INTERNATIONAL JOUNAL OF: BUILT ENVIRONMENT AND EARTH SCIENCE

TIMBOU-AFRICA ACADEMIC PUBLICATIONS
INTERNATIONAL JOURNAL, NOVEMBER, 2022 EDITIONS
VOL. 11 NO. 4 ISSN: 1881-2167

AN ASSESSMENT OF OFF AND MINI-GRID ELECTRICITY BENEFICIARIES AND AVERAGE CAPACITY OF ELECTRICITY CONSUMED PER MONTH IN SELECTED COMMUNITIES WITHIN NORTH CENTRAL, NIGERIA.

NANEN D. HEMBE[1] AND KAMA, HOSEA GOBAK[2]

Dept. of Geography, Nasarawa State University, Keffi, Nigeria[1]
Department of Environmental Science; Faculty of Sciences National Open University of Nigeria, Jabi-Abuja[2]

ABSTRACT

Electric power supply from mini-grids is gaining prominence as a strategy with great potential to contribute meaningfully at improving access to electricity globally, especially to rural areas. However, there is substantial evidence to suggest that policy and development initiatives focus more on increasing generation alone and this is not enough to resolve the inefficiencies in the power sector. This study undertakes an impact assessment of mini grids on the most important stakeholders in the sector, the beneficiaries. The mixed method approach involving both qualitative and quantitative data

Introduction

The gap between electric power supply and demand requires sustained efforts to bridge. This is due to astronomical increase in global populations resulting to increased demand for electricity and corresponding increase in pressure on infrastructure, goods and services triggering a demand and supply imbalance (Swain, 2011). According to figures released by the WBG sustainable Energy for all (SE4ALL) 2018 database, world population stood at 7.51 billion, while Nigeria's population was 195.8 million people, comprising an urban population of 98.6 million out of which only 22.6 million have access to electricity and a rural population of 97.26 million people out of which 86.8 million people have access to electricity (WBG, 2019). The poverty headcount ration stood at $1.90 a day in 2011, with over 70 million of the population living in poverty despite the country been endowed with abundant natural resources and huge oil wealth.

In view of the issue of poor access to electricity especially in rural areas, there's been global efforts spearheaded by the United Nations-Sustainable Development Goals initiative with an ambitious target of achieving access to affordable reliable, modern and clean energy for all by 2030 (WBG, 2018). However, the focus of most policies and programs presently seem to focus more on increasing electricity generation as a means to resolve the inefficiencies in the power sector and the problem of supply shortages without paying sufficient attention to stakeholders,

collection was adopted to achieve the aim. The sample size is all the projects executed by REA between 2016 and 2021 in North Central, Nigeria. The study revealed that residential connections use an average of 1-3kWh/day, Business connections use an average of 3-5 kWh/day, while productive users such as welders and millers use 12-15 kWh/day. Sources of fuels used for cooking by beneficiaries in the study area was assessed and it was found that only 6% used electricity for cooking. The study concludes that the performance of off or mini-grid projects within communities in the study area differs significantly from community to community, even when executed under the same policy framework or by the same agency. The study recommends REA and their development consultants to prioritize energizing productive uses and incorporate the Beneficiary Assessment model in PPPs to accommodate local circumstances and beneficiary preferences.

Keywords: Off-Grid Electricity, Community, REA, Beneficiaries, capacity, Kilo Watts hour.

interests, quality of delivery, risk bearing, beneficiary satisfaction and perceptions (Torero, 2015; WBG, 2008).

This has prompted a response by governments and stakeholders geared towards improving the rate of success of electric power initiatives by adoption of a variety of strategies such as diversification of the electricity generation fuel mix, investment in a variety of technologies such as renewables, mini grids, off-grids, adoption of efficient models of project financing and ownership structure, especially for electrification of rural communities (Dagnachew, Lucas, Hof, Gernaat, e Boer, Vuuren 2017). Thus, the emergence of Public-Private Partnerships (PPPs); a model that opens the door to private sector finance and professional expertise to contribute in planning, building, operation and maintenance of public infrastructure. This model features prominently amongst coordinated efforts to deliver major infrastructural initiatives globally, with projects such as Hospitals, Highways, Dams, Railways, Ports, Housing and Electricity built in close collaboration with the private sector (Martins, Marques and Cruz, 2011). This model has increasingly gained great appeal amongst governments in search for more sustainable sources of project financing, due to shrinking public budgets, inadequate to solely cater for infrastructure in the face of rising population. The ultimate focus of these partnerships is to create mutuality of interest where the Private Sector players make profit, the Public Sector players reduce costs and the beneficiaries enjoy better services (Martins, Marquez and Cruz, 2011).

It is noteworthy that, between 2000-2016, nearly all the gains made at improving access to electricity worldwide were from new fossil powered grid connections, however this trend slowed between 2017-2019 with an increased share of off-grid and mini-grid renewable connections (WEC, 2019), which signals growing appeal for decentralized electricity generation initiatives, with most decentralized systems powered by renewable fuels, evidencing a gradual switch from exhaustible conventional sources of electricity otherwise referred to as fossil fuels (WEC, 2019) to renewable energies generated from natural, inexhaustible sources of the sun, water and wind. Energy generation from these sources is referred to as Solar, Hydro and Wind energies respectively. The inroad made by renewables into the global electricity generation fuel mix is led by off-grid solar Photovoltaic technologies as efforts at achieving improved access to electricity gathers momentum.

In Nigeria, thermal and hydroelectricity generation are the most prominent generation technologies used, comprising 22 thermal plants with an installed capacity of about 10, 600 MW (85% of total installed capacity) and 3 numbers hydro plants with installed capacity of about 1, 900 MW (15% of Nigeria's total installed capacity) (USAID, 2019). The Nigerian electricity generation situation can best be described as acute capacity shortage where supply is insufficient and unable to service an ever-growing population (Joseph, 2014). This is a result of under-investment in generation, operation, maintenance, lack of human capacity development and non-diversification of the power generation fuel mix (Sambo, Garba, Zarma and Gaji, 2010; Okoro and Chikuni, 2007). Electric power supply capacity shortage inhibits national development and progress with negative impacts on economic activities across various sectors. It is in this regards, various reforms have been considered for improving the Nigerian electric power sector, including deployment of mini-grid technologies, introduction of renewable fuels into the generation fuel mix and adoption of PPPs to open the door to private finance and beneficiary participation for improved sustainability. These reforms and strategies have proven to contribute in tackling capacity shortage especially in rural areas, commonly characterized by poor access, low economic activities, and low demand for electricity and generally unattractive for grid extension (ESMAP, 2000).

Incorporating beneficiary interests and preferences is crucial to planning, formulation, structuring and reform of existing policy initiatives in the electric power sector through post development progress tracking, identifying shortcomings and unearthing information necessary for improved quality of delivery to ensure socio-economic impact and achievement of project aim.

This study is motivated by lack of adequate academic reviews focusing on the beneficiaries of rural electrification schemes through mini and off grid solutions. The study gives a voice to the below the pyramid otherwise voiceless and hard to reach beneficiaries that are easily ignored or forgotten in the process of policy formulation and implementation despite been the most important stakeholders.

The structure of the study is straightforward. Section 1 gives a background and introduction of the subject and highlights the importance of the study; Section 2 presents materials and methods adopted to achieve the aim including information about the study area, the study design, sampling techniques, methods of data collection and data analysis; Section 3 is results and discussion, and Section 4 is the Conclusion and Recommendations.

MATERIALS AND METHODS

Study Area

The study area falls within the central part of Nigeria, which connects the Northern part of the country with the Southern part. The region comprises of six number states namely, Benue, Plateau, Kogi, Nasarawa, Kwara, Niger and the FCT. It lies within Guinea Savanna and it is between latitude 14^{o} and 16^{o} North of the Equator and longitude 12^{o} and 13^{o} East of the Greenwich Meridian. The 6 States and the FCT cover a total land mass of approximately 236,977 Square Kilometers, broken down as Federal Capital Territory (FCT)-8000 Square Kilometers, Plateau-26,899 Square Kilometers, Benue- 34,059 Square Kilometers, Niger- 74,244 Square Kilometers, Kogi- 29,833 Square Kilometers, Kwara- 36,825 Square Kilometers.

TIJBEES
ISSN: 1881-2167

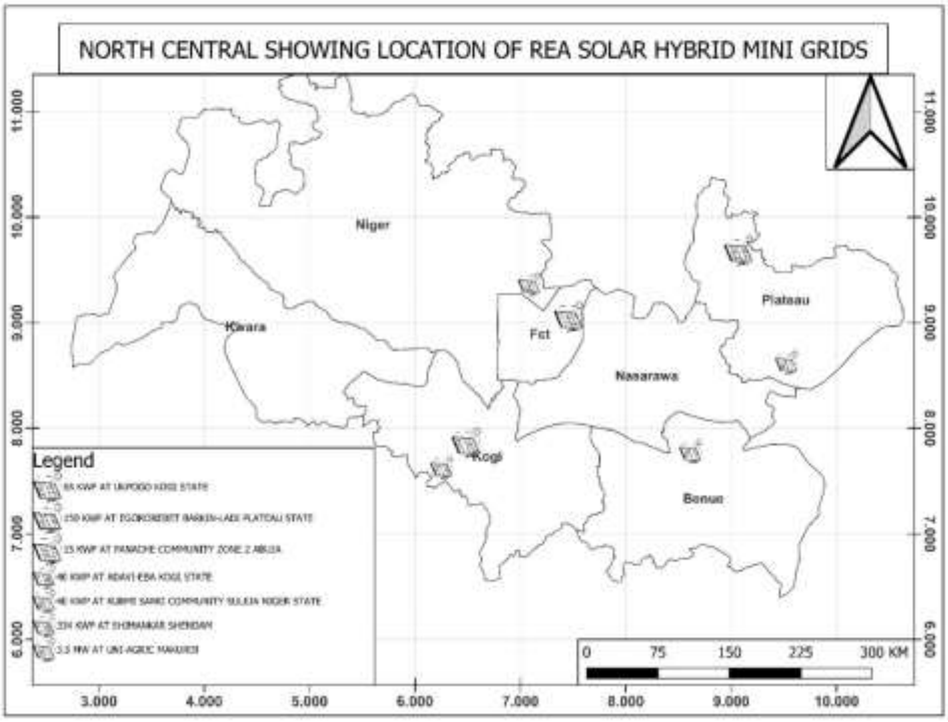

Figure 1: Location of mini-grids built by Rural Electrification Agency (REA) in North Central, Nigeria
Source: NARSDA, 2021.

Climate

The geopolitical zone lays within the AW climate (Tropical Savanna) which experiences two distinct seasons, the wet and dry seasons (Ayanlade, Odekunle, Orinmogunje and Adeoye, 2009). The rainy season lasts from April to October with an annual rainfall in the range of 1000-1600mm, while the dry season begins by November and ends by March.

Rainfall

North Central Nigeria receives rainfall for an average period of 7-8 months in a year, ranging from April to November; under normal circumstances (unpredictability and unusual behavior have been observed in recent years). The total rainfall ranges from 1000mm- 1600mm across the states in the zone (Odekunle, 2004). The pattern of rainfall in North Central Nigeria is unimodal, where rainfall increases in frequency and amount beginning from the month of May and peaking in August (Mohamed-Saleem, 1986). An average daily rainfall could last for hours and could extend in some cases for longer periods. The rainy season usually comes to an end towards the end of each year, and is preceded by the cold, windy and dusty harmattan season which arrives by mid or late November and lasts till February of the preceding year, before the rains return again between March and April.

Temperature

Temperatures vary between the high plateau and lowlands in Central, Nigeria. In the Plateau it fluctuates between 21 and 27°C, while in low lands it is above 27°C (Odekunle, 2004). Temperature ranges between 13-22°C during the harmattan period in Plateau State, while it fluctuates between 21-40°C in the other states. This indicates a relatively high temperature during the day in the Zone. The hottest periods occur between March and April, just before the rainy season begins. This high temperature reduces during the rainy season between April and November, when the harmattan arrives, temperatures drop further and lasts until February of the preceding year.

Study Design

The study adopts a mixed method approach which involves qualitative and quantitative data collection. Quantitative data was extracted through structured questionnaires from which relevant information on socio-economic impact of the electricity schemes, impact of mini and off-grid electricity on other sources of energy were categorized and analyzed. While qualitative data was collected through key informant interview of stakeholders, community leaders and representatives.

Methods of Data Collection

The study depended on data obtained via the desk review of project documents, project monitoring reports and record of oversight functions carried out by Rural Electrification Agency (REA), while graphs and charts were used to present results and to assess the number of beneficiaries and average capacity of energy consumed by beneficiaries per month.

In respect of key stakeholder interview from which relevant data for the study was extracted, select members of the public and private sector participants, including officials of the REA of Nigeria, host community leadership/traditional heads, select mini-grid developer(s)/Consultants and National Agency for Science and Engineering Infrastructure (NASENI) were interviewed. Two representatives of each of the organizations were contacted in order to have balanced information and reflective perspective of the organizations and stakeholders involved directly and indirectly in the project implementation as tabulated overleaf.

Table 1: Schedule of Key Informant Interview

S/N	INSTITUTION	NUMBER OF INFORMANTS	INFORMANT
1	Rural Electrification Fund	2	Director/Coordinator/Project Engineers
2	NASENI	2	Coordinator/Head/Staff of Renewable Energy Department
3	Plant Developers/ Consultants	2	Coordinator/Head/Chief Engineer of 1) Sterling & Wilson Nigeria Limited. 2) Solmenz Engineering ventures Nigeria Limited.

Source: Author's fieldwork, 2021

Table 2: Beneficiary Questionnaire Distribution

S/N	MINI-GRID/ LOCATION/ COMMUNITIES	BENEFICIARY POPULATION	QUESTIONNAIRE DISTRIBUTION
1	3.5 MW at Federal University of Agriculture, Makurdi	10,000	197
2	334 kWp at Shimankar, Shendam	1,972	39

ISSN: 1881-2167

3	65 kWp at 250bed Hospital, Ukpogo, Okene	1,650	33
4	150 kWp at Egororebet, Barkinladi	1,750	35
5	40 kWp at 250 Bed Hospital, Adavi-Eba	1,600	32
6	40 kWp at Kurmi Sarki community, Suleja	1,500	30
7	15 kWp at Panache Community Park, FCT	1,400	28
	TOTAL	**19, 872**	**394**

Source: Author's fieldwork, 2021

Sample and Sampling Technique

A multi-stage sampling technique was adopted for this study, whereby purposive selection of all the projects executed by REA between 2016 and 2021 in North Central, Nigeria was picked from the total number of projects executed by the Agency across the 6 geopolitical zones. The study selected all the mini-grids developed and commissioned by the REA in the study area to achieve a reflective and realistic sample size.

Questionnaires were distributed across the selected sample size based on the number of beneficiaries per community. Also, business operators/owners and community heads were sampled randomly in each host community.

Table 3: Sampled Communities and Year of commissioning of Mini-Grid

S/N	PROJECT TITLE	STATE	LOCAL GOVT. AREA	YEAR OF COMMISSIONING
1	Provision of 150 kWp Solar Mini-grid electrification to Egororebet in Barkinladi	PLATEAU	BARKINLADI	2016
2	Provision of 15 kWp Solar Mini-grid electrification to Panache community car park	FCT	AMAC	2018
3	Provision of 40 kWp Solar Mini-grid electrification to Adavi-Eba LGA	KOGI	ADAVI	2019
4	Provision of 65 kWp Solar Hybrid Mini-grid electrification to 250 bed cottage hospital, Ukpogo, Okene LGA	KOGI	OKENE	2019
5	Provision of 40 kWp Solar Mini-grid electrification to Kurmi Sarki community	NIGER	SULEJA	2019
6	334 kWp at Shimankar, Shandam, Plateau State	PLATEAU	SHIMANKAR	2020

7	3.5 MW Solar Hybrid Plant, Federal University of Agriculture, Makurdi	BENUE	MAKURDI	2021

Source: Author's fieldwork, 2021

Data Analysis

Both inferential and descriptive statistics were employed, alongside quantitative tools to achieve the aim of the study. The data is presented using frequencies, percentages and mean. Tables, graphs and charts are used to summarize results for ease of comprehension. ANOVA was used to measure impact and social benefits of the mini-grids.

RESULTS AND DISCUSSION

Beneficiary communities and average capacity of energy consumed

The study extracted information from REA about mini-grid locations within the study area, their capacity and target number of beneficiaries as tabulated below;

Table 4: Mini-grid location, capacity and beneficiary population

S/N	MINI-GRID/ LOCATION/ COMMUNITIES	CAPACITY OF MINI-GRID	BENEFICIARY POPULATION
1	Federal University of Agriculture, Makurdi	3.5 MEGA WATTS	10,000
2	Shimankar Community, Shendam	334 KILO WATTS Peak load	1,972
3	250 Bed Hospital, Ukpogo, Okene	65 KILO WATTS Peak load	1,650
4	Egororebet Community, Barkinladi	150 KILO WATTS Peak load	1,750
5	250 Bed Hospital, Adavi-Eba	40 KILO WATTS Peak load	1,600
6	Kurmi Sarki community, Suleja	40 KILO WATTS Peak load	1,500
7	Panache Community Park, FCT	15 KILO WATTS Peak load	1,400
	TOTAL	**4.144 MW**	**19, 872**

Source: Author's fieldwork, 2021

For each of these communities, it is estimated that residential connections use an average of 1-3kWh/day; Business connections use an average of 3-5 kWh/day, while productive users such as welders and millers use 12-15 kWh/day. It was also revealed that the maximum connections required per mini-grid is dependent on accurate load analysis, effective load allocation and load management based on the capacity of the mini-grids. This helps to prevent overburdening of the components and frequent draining of batteries. Energy output per time from solar mini-grid is calculated as follows,

Capacity factor of panels x *Hours of sunlight per day* x *Efficiency ratio*

E.g.: 250 Watts x 5 Hours x 0.75 = 937.5 kW

TIJBEES
ISSN: 1881-2167

To determine daily energy use;
Multiply the power rating (Watts) of appliances used by beneficiaries x No. of hours/day appliance is operated.
Examples are tabulated below.

Table 5: AC Load

APPLIANCE	POWER RATING	NO. OF APPLIANCES	USAGE TIME/HOUR	ENERGY WATTS/HOUR
FAN (AC)	80	1	5	400
TV (AC)	100	1	10	1000
TOTAL LOAD				**1,400**

Table 6: DC Load

APPLIANCE	POWER RATING	NO. OF APPLIANCES	USAGE TIME/HOUR	ENERGY WATTS/HOUR
Lighting bulb (DC)	12	2	8	192
Lighting bulb (DC)	9	3	6	162
TOTAL LOAD				**354**

The result in example 5 (1,400) is the total load (energy) (Wh) consumed by the appliances used by a particular households/day. However, appliances can either be AC or DC and their energy assessment should be carried out separately, because AC loads have to be divided by efficiency factor of the inverter (usually about 85-90%) to obtain energy requirement to power the appliance.
To calculate the AC energy usage, assume inverter efficiency is 90%, thus;
Daily AC load = 1,400 Wh/0.9
Total AC load = 1555 Wh
To calculate total load/energy usage;
DC load+ AC load = 1555 Wh + 354 Wh
Total load on system = 1909 Wh
Kilowatt's hour = $\frac{\text{watt hour}}{1000}$
$= \frac{1909}{1000}$
= **1.909-Kilowatt hour/day**

Table 7: Common electrical appliances used with mini-grids in the study area

SECTOR	APPLIANCE	POWER REQUIREMENT
Home Appliances	Television	80 watts -180 Watts
	LED Bulb Lighting	5 watts -100 Watts
	Radio	3.75 watts - 5 Watts
	Air conditioner	746 watts – 1.5Kilowatts hour
	Electric kettle	600 watts -1000 watts
	Microwave	600 watts – 1000 watts
	Blender	500 watts – 1000 watts
	Standing/ceiling fan	35 watts - 55 watts
	Pressing Iron	1000 watts -1200 watts
	Phone charging	6 watts – 8 watts
	Electric shaver	15 watts – 18 watts
	DVD Player	15 watts – 18 watts
	Blu Ray player	15 watts – 18 watts
Agriculture/ Fishing	Grinder for pulse & Beans	700 Watts – 1.5 Kilowatts hour
	Water irrigation pump	360 Watts – 2.5 Kilowatts hour
	Packager	300 Watts – 400 watts
	Fish dryer	500 – 1000 Kilowatts hour
	Milling machine	18 Kilowatts– 26 Kilowatts hour/ time
Commercial uses	Computer/Laptop	15 watts – 100 watts
	Printer/Scanner	0.5 watts - 2 Kilowatts hour
	Sewing Machine	80 watts – 200 watts
	Hair Dryer	600 watts – 1000 watts
	Washing machine	360 watts – 1000 watts
	Welding machine	3.5Kilowatts–4.3 Kilowatts/hour
	Well Pump 1 HP	750 watts – 900 watts
	Chain saw 12’	1000 watts – 1100 watts
Healthcare	X-Ray Machine	15 watts – 80 Kilowatts hour
	CT Scan	7-10 Kilowatts hour/day
	Ultrasound	2.78- 3.5 Kilowatts hour/ day

Source: Author’s fieldwork, 2021

To enhance greater efficiency of mini and off grid plants, a common load trend assumption for beneficiaries is for productive and commercial uses to be carried out during the daytime when there is adequate sunlight, while residential loads are expected to peak during the early hours of the morning and in the evenings.

This study established that, most beneficiaries use electricity from the mini-grids for low load activities such as lighting, television, radio, charging of telephones and powering of computers with only a small fraction using electricity for cooking and other high load consuming activities.

The implication with most beneficiaries not using electricity from mini-grids for cooking is that they still depend on other sources including biomass, fuel and charcoal for cooking.
As indicated in figure 2. the sources of fuels used for cooking by beneficiaries in the study area comprise 32% of total respondents depend on fuel wood/ biomass for cooking, 28% depend on kerosene for cooking, 21% depend on charcoal for cooking, 13% depend on gas for cooking, while only 6% depend on electricity for cooking. This finding aligns with findings by Joern, F. et al. in a 2021 study to evaluate the impact of a mini-grid in a Tanzanian village.

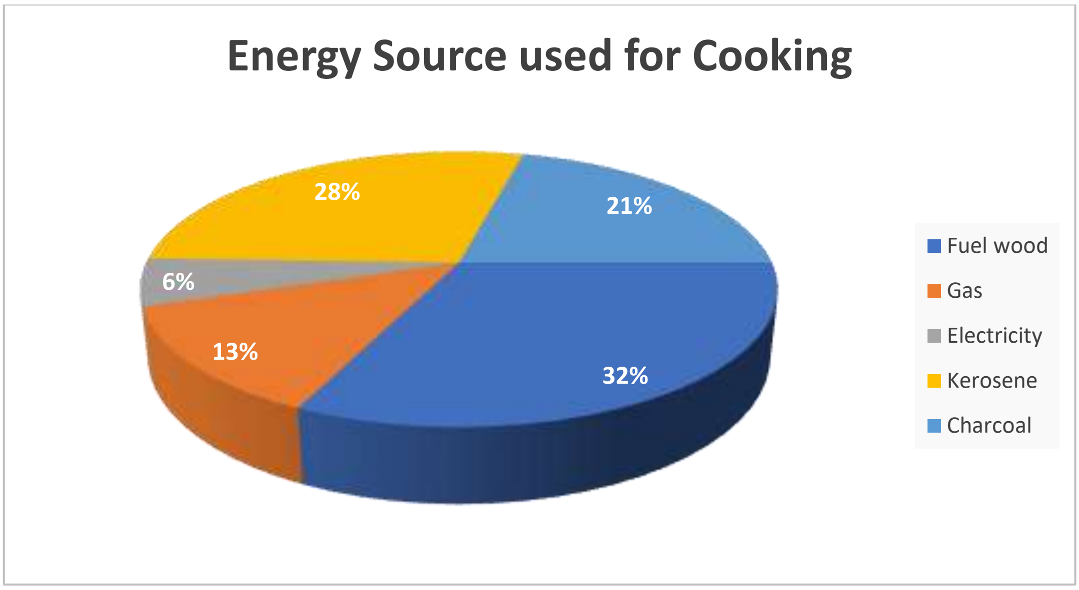

Figure 2: Energy source used for cooking
Source: Author's fieldwork, 2021

The ranking of top energy sources used for cooking is presented in figure 3, indicating that Fuel Wood-Kerosene-Charcoal ranked highest at 46%; Gas-Electricity-Kerosene came next at 26%; while Gas-Kerosene-Charcoal and Fuel-Gas-Charcoal were 17% and 11% respectively.

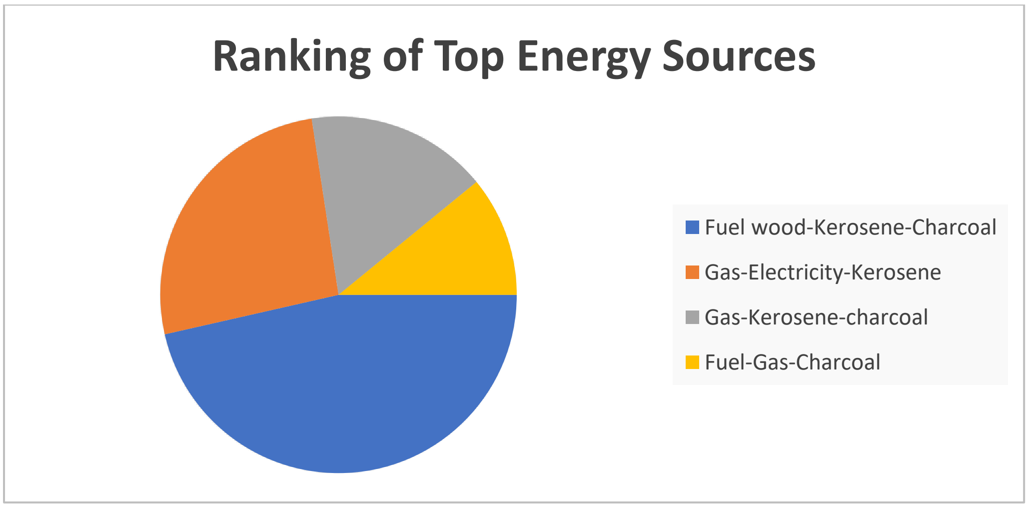

Figure 3: Ranking of energy sources used for cooking
Source: Author's fieldwork, 2021

Figure 2, shows how much beneficiaries in the study area spend on fuel per month, despite availability of electricity from mini-grids. 41.11% stated that they spend N1000-9000 on fuel every month, while 34% spend between N500-900 on fuel every month, with 11.2% spending N10,000-19,000 on fuel every month. 9.4% of the total number of respondents stated that they spend N20,000-N50,000 monthly on fuels.

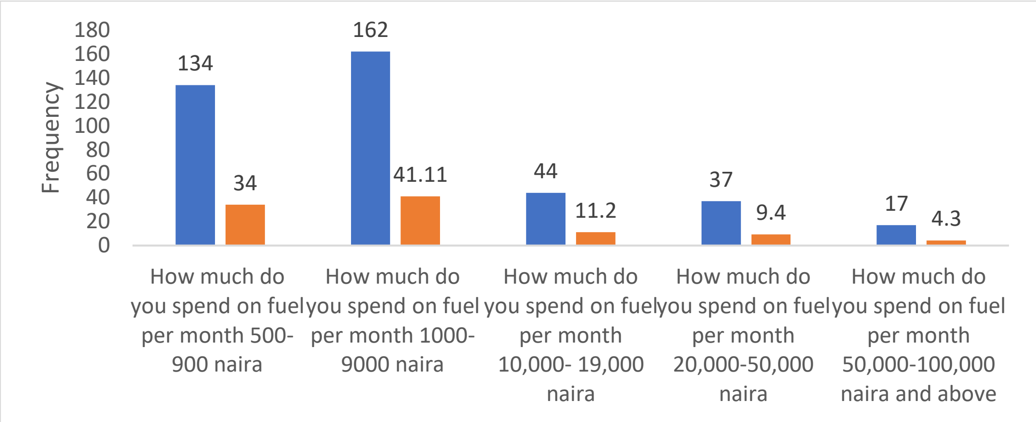

Figure 4: Expenditure on fuel per month
Source: Author's fieldwork, 2021

Effect of mini-grids on the demand for other sources of energy for lighting

This study established that, the provision of electric power through solar hybrid mini-grid to unelectrified communities, significantly affected beneficiaries demand and use of other sources of energy for lighting, with 58% of the respondents agreeing that it affected demand for other sources of energy for lighting, while 41.6% disagreed that it had effects on demand for other sources of fuels. However, the study finds that prior to introduction of the mini grids to the study area, 40.3% of the respondents (159) were using fuel for lighting, 34.8% (141) were using batteries, 13.7% were using diesel, 6.1% were using candle and 4.1% were using biomass for lighting. The study also finds that availability of mini-grids in the study area was very effective at resolving the issue of lighting for beneficiaries and it also improved the communities through street lighting thought to be linked to a general improvement in security within the communities.

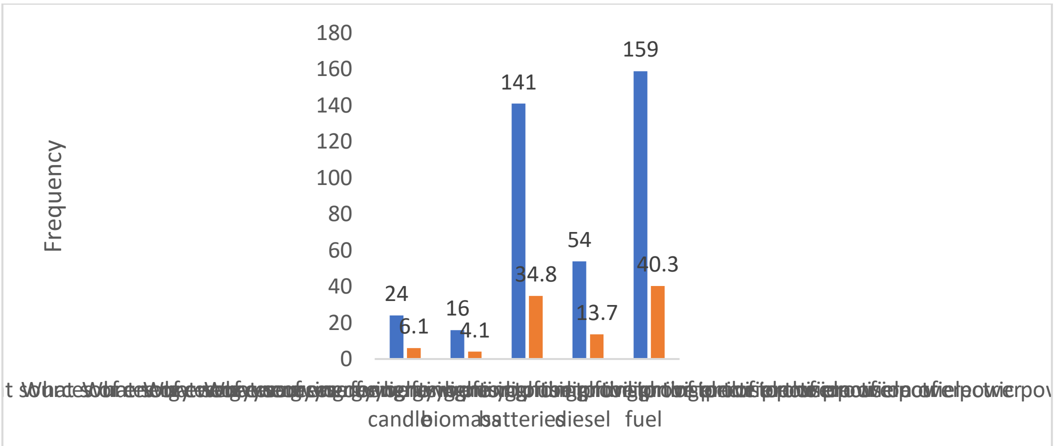

Figure 5: Sources of fuels for lighting prior to provision of mini-grids
Source: Author's fieldwork, 2021

CONCLUSION AND RECOMMENDATION

The assessment of rural electrification schemes in select communities in the North Central established that, the mini-grid initiative of the Federal Government of Nigeria executed through REA has extended access to electricity to some hard to access communities in the country that are economically unattractive for national grid extension. The assessment showed that the performance of mini-grid projects within communities in the study area differs significantly from community to community, even when executed under the same policy framework or by the same agency. It is evident that the initiative is more successful for lower load requiring activities, while for larger load requiring activities such as commercial and productive uses, off and mini-grids seemed to be less effective and work in progress. The study recommends that REA and their development consultants should ensure adequate user enlightenment on the need for appropriate use of electricity and energy conservation and encourage use of electrical appliances with low power ratings. Also recommended is Research and Development to identify the best electrical appliance technologies that can allow rural households use off and mini grid electricity for cooking; allocation of higher loads to commercial and productive users to improve income for plant maintenance and sustainability; Incorporate Beneficiary Assessment model into PPPs to compel plant developers and consultants to develop plants in tune with local circumstances, choices and beneficiary preferences. REA should also ensure incorporation of post-development appraisal in their strategy, allowing for scheduled appraisal of the socio-economic impact and challenges of completed and commissioned plants in order to avoid drop and go development.

Reference

Ayanlade, A, Odekunle, T.O, Orinmogunje O.I, & Adeoye, N.O. (2009). Inter annual climate variability and crop yields anomalies in Middle belt of Nigeria.

Brew-Hammond, A. (2010). Energy access in Africa: Challenges ahead. *Energy policy, 38*(5), 2291-2301.

Dagnachew, A.G., Lucas, P.L., Hof, A.F. (2017). Towards universal electricity access in Sub-Saharan Africa: A quantitative analysis of Technology and Investment requirement. January, 2017.

ESMAP, 2000. Energy Services for the World's Poor. Energy and Development Report 2000. ESMAP Report. Washington DC: World Bank.

Martins, A. C., Marques, R. C., & Cruz, C. O. (2011). Public–private partnerships for power generation: The Portuguese case. *Energy policy, 39*(1), 94-104.

Martins A.C., Marquez, R.C, Cruz, C.O. (2011). Public-Private Partnerships for wind power Generation: The Portuguese case.

Mohamed-Saleen, M.A. (1986). The Ecology, Vegetation and Land use of Sub-humid Nigeria.

Odekunle, T.O. (2004). Rainfall and the length of the growing season in Nigeria. Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria.

Sambo, A.S., Garba B, Zarma, I.H, & Gaji, M.M. (2010). Electricity Generation and the present challenges in the power sector. Energy Commission of Nigeria.

Swain, A.K. (2011). 'Participatory Management of Electricity Distribution in Eastern India. University of York. August 2011.

USAID, 2019: Power Africa fact sheet. Available@ https://www.usaid.gov/powerafrica/nigeria Last visited on 10 April, 2020.

WBG. (2018, April 18). Access to Energy is at the Heart of Development. *Energy.* 1, from https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7

WEC. (2019). World Energy Trilemma Index 1-77. The World Energy Council, 2019, available at www.worldenergy.org Last visited on 15 March, 2020.