Centralized Electricity Grid and the Rural Economy of Nigeria

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Abstract. Electricity is necessary for economic development and no doubt, the best way to ensure adequate supply is through the grid. Nigeria operates a centralized grid system and little is known about how the centralized grid system impacts on the rural economy. This paper examines the impact of the centralized electricity grid on rural electrification and rural economy of Nigeria. Questionnaires were employed to generate data, from 894 respondents in three senatorial districts, in Imo State. Data analysis was conducted using descriptive and inferential (X² -Chi square) statistics. Result shows that the electricity situation in rural areas is abysmal. Consequently, rural living standard is very low, due to lack of income opportunities. It is concluded that given Nigeria’s large geographical size, the centralized grid rural electrification is fundamentally inadequate. A decentralized electricity structure with emphasis on mini-grids and a priority on localized generation is recommended.

Keywords: Electricity, Nigeria, Centralized grid system, Rural economy, Imo State.

1. Introduction

Electricity is the most convenient form of energy usage and a key driver of socio-economic development [1]. The global mass consumption fast-tracked by the dynamic information and communication technology (ICT) that is propelled by steady electricity supply signifies this [2]. In Africa, mostly public utilities have constructed large-scale centralized electricity grids to ensure adequate supply, but this is not largely effective. Distributed generation could create electric power on a small scale at locations throughout an electricity network [3]. This is not the case in many developing countries including Nigeria; making electricity generating sets widespread despite the cost inefficiencies, health and environmental risks.

Rural areas are significant to economic growth in any nation as food producers and ready markets for domestic products. Adequate electricity supply will improve performance in the
various areas of rural needs, which include home lighting, agro-processing, SME (small-medium enterprises), irrigation/water pumps, storage/cooling, entertainment, communication and education. Thus, the economic justification for investments in rural electrification is enormous [4]. However, high grid extension cost, low revenue prospects and lack of access roads pose severe impediments to rural grid extension and consequently, rural access to electricity. The geographical size of the country (355,425.78 square miles or 909,890 square kilometres) makes rural road networking pretty difficult, which also impedes grid extension [5].

Electricity demand far outweighs supply; making it irregular or unavailable in many places. At present, about 25 grid-connected power plants with installed daily capacity of about 10,396MW generate less than 4000 MW that barely meets the need of just 40% of the population [6]. Sambo [7] outlined some problems of the electricity sub-sector: high energy loss due to dilapidated equipment and power theft; inefficient metering and billing system, incompetent manpower and lack of funds. Besides, the complex centralized grid routing electricity to all parts of the country poses a significant obstacle to rural grid electrification. Until the unbundling of PHCN (Power Holding Company of Nigeria) in 2012, States had no political impetus to generate electricity and yet today, most States have not dared to venture into the sub-sector. The study samples were drawn from Imo State and the observations were assumed representative of situations elsewhere in the country. As a result, the study is guided by two hypotheses. First it was hypothesized that the sample areas' perception of centralized grid would be associated with their rating of electricity situation in the area. The second was that, connectedness to the national grid (CNG) would amount to improved standard of living.

About 90% of 840 million people globally without access to electricity lives in sub-Saharan Africa and Asia and 80% of this lives in rural areas. Globally, rural electrification has improved in the last decade with outstanding performances in India (100% rural electrification), Indonesia (95%), Bangladesh (80%), Kenya (73%) and Ethiopia (45%). However, the scenarios in most parts of Africa are not that fantastic, particularly the sub-Sahara where 600 million (57% of its population) had access rate widely below 25% [8, 8]. It was really precarious in Nigeria: population growth of 2.6%, over 50% rural population with 68% dependence on subsistence farming, 70% rural poverty level and one of five countries in sub-Sahara Africa with half of the people without electricity [9, 9, 9]. A National Rural Electrification Programme (NREP) in 1981 was aimed at increasing electricity access through the national grid. Decades later, many rural areas still do not have electricity [10]. Alternative village electrification projects through SHS (solar home systems) in many instances largely collapsed within a short period of their commissioning [11].

The connection between electricity and socio-economic development is not in doubt [4]. This study espoused that only grid-based electricity would guarantee enough electricity to drive meaningful development; it would lead to employment and income opportunities and improved well-being. Echoing this, Barkat et al [12] found that rural electrification programme in Bangladesh created 63,220 electrified rural industries, generated 983,829 employments in various capacities- 11 times more jobs than in non-electrified villages. In addition, 848,630 rural jobs were created in small scale and wholesale businesses beside 1.1 million people that worked in farmlands using electricity connected irrigation equipment. Thus, average income in electrified villages rose compared with non-electrified villages in 2001. Moreover, 16.4% of the annual income of electrified households was attributed to electricity, while 9.3% of the annual income of the total rural households (19.1 million) was
associated with rural electrification. However, economic and physical factors remain core challenges to grid rural electrification in many developing countries.

Nepalese Government defied mountainous topography to deploy solar home systems and mini-micro hydropower plants in rural. Considerably, Community-Based Integrated Energy Development (CBIED) provided basic need by improving agriculture and businesses through a decentralized energy development.

Table 1

| Socio-economic benefits of Electricity to different groups at Lamjung. |
|---------------------------------------------------------------|
| Electrified pump set                                         |
| Labour:                                                      |
| Increased agricultural productivity due to irrigation.        |
| Agro-processing:                                             |
| Mechanization reduced drudgery and favoured large farmers, by cutting down labour demands. |
| Lighting / communication:                                    |
| Longer working day; greater communication with the outside world: health and cleanliness awareness. |
| Industry and small business application:                     |
| Improved productive efficiency and potential stimulation of local economy. |

Source: McMenemy et al, 2010 adapted.

Consequently, electrified irrigation pumps and electricity from micro-hydro power (MHP) plants boosted agro-processing; even though only ‘15% of Nepal’s 88% rural population had access to electricity’ [13].

Dinkelman [14] observed increased rural employment in KwaZulu-Natal (KZN), South Africa employing a four-year survey in 1995, 1997, 1999 and 2001. Female employment increased by 9.5% (equivalent to 15,000 more women in the labour force- 0.75% of the estimated new jobs created nationwide). South Africa’s National Electrification Programme (NEP) saw 300,000 new grid connections annually- 28% of KZN households (470,000) and 20% of communities in the sample area between 1994 and 2010. However, work increased on the intensive margin for women (about 8.9 more hours per week, a 3.5% increase) in 15% of districts with average increase in electricity. Cabraal, Barnes and Agarwal [15] reported that electric water pumps boosted farm income in rural India by 11 thousand rupees (about $203 US dollars) annually, Kirubi, Jacobson, Kammen and Mills [16] also noted that Kenya’s rural electrification model based on the “American experience” of “opening up” rural areas through massive infrastructure expansion (particularly, electricity and railroads) based on ‘area coverage’, ‘grid extension’ and ‘integrated rural development’; resulted in agricultural mechanization and growth of SME (small-medium enterprises). Further, Barnes and Toman [4] argue that electricity facilitates the use of modern machinery and techniques in agriculture and industry, thereby improving economic activities and social services that meet basic human needs. Torero [17] adds that electricity access could improve economic conditions by influencing poverty and income. Hence, the capacity of electricity to promote rural productivity and human development is not in doubt.
2. Methodology
This study used the cross-sectional survey research design. Data were collected from a sample of 894 respondents selected from the three senatorial zones in Imo State using multistage sampling procedures. Although, a sample of 1056 was earlier determined using Z score statistical method at 95% level of significant, 894 (85%) of the instruments were adequately or completely filled and returned. Therefore, it was considered valid for the data analysis. Questionnaire was the instrument for data collection and was self and other administered.

Questionnaires were designed to obtained respondents’ socio-demographics, connectedness to grid electricity supply, rate of electricity supply, impact of electricity supply on socio-economic life of the people etc. Data were analyses were through descriptive and inferential (Chi-square) statistics. Comprehensive information on methodology is limited by space.

3. Results and Discussions

| Table 2: Selected respondents’ socio-demographic characteristics |
|---------------------------------------------------------------|
| **Socio-demographics**                                      | **Dimensions** | **Frequency** | **Percentages (%)** |
| Farming                                                      | 149            | 16.7          |
| Trading                                                      | 159            | 17.8          |
| Artisan                                                      | 97             | 10.8          |
| Civil servants                                              | 161            | 18            |
| Others                                                      | 328            | 36.7          |
| **Education**                                               |                |               |
| Primary                                                     | 103            | 11.5          |
| Secondary                                                   | 330            | 37            |
| Tertiary                                                    | 398            | 44.5          |
| No Formal Education                                         | 63             | 7             |
| **Nature of area**                                          |                |               |
| Rural                                                       | 600            | 67.1          |
| Urban                                                       | 79             | 8.8           |
| Semi-Urban                                                  | 215            | 24.1          |
| **Residential status**                                      |                |               |
| Indigene                                                    | 659            | 73.7          |
| Migrant                                                     | 235            | 26.3          |

The socio-demographic information of the respondents reviewed that 16.7% of the respondents were farmers, 17.8% were traders, 10.8% were artisans while 18% were civil servants. Also, 36.7% were students, the unemployed persons and housewives. Nevertheless, more than one-third of the respondents (44.5%) had tertiary education certificate, 11.5% had only primary school certificate, 37% had secondary school certificate while 7% of the respondents had no formal education. Furthermore, more than half of the respondents (67.1%) were rural residents, 8.8% resides in urban areas while 24.1% resides in semi-urban areas. In all, majority of the respondents were indigenes of Imo state (73.7%) while 26.3% were migrants.

The nature of electricity supply, measured as the extent to which households in Imo state had access to electricity was the first issues cross tabulated connectedness to the national grid. This is to enable the study ascertain how individual’s connectedness with the national grid affects their state of electricity supply, frequency of electricity supply and length of electricity supply. Data presented in Table 3 showed that 73.5% of people who were connected to the national grid perceived the nature of electricity supply in their area as positive which implies
that so many households in the area have access to electricity while only 6.4% of those not connected to national grid regarded electricity supply in the area as positive. Inversely, 86.2% of those not connected to the national grid regarded nature of the electricity supply in the area as negative, implying that many households in their area do not enjoy access to electricity while only 19.7% of those connected to national grid shares in such conception. It was further observed that 76.6% of the respondents rated electricity situation in the state (number of times they had light) as very poor. This was made up of 77.5% of respondents whose households’ were connected to the national grid and 73.9% of those whose households were not connected to national grid. This implies that connection to the grid does not alter the general perception people have about the rate of electricity supply in the areas. Only 13% of the respondents rated the scenario as good, which included 13.9% of those who were connected to national grid and 11.9% of those who were not connected.

Table 3: Connectedness with National grid and perceived state of electricity supply, rating of electricity situation in the area and rating of grid rural electrification

| CNG | Nature of electricity supply | Total |
|-----|-------------------------------|-------|
|     | Negative | Neutral | Positive |       |
| Yes | 133 (19.7%) | 46 (6.8%) | 497 (73.5%) | 676 (100%) |
| No  | 188 (86.2%) | 16 (7.3%) | 14 (6.4%) | 218 (100%) |
| Total | 321 (35.9%) | 62 (6.9%) | 511 (57.2%) | 894 (100%) |

| CNG | Rating of electricity situation in the community | Total |
|-----|-----------------------------------------------|-------|
|     | Very poor | Poor | Good |       |
| Yes | 524 (77.5%) | 58 (8.6%) | 94 (13.9%) | 676 (100%) |
| No  | 161 (73.9) | 31 (14.2%) | 26 (11.9%) | 218 (100%) |
| Total | 685 (76.6%) | 89 (10%) | 120 (13%) | 894 (100%) |

| CNG | Rating of Grid rural electrification | Total |
|-----|-----------------------------------|-------|
|     | Negative | Neutral | Positive |       |
| Yes | 325 (48.1%) | 96 (14.2%) | 255 (37.7%) | 676 (100%) |
| No  | 171 (78.4%) | 11 (5.1%) | 36 (16.5%) | 218 (100%) |
| Total | 496 (55.5%) | 107 (12%) | 291 (32.5) | 894 (100%) |

NOTE: CNG = Connected to National grid; percentages are calculated using row total. This was to enable the study determine the electricity status of individuals who are connected to national grid.

On the other hand, the respondents rating of grid rural electrification varied significantly, across household CNG status. It was found that 48.1% of the respondents who have connected to the national grid rated grid rural electrification as negative in the area while the proportion increased to 78.4% among those who were not connected. Also, more than one-third (37.7%) of the respondents, who were connected to the national grid rated grid rural electrification as positive while only 16.5% of the respondents who were not connected rated grid rural electrification as positive. The study hypotheses presented in Table 3 further demonstrated that areas’ rating of centralized grid (RCG) was not associated with their rating of electricity situation ($p > .05$). This implies that the current state of the centralized grid does not promote steady electricity supply. This was substantiated by the second hypotheses which demonstrated that connecting to the national grid has no statistical association with improved living standard ($p > .05$). Hence, beside generation of more electricity, only an upgrade of the transmission/distribution system can ensure adequate and regular electricity supply in rural areas. This has not happened; so, the rural electricity crisis lingers.
Table 4: Study hypotheses

| RGC by Zones | Rating of electricity situation in the area | Total |
|--------------|-------------------------------------------|-------|
|              | Low (72.9%)                               |       |
| East         | 258                                       | 72.9% |
|              | Neutral (6.5%)                            |       |
|              | 23                                        | 6.5%  |
|              | High (20.6%)                              |       |
|              | 73                                        | 20.6% |
| North        | 202                                       | 75.1% |
|              | Neutral (5%)                              |       |
|              | 14                                        | 5%    |
|              | High (10.4%)                              |       |
|              | 28                                        | 10.4% |
| West         | 225                                       | 83.3% |
|              | Neutral (10%)                             |       |
|              | 27                                        | 10%   |
|              | High (7%)                                 |       |
|              | 19                                        | 7%    |
| Total        | 685                                       | 76.6% |
|              | Low (10%)                                 |       |
|              | 89                                        | 10%   |
|              | Neutral (13.4%)                           |       |
|              | 120                                       | 13.4% |
|              | High (39.6%)                              |       |
|              | 354                                       | 39.6% |

\( \chi^2 = 5.911; \text{ df} = 4; p = 0.21 \)

| CNG | Rating of living standard | Total |
|-----|---------------------------|-------|
|     | Improved                  | Not improved | No answer |
| Yes | 343 (15.1%)               | 300 (44.4%) | 33 (4.9%)  |
| No  | 33 (42.1%)                | 158 (72.5%) | 27 (12.4%) |
| Total| 376 (42.1%)               | 458 (51.2%) | 60 (6.7%)  |

\( \chi^2 = 18.13; \text{ df} = 2; p = 0.52 \)

NOTE: RGC = rural grid coverage; CNG = Connected to national grid; Percentages was by row total

4. Conclusion and Recommendations

This study has clearly shown close relationships between the electricity situation in Nigeria and the poor socio-economic conditions in its mostly rural settings. The electricity distribution is a structure of complex, but centralized networks through which electricity is routed to all parts of the country. No matter where and how electricity is generated, the grid remains the monotonous transmission channel; making delivery to remote parts of the country delayed or unaccomplished. Consequently, electricity supply has been drastically poor and significantly retarding socio-economic development in rural areas where over 50% of the population resides. The profit-driven and monopolistic Distribution Companies are likely to prioritize supply to urban areas for limited cost risk and high revenue prospects. Moreover, transportation difficulty posed geographical impediments rural grid extension. Thus, there is vast lack of development in various rural sectors such as health, education, business, agriculture and access to potable water.

This study is significant as a guide to further research in this area. It is therefore recommended that:

- The geographical size of the country is a major impediment to the central grid rural electrification.
- Localized generation/distribution: it is crucial to group the monotonous grid into several mini-grids. It will enhance electricity supply by bringing generation points closer to transmission stations and distribution lines, to save time, costs and transmission losses.
- Since the grid is the best way to provide sustainable electricity supply, an overhaul of the grid is vital for effective electricity delivery in Nigeria.
- Rural electrification through renewable energy-based mini-grids has been successful in several countries. This can be replicated in Nigeria within socio-cultural contexts. Dependence on rural agriculture should make rural electrification a thrust of the national energy policy and all levels of governments should be actively involved.
- Whatever the approach, full community involvement is prerequisite because, rural communities know their priorities best. Counterpart fund should only be supportive.
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