Effect Of Access To National Grid Electricity Connection On Households' Energy Spending In Bauchi State Nigeria

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Abstract
Access to electricity from national grid has been linked to improved socio-economic development among households and communities as a whole. In order to ensure rural areas, have access to electricity, the Nigerian government, through the Rural Electrification Agency (REA), executes project in rural areas with the goal of improving socio-economic development of the people. This study aims to evaluate the impact of access to RE on households' energy expenditure in some selected rural electrification (RE) project locations in Bauchi State Nigeria. The study utilized the survey research design where questionnaire was used as instrument for data collection. A total of 336 respondents were sampled using a multi-stage sampling strategy. Data was analysed using both descriptive statistics (frequency count and percentage; mean and standard deviation) and inferential statistics (Mann-Whiteny U test and multiple regression analysis). The study found that there is statistically significant difference between grid-connected households and off-grid households with regards to monthly energy expenditure (Mann-Whitney U = 3823.500; Asymp. Sig. = 0.000) with grid-connected households spending higher on monthly energy cost (₦ 30, 675.57; approx. USD 19.47).) than the off-grid household (₦ 18, 081.08; approx. USD 11.48) (app $19.47). The result further revealed that connection to national grid (β = .342; t = 6.158; p < .05) and distance to secondary school (β = .448; t = 2.456; p < .05) have a statistically significant positive effect on monthly energy spending. However, distance to primary school (β = -.562; t = -4.876; p < .05) was found to have negative statistically significant effect on monthly energy spending. This study recommends that as higher energy cost tends to negatively affects households' welfare, rural electrification projects should factor in the issue of affordability while designing RE projects so as to ensure the target goal of improving community and households' socio-economic development is met.
Keywords: electricity, energy, national grid, rural electrification, welfare
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I. Introduction
In a bid to achieve the Federal Government of Nigeria (FGN)'s Economic and Recovery Growth Plan (ERGP) and the Power Sector Recovery Programme (PSRP) objectives, the Rural Electrification Agency (REA) developed a number of strategies towards achieving these cardinal objectives. One of these strategies is to ensure close co-ordination of rural electrification expansion with economic development objectives. Some key economic development objectives contained in the FGN's Rural Electrification Policy include the promotion of agriculture, industrial, commercial and other economic and social activities in rural areas; raising the living standards of rural populations through improved water supply, lighting and security as well as protecting the nation's health and environment by reducing indoor pollution and other energy-related environmental problems.

To measure the achievement of these objectives, the FGN set a target of making available reliable electricity to 75% of both urban and rural population by the year 2020. As part of its mandate towards actualizing the FGN's target, REA have provided 5 million households, which is estimated to include 25 million individuals in rural areas and under-served urban areas with electricity through its programme 'Solar Power Naija' (Rural Electrification Agency, 2021). This and other electrification programmes being implemented by REA is expected to have huge impact on the households and communities where the projects are implemented.

Previous empirical studies reported mixed results on the impact of rural electrification (RE) on economic development of rural dwellers. Whereas some studies reported significant impact of RE on income and living standard of households, other studies have shown otherwise (Olanrele, 2020; Lee, Miguel and Wolfram, 2017; Peters & Sievert, 2016; Aragaw, 2012; Kanagawa & Nakata, 2008). Many RE schemes have been found to be unsustainable overtime because of failure of the projects to fully account for operation and maintenance costs in the initial project cost estimates. This amplified the need for service users to pay for the services provided. However, there is widespread notion among rural populace in Nigeria that it is the sole responsibility of government to highly subsidize infrastructural facilities including electricity. This belief affects

rural dwellers' willingness to pay for electricity and by extension affects the level of usage. In addition, reliability of electricity in Nigeria is poorly rated which lead people to resort to alternative sources (diesel generators, etc) for electricity. Therefore, as the overall goal of RE scheme is to ensure improvement in socio-economic status of households through provision of electricity, this study sets to evaluate the effect of access to RE on households' expenditure in some selected RE project locations in Bauchi State Nigeria with a view to providing empirical evidence for informed decisions.

II. Literature Review

The connection between access to electricity and welfare improvement of rural households has widely been investigated. Extant literature revealed the existence of a complex interaction among various socio-economic indicators and electricity use. A number of studies have attempted to investigate this relationship using varied methodologies and data sets. For instance, Gibson and Olivia (2010) investigated the effect of infrastructure access and quality of non-farm enterprise in rural Indonesia. It was found that households' participation in non-farming enterprises after being connected to electricity increased by 13.3%. In addition, the findings showed that the percentage of enterprises operated by rural households increase to 43% higher after access to electricity.

In a study that investigated the impact of electricity access to rural enterprises in Bolivia, Tanzania and Vietnam, Koojiman-van Dijk and Clancy (2010) found that 25% of households with electricity operated home business compared to about 15% of households without access to electricity. Aragaw (2012) found that households and communities in rural areas diversified their income and received improved public services (education, health and portable water) and improved quality of life, better lighting and reduced indoor air pollution because of access to electricity.

Burney, Alaofe, Naylor and Taren (2017) evaluated the impact of solar market garden on level and structure of women empowerment in Benin Republic. Using a quasi-experimental design, the authors estimated the changes in empowerment for project beneficieries after one year of the project development by comparing the empowwerment metric to non-beneficieries of the scheme for both treatment and comparison villages. The finding showed that the Solar Market Garden project significantly and positively impacted women's empowerment.

Similarly, Winther, Matinga, Ulsrud and Standal (2017) reviewed empirical literature on women's empowerment through electricity access. The important finding of the review is that access to electricity by rural women improves their welfare.

Groth (2019) investigated the effects of electricity on households' weekly energy expenditures and consumption in rural Tanzania using Propensity Score Matching (PSM). The result suggests that access to solar-based technologies reduce weekly consumption and expenditure on paraffin and kerosene among dwellers of off-grid locations

Using a randomised controlled experiment, Lee, Miguel and Wolfram (2020) conducted a study that aimed at evaluating the impact of household electrification in rural areas in Kenya. It was found that about 16 to 32 months after installation of home grid connection in the study area, there was little evidence of any significant economic or noneconomic gains across the various results obtained.

Olanrele (2020) investigated the effect of RE on household welfare indicators (monthly income and per capita expenditure) in rural areas of Oyo state, Nigeria. Using field survey method, a total of 393 households participated in the study. Monthly income and monthly per capita expenditure were used as dependent variables while access to RE and household and community characteristics were used as independent and control variables respectively. The finding showed that access to grid electricity increases household income by about 1.3%.

Babalola, Daramola and Iwarere (2021) The investigated the socio-economic impacts of energy access through off-grid systems in rural communities, focusing on Gbamu-Gbamu village in southwest Nigeria. Using a survey research design, a sample of 83 micro and small enterprise participated in the study. The study used descriptive statistics, paired-sample t-test, cross-tabulation, Chi-Square test and regression analysis to analyse the data. It was found that the number businesses significantly increased after the installation of mini-grid in the study area. Similarly, the study found a significant drop in generator usage after mini-grid installation which resulted to reduction in energy expenses as well as increase income among business owners in the study area. Moreover, it was found that factors such as gender, year of business establishment, household size, and building tenure significantly influence the income of businesses in the study area.

Uzoma et, al., (2021) conducted a study that examined the impact of the centralized electricity grid on rural electrification and rural economy of Nigeria. The study used questionnaire and collected data from 894 respondents in three senatorial districts, in Imo State. The data analysis was conducted using descriptive and inferential Chi square) statistics. The findings showed that connection to national grid has no statistically significant association with improved living standard. The study recommended the establishment of a

decentralized electricity structure with emphasis on mini-grids and a priority on localized generation in order to improve households' welfare.

Pelz, Pachauri and Falchetta (2023) evaluated the short-run effects of grid electricity access on rural non-farm entrepreneurship and employment in Ethiopia and Nigeria with a view to understanding the economic impacts of electrification on household-level non-farm activities and employment trend. The study used nationally representative household-level observational panel survey datasets that was collected in three waves between 2010 and 2015 in Nigeria and Ethiopia. The data was analyse using difference-in-difference analysis with staggered treatment timing to account for endogeneity. The study found that there was limited evidence of change towards non-farm entrepreneurship and employment as a result of rural electrification in both countries,

III. Methodology

The study adopted a quantitative research strategy where survey research design was used. The data was collected using an abridged version of a questionnaire adapted from the World Bank's report on the study 'Monitoring and Evaluation in Rural Electrification Projects: A Demand-Oriented Approach'. The questionnaire contained questions covering demographic, socio-economic, energy sources and expenditure. A total of 336 households participated in the study. The participating households were selected using a multi-stage sampling strategy across three Local Government Areas (LGA) of Bauchi State, Nigeria. The sampling process involved selection of one LGA from the three Senatorial Districts of the State. Thereafter, a REA project location was selected from each LGA and subsequently the households were selected. The collected data was analysed with the aid of Statistical Package for Social Science (SPSS) software where both descriptive (frequency count and percentage; mean and standard deviation) and inferential statistics (Mann-Whiteny U test and multiple regression analysis) were used.

IV. Results

Socio-economic characteristics of respondents

Table 1 shows the socio-economic characteristics of the respondents. As indicated approximately 50 percents were household heads while the remaining half were members of households. The gender distribution of the respondents shows that 100 percents were male. About 62 percents of the respondents were married while approximately 38 percents were single. Majority of the respondents (approximately 90 percents) indicted that they could read and write while only 10 percents indicated otherwise. Exactly 43.2 percents of the respondents were enrolled in school at the time of the data collection while approximately 57 percent indicated that they were not. The educational status of the respondents showed that slightly more than half (56.5 percents) had tertiary education, more than one-quarter (28.1 percent) of the respondents indicated that they had secondary certificates while approximately 18 percents had primary certificate.

Analysis of the source of income of the respondents shows that about 32 percents indicated petty trading as their source of income. Exactly 30.4 percents indicated sales of crop as their source of income while approximately a quarter of the respondents (24.7 percents) indicated that they source their income from artisanship. Only 3,6 percents of the respondents indicated wages/salary as their source of income while 6 percent and approximately 4 percent indicated sales of livestock and hiring of cart as their sources of income respectively.

Regarding ownership of livestock, approximately 46% of the respondents indicated that they own goat/sheep while exactly 23.8 percents of them indicated that they own cattle. Approximately 19 percent indicated that they own hen while the remaining own either of horse, donkey, fowl or nothing.

Analysis of the respondents' ownership of assets other than livestock indicated that slightly above a quarter (27.7 percent) owned bicycles while majority indicated that they owned motorcycles. Exactly 14.3 percents showed that they own grinding/milling machine while only approximately 10 percents owned a lorry. The remaining indicated that they owned either a car, sewing machine, cart or generator or nothing.

Information regarding the type of house occupied by the respondents indicated that 17 percents live in mud row house while the majority (30.4 percents) live in concrete block row house type. Approximately 22 percents live in round hut, 18.2 percents in mud bungalow house while approximately 13 percents live in concrete bungalow house type. Regarding use of part of house for business, only 34.2 percents of the respondents indicated that they use part of their house for business operation. Furthermore, analysis of the business type of the respondents showed that the predominant business is retailing (27.4 percents), tailoring (19 percents) and milling (14.6 percents).

Table 1: Socio-economic characteristics of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
	Status/Role				
Valid	Household Head	166	49.4	49.4	49.4

	Member of Household	170	50.6	50.6	100.0
	Total	336	100.0	100.0	
Marital Status					
Valid	Married	207	61.6	61.6	61.6
	Single	129	38.4	38.4	100.0
	Total	336	100.0	100.0	
Gender					
Valid	Male	336	100.0	100.0	100.0
Can read and write (literacy)					
Valid	Yes	302	89.9	89.9	89.9
	No	34	10.1	10.1	100.0
	Total	336	100.0	100.0	
Presently enrolled in school					
Valid	Yes	145	43.2	43.3	43.3
	No	190	56.5	56.7	100.0
	Total	335	99.7	100.0	
Missing	System	1	.3		
	Total	336	100.0		
Highest Education attained					
Valid	Elementary	59	17.6	17.6	17.6
	Secondary	94	28.0	28.1	45.7
	Tertiary	182	54.2	54.3	100.0
	Total	335	99.7	100.0	
Missing	System	1	.3		
	Total	336	100.0		
Source of income					
Valid	Sales of Livestock	20	6.0	6.0	6.0
	Sales of Crops	102	30.4	30.4	36.3
	Petty Trading	106	31.5	31.5	67.9
	Hiring of Cart	13	3.9	3.9	71.7
	Wages/Salary	12	3.6	3.6	75.3
	Artisan	83	24.7	24.7	100.0
	Total	336	100.0	100.0	
Ownership of Livestock					
Valid	Cattle	80	23.8	23.9	23.9
	Goat/Sheep	153	45.5	45.7	69.6
	Hen	63	18.8	18.8	88.4
	Horse	26	7.7	7.8	96.1
	Donkey	9	2.7	2.7	98.8
	Fowl	4	1.2	1.2	100.0
	Total	335	99.7	100.0	
Missing	System	1	.3		
	Total	336	100.0		
Ownership of assets					
Valid	Bicycle	93	27.7	27.8	27.8
	Motorcycle	128	38.1	38.2	66.0
	Milling/Granding Machine	48	14.3	14.3	80.3
	Lorry	33	9.8	9.9	90.1
	Car	11	3.3	3.3	93.4
	Sewing Machine	13	3.9	3.9	97.3
	Cart	7	2.1	2.1	99.4
	Generator	2	.6	.6	100.0
	Total	335	99.7	100.0	
Missing	System	1	.3		
	Total	336	100.0		
Type of house					
Valid	Mud row house	57	17.0	17.0	17.0
	Concrete block row house	102	30.4	30.4	47.3
	Round Hut	73	21.7	21.7	69.0
	Mud bungalow	61	18.2	18.2	87.2
	Concrete block bungalow	43	12.8	12.8	100.0
	Total	336	100.0	100.0	
Use part of house for business					
Valid	Yes	115	34.2	34.2	34.2
	No	221	65.8	65.8	100.0
	Total	336	100.0	100.0	
Type of business					
Valid	Milling	49	14.6	15.1	15.1
	Barbing saloon	22	6.5	6.8	21.8
	Retail shop	92	27.4	28.3	50.2

	Tailoring	64	19.0	19.7	69.8
	Auto Repair	24	7.1	7.4	77.2
	Carpentry	28	8.3	8.6	85.8
	Phone Accessories/Charging	18	5.4	5.5	91.4
	Blacksmithing	12	3.6	3.7	95.1
	P.O.S Business	6	1.8	1.8	96.9
	Other	10	3.0	3.1	100.0
	Total	325	96.7	100.0	
Missing	System	11	3.3		
Total		336	100.0		

Descriptive statistics

Table 2 shows the descriptive statistics of age, monthly energy spending and amounts spent on various energy sources across all households, grid connected households and off-grid households. The results indicated that the mean age of the respondents across all households is 32.18 years while mean age for grid connected households and off-grid households are 32.67 years and 34 years respectively. This implies that respondents from the off-grid households were older than those from grid-connected households.

The mean monthly energy spending for all households is ₦ 34, 919.64 while that of grid-connected and off-grid households were ₦ 30, 675.57 and ₦ 18, 081.08 respectively. This suggests that grid-connected households spent more on energy monthly compared to the off-grid households. This result may be link to the high cost of electricity billing in the study area as a result of the recent review of the tariff by the electricity Distribution Companies (Discos) across the franchise states in Nigeria.

Table 2: Descriptive statistics

	All Households					Grid Connected Households					Off-grid Households				
	N	Min	Max	Mean	Std. Deviation	N	Min	Max	Mean	Std. Deviation	N	Min	Max	Mean	Std. Deviation
Age in years	336	19	60	32.18	9.339	262	19	60	31.67	9.049	74	19	60	34.00	10.160
Monthly Energy Spending	336	6000	140000	34919.64	29082.991	262	6000	140000	39675.57	30268.747	74	6000	60000	18081.08	15400.81:
Kerosine/diesel for lamp lighting	290	300	10000	1251.55	1783.146	221	300	10000	1486.43	1975.301	69	300	3000	499.28	369.170
Torch	312	300	25000	4581.25	5926.130	238	300	25000	5155.88	6424.014	74	300	20000	2733.11	3331.381
Solar lantern/lamp	227	500	30000	5088.11	6391.067	201	500	30000	5512.44	6643.463	26	800	9000	1807.69	1876.576
Fuelwood	197	1000	25000	4992.39	4359.273	178	1000	25000	5119.10	4468.316	19	1000	14000	3805.26	2991.186
Charcoal	160	500	30000	2483.44	3398.005	157	500	30000	2509.87	3424.808	3	800	1500	1100.00	360.555
LPG	45	1000	10000	2482.22	2002.418	44	1000	10000	2504.55	2019.896	1	1500	1500	1500.00	.
Household-owned electric generator set	9	1900	15000	6711.11	5043.670	8	1900	15000	7050.00	5281.234	1	4000	4000	4000.00	.
Electricity Bill	262	2000	30000	4600.00	5433.407	262	2000	30000	4600.00	5433.407	-	-	-	-	-

Difference between grid connected and off-grid households in monthly energy spending

To test whether there is significant difference between households connected to national grid and those not connected in terms of monthly energy spending, Mann-Whitney U test was conducted. Table 3 shows the mean ranks of the two groups. The result reported that households connected to the national grid have significantly higher mean rank (190.91) compared to those not connected (89.7). The Mann-Whitney U value of 3823.500 and a significance level (Asymp. Sig.) of 0.000 indicate a significant difference in energy expenditure between households with and without grid connection in their monthly energy spending. This implies that households connected to national grid tend to spend more on energy monthly than the unconnected households.

Table 3: Ranks and Test Statistics[a]

	Connection to National Grid	N	Mean Rank	Sum of Ranks
Average Household Monthly Energy Spending	No	74	89.17	6598.50
	Yes	262	190.91	50017.50
	Total	336		
		Average Household Monthly Energy Spending		
Mann-Whitney U		3823.500		
Wilcoxon W		6598.500		
Z		-7.999		
Asymp. Sig. (2-tailed)		.000		

a. Grouping Variable: Connection to National Grid

Effect of connection to national grid on households' monthly energy spending

To test the effect of connection to national grid on households' economy, regression analysis was conducted. The monthly energy spending was used as a proxy of the economy and served as the dependent variable while expenditure on children school, business type, marital status, literacy, distance from healthcare center, distance from LGA_HQ, age in years, expenditure on food and foodstuff, expenditure on medical care, type of house, connection to national grid, education, distance to water source, distance to primary school, and distance to secondary school served as the predictors.

Table 4 shows the model summary of the regression. The result reported a multiple correlation coefficient of .432 which shows that there is moderate positive relationship between the independent variables and the dependent variable. In addition, the R^2, which measures the overall model performance is reported. The R^2 of .187 implies that approximately 19% percent change in households' monthly energy spending is explained by the combined effects of the fifteen (15) predictors included in the model.

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.432[a]	.187	.147	26911.461

a. Predictors: (Constant), Children school, Business Type, Marriage, Literacy, Dist_Healthcentre, Dist_LGA_HQ, Age in years, Food and foodstuff, Medical care, House, Connection to National Grid, Edu, Dist_Water, Dist_primary, Dist_Secondary

To test the significance of the regression model, ANOVA test was reported as shown in Table 5. As indicated, the F-value is higher than the Critical value at 5% level of significance (F = 4.727; p < .05). The result suggests that the regression model is statistically significant which implies that the predictors used collectively have statistically significant relationship with household energy expenditure.

Table 5: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51348889256.913	15	3423259283.794	4.727	.000[b]
	Residual	223786059973.856	309	724226731.307		
	Total	275134949230.769	324			

a. Dependent Variable: On average how much does your household spend on energy monthly
b. Predictors: (Constant), Children school, Business Type, Marriage, Literacy, Dist_Healthcentre, Dist_LGA_HQ, Age in years, Food and foodstuff, Medical care, House, Connection to National Grid, Edu, Dist_Water, Dist_primary, Dist_Secondary

Table 6 displayed the relative effect of individual predictors on households' monthly energy expenditure. As indicated in the result, connection to national grid variable (β = .342; t = 6.158; p < .05) and distance to secondary school variable (β = .448; t = 2.456; p < .05) shows a statistically significant positive relationship with the dependent. However, distance to primary school variable (β = -.562; t = -4.876; p < .05) reported negative statistically significant relationship with the dependent variable. Other predictors reported no statistically significant effect.

Table 6: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16737.701	9983.859		1.676	.095
	Marriage	-1022.494	3102.941	-.017	-.330	.742

Edu	-2098.422	3261.142	-.036	-.643	.520
Literacy	-4630.372	5346.300	-.048	-.866	.387
Age in years	227.210	166.530	.072	1.364	.173
Connection to National Grid	24056.624	3906.670	.342	6.158	.000
Dist_primary	-49748.528	10202.837	-.562	-4.876	.000
Dist_Secondary	32207.076	13114.935	.448	2.456	.015
Dist_Healthcentre	14949.906	12695.665	.215	1.178	.240
Dist_LGA_HQ	33.594	123.771	.014	.271	.786
Dist_Water	-4215.963	4381.290	-.072	-.962	.337
House	-276.491	3114.288	-.005	-.089	.929
Business Type	-1490.469	4366.991	-.018	-.341	.733
Food and foodstuff	-2024.089	3435.869	-.031	-.589	.556
Medical care	-1149.960	3935.422	-.016	-.292	.770
Children school	673.008	3192.745	.011	.211	.833

a.   Dependent Variable: On average how much does your household spend on energy monthly

The study found that households connected to the national grid spent more on energy compared to off-grid households. This result aligns with the findings of previous studies where access to electricity was shown to lead to increased economic activities and expenditures, as reported in Gibson and Olivia (2010) and Koojiman-van Dijk and Clancy (2010).

Furthermore, the result of the regression analysis showed a positive relationship between grid connection and household energy spending, indicating that access to electricity can increase household income and expenditure. This is consistent with the findings of Olanrele (2020) who reported a positive impact of rural electrification on household welfare.

V.   Conclusion And Recommendations

The study evaluated the effect of access to RE on households' expenditure in some selected RE project locations in Bauchi State Nigeria. Investigating the relationship between electricity access and household welfare has been a subject that attracts researchers. Several studies have established positive impact of electrification on various aspects of households' socio-economic development. On the other hand, other studies have shown negative impact of electrification on the welfare of households.

These findings are indication of the broader narrative that electricity access is a cornerstone for enhancing quality of life and catalyzing economic growth. Previous studies that investigated the welfare impacts of rural electrification found significant positive impacts on households' income and expenditure, thus suggesting that gain in total income due to electrification can be substantial. Such findings align with the finding of the present study, which found a positive relationship between grid connection and household energy spending, implying an increase in household income and expenditure. This follows from the fact that higher energy prices can potentially reduce welfare by forcing households to spend more to satisfy their energy needs. This emphasize the importance of not only providing access to electricity but also ensuring that it is affordable, to prevent energy poverty or insecurity.

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