
Farmer	6	40
Trader	2	13
Artisan.	1	7
Civil Ser.	4	27
H/wife	2	13
Marital status		
Marr.	14	93
Wid.	1	7
Total	15	100

Table 8: Respondent's classification of community

Variables	Rural	Urban	Semi-Urban	No answer	Total
Score	562	79	215	38	894
Percentage	63	9	24	4	100

Table 9: Community connected to the national grid

Variables	No	Yes	Total
Score	218	676	894
Percentage	24	76	100

Table 10: Being personally connected to the national grid

Variables	No	Yes	Total
Score	141	535	676
Percentage	21	79	100

Table 11: Having electricity supply at all

Variables	No	Yes	Total
Score	321	*573	894
Percentage	36	64	100

Table 12: Perception of electricity situation in community

Variables	It's okay	It's not okay	No answer	Total
Score	120	685	89	894
Percentage	13	77	10	100

Table 13: Perception of rural electrification in Nigeria through the national grid

Variables	It's okay	It's not okay	No answer	Total
Score	291	496	107	894
Percentage	33	55	12	100

They testify that electricity attracted visitors to their communities who do businesses and also build houses.

In Table 9, 76% of respondents indicate that their communities are connected to the grid while 79% on Table 10 testifies being personally connected. The high scores suggest that government at various times made significant efforts concerning grid rural electrification. Since, Table 10 is derived from Table 9 is important to discuss them side by side for clarity. The consecutive high scores would not necessarily translate to effective delivery of electric to rural populations. Only a matter of time, an empirical picture of rural electrification in Nigeria is painted in this study.

Essentially, 64% on Table 11 has electricity supply at all while 36% does not have. Note that the phrase 'at all' actually highlights the problem that the grid does not meet expectation so much, so that, people accept what they see. Thus, although, the yes' frequency is relatively high, Table 12 and 13 incidentally depict a dismal situation.

As regards the electricity situation in the community at present, a whopping 77% say 'it's not okay' in Table 12. This is further amplified in Fig. 1. It is not also surprising that Table 13 on perception of rural electrification through the grid yields a high negative

Table 14: Having an alternative source of electricity

Variables	No	Yes	Total
Score	373	521	894
Percentage	42	58	100

Table 15: Perception of widespread use of electricity generators

Variables	It's okay	It's not okay	No answer	Total
Score	306	471	117	894
Percentage	34	53	13	100

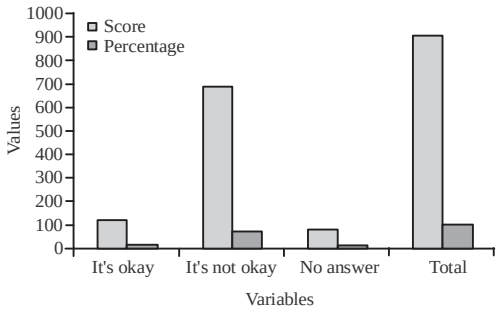

Fig. 1: Bar chart on respondent's perception of electricity situation

response of 55%. This is so, because the centralized grid is the epitome of the Nigerian electricity network which the communities depend on. Major feedbacks from the in-depth interviews ('very bad', 'it is not good at all,' 'no electricity') also substantiate this position.

With regard to having alternative source of electricity in Table 14, 58% say they have generating sets and most mentioned the popular 'I pass my neighbour'. This high score agrees with the on-going discourse-it reflects the horrible situation and the dire need for electricity. The adjective 'alternative' signifies the unreliability of the conventional infrastructure.

Table 15 does not necessarily strike a balance; even generator users lamented the problems they experienced. It is deduced that: 'if generators give us light at all, then 'it's okay' since we have no other choice'. After all, most respondents mentioned smoking, high fuel and maintenance costs, noise and risk of fire outbreak as major problems of using generators. The impacts of air pollutions on health could be terminal. In fact, generator-related fire outbreaks and deaths occur frequently in the country. Rampant use of generators just described though not a good development as such is motivated by dire need. No wonder about 50% of installed capacity of the grid is generated by households and industries and over 90% of businesses in the country operate generators[17].

Surprisingly, awareness of renewable energy sources, particularly solar, on Table 16 is very high (72%). Another high percentage (57%) in Table 17, expressed desire to see solar energy integrated into the national grid.

Table 16: Awareness of renewable energy sources for electricity generation

Variables	No	Yes	Total
Score	251	643	894
Percentage	28	72	100

Table 17: Integrated solar electricity into the national grid

Variables	It's okay	It's not okay	No answer	Total
Score	511	223	160	894
Percentage	57	25	18	100

Table 18: Willingness to pay for a community solar electric mini-grid

Variables	It's okay	It's not okay	No answer	Total
Score	523	214	157	894
Percentage	59	24	17	100

Table 19: Perception of the grid-rural electrification according to senatorial zones

Variables	Imo East-f/%	Imo North-f/%	Imo West-f/%	Total f/%
It's okay	210 (59.3)	90 (33)	30 (11)	330 (37)
It's not okay	97 (27.4)	148 (55.0)	162 (60)	407 (45.5)
No answer	47 (13.2)	31 (12)	79 (29)	157 (17.5)
Total	354 (100)	269 (100)	271 (100)	894 (100)

*f = frequency; % = percentage

A high percentage (59%) in Table 18, also indicated willing to make contributions to install solar electric mini-grids in their community, if that would solve the electricity quagmire. There is general perception of failure and a lack confidence in public infrastructure as well as a preference for communal ownership in the hope that would ensure good service.

Hypothesis testing: The study hypothesis are hereby tested using selected bi-variate tables. The X^2 is utilized for this purpose to ascertain their significance or non-significance. The level of significance is 0.05 (95%) while the degree of freedom is 4.

Test of hypothesis 1; Rural electrification improves as the grid is more centralized: This hypothesis is tested using group data from senatorial zones on perception of the grid-rural electrification in the country (Table 19 and 20):

- X^2 = 176.1-894 = -717.9
- $X^{2obt.}$ = -717.9
- $X^{2crit.}$ = 9.488
- d/f (degree of freedom) = R-1×C-1 (3-1) (3-1) = 2×2 = 4, hence, $p \leq 0.05$

Since, the calculated value of Chi-square is ≤(less than/equal to) its table value, hypothesis 1 is rejected because it is null. Thus, the statement that grid-rural electrification improves as the grid is more centralized is non-significant. The reverse is the case. The vastness of

Table 20: Using the $X^2 = \Sigma (O^2/E)-N$

O	O^2	$E = R^t xC^t/N$	O^2/E
210	44100	556.2	79.2
90	8100	986.3	8.2
30	900	2981	0.3
97	9409	1485.3	6.3
148	21904	739.7	29.6
162	26244	680.8	38.5
47	2209	1182.5	1.8
31	961	1362.3	0.7
79	6241	538.5	11.5
894			176.1

Table 21: Perception of the impact of the grid on rural development according to age

Variables	15-24-f/%	25-39-f/%	40 and above-f/%	Total
No	137 (49)	174 (48)	124 (49)	435 (49)
Yes	83 (30)	112 (31)	75 (30)	270 (30)
No answer	58 (21)	79 (21)	52 (21)	189 (21)
Total	278 (100)	365 (100)	251 (100)	894 (100)

Table 22: Using the X^2

O	O^2	$E = R^t xC^t/N$	O^2/E
137	18769	882.7	21.2
174	30276	912.5	33.1
124	15376	880.5	17.4
83	6889	904.3	7.6
112	12544	879.9	14.2
75	5625	903.6	6.2
58	3364	905.8	3.7
79	6241	873.2	7.1
52	2704	912.2	2.9
894			113.4

Nigeria makes routing electricity via. a centralized grid difficult. Rough terrains contribute to delays and high cost of grid coverage in rural locations of the country.

Test of hypothesis 2; The more centralized the grid, the more rural development improves: Hypothesis 2 is tested with group data on age on the impact of the centralized grid on rural development (Table 21 and 22):

- X^2 = 113.4-894 = -780.6; $p \leq 0.05$

The calculated value of Chi-square ($X^{2obt.}$) is less than/equal to its table value ($X^{2crit.}$). Hence, the H_i is rejected and the H_o is accepted. Apart from generation of more electricity, only efficient transmission and distribution can ensure effective electricity supply that will create opportunities for rural development. This transformation of the transmission cum distribution systems (the grid) has not happened. Therefore, there is already a rural electricity crisis forestalling rural development in Nigeria due to poor rural electrification strategies.

CONCLUSION

Rural electrification in Nigeria is enmeshed in a morass of complex, clumsy centralized grid that routes

electricity to all parts of the country. No matter where and how electricity is generated, the national grid remains the monotonous supply channel that delays or forestalls delivery, particularly to remote areas. The grid is, no doubt, the best way to ensure reliable electricity supply to drive meaningful socio-economic development including in rural areas where over 50% of the nation's population resides and living standards are very low. Unfortunately, the centralized grid has not reached all the nooks and crannies. Consequently, rural development is significantly retarded throughout the country, since, electricity supply has been deplorable due to several limitations that include low generation capacity, lack of grid coverage and inefficiency of the complex grid. Moreover, the monopolistic DISCOs might prioritize supply of available electricity for economic reason-focusing on areas with high revenue forecast, particular in urban centres. By this, rural communities are deprived development in various rural sectors: health, education, business, agriculture, access to portable water as well as domestic life of women, girls and children.

Electricity is arguably a primary factor of development in various sectors of the rural life. This expository study paints a logical picture of the turbulent history of rural electrification in Nigeria. However, research is open-ended; hence, the study has not exhausted the topic area but serves as a guide to further studies. It is therefore best concluded by recommending that the national grid be vigorously overhauled and apolitically decentralized. This should keep in view a localized Generation, Transmission and Distribution (GTD) for effective electricity delivery to rural areas.

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