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CONTEMPORARY ISSUES AND SUSTAINABLE PRACTICES IN THE BUILT ENVIRONMENT

EDITORS:
Asimiyu M. JUNAID
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School of Environmental Technology International Conference (SETIC) 2018

10-12 APRIL 2018

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FOREWORD

The organising committee of the 2nd School of Environmental Technology International Conference is pleased to welcome you to Federal University of Technology Minna, Niger State Nigeria.

The conference provides an international forum for researchers and professionals in the built and allied professions to address fundamental problems, challenges and prospects that affect the Built Environment as it relates to Contemporary Issues and Sustainable Practices in the Built Environment. The conference is a platform where recognised best practices, theories and concepts are shared and discussed amongst academics, practitioners and researchers. The scope and papers are quite broad but have been organised around the sub-themes listed below:

- Architectural Education and ICT
- Building Information Modeling
- Construction Ethics
- Energy efficiency and Conservation
- Environmental Conservation
- Facility Management
- Green Construction and Efficiency
- Health and Safety Issues
- Information Technology and Building Maintenance
- Information Technology and Construction
- Information Technology and Design
- Innovative Infrastructure Development
- Resilient Housing Development
- Smart Cities Development
- Social Integration in Cities
- Sustainable Building Materials Development
- Sustainable City Growth
- Sustainable Cost Management
- Sustainable Property Taxation
- Sustainable Architectural Design
- Sustainable Urban Transportation Systems
- Theory and Practices for Cost Effectiveness in Construction Industry
- Urban Ecology Management
- Urban Land Access
- Disasters, Resilient Cities and Business Continuity

We hope you enjoy your time at our conference, and that you have the opportunities to exchange ideas and share knowledge, as well as participate in productive discussions with the like-minded researchers and practitioners in the built environment and academia.

Local Organising Committee
School of Environmental Technology International Conference (SETIC) 2018
APRIL 2018

ACKNOWLEDGEMENTS

We have tried to build on the success of the maiden of SETIC held in 2016 which came with good feedbacks and memories. The success of the 2nd School of Environmental Technology International Conference holding at the Main Campus of the Federal University of Technology Minna, Nigeria is predicated on the support and goodwill from Vice-Chancellor of Federal University of Technology, Dean School of Environmental Technology and many other highly motivated people.

I sincerely wish to appreciate you for attending this Second edition of SETIC and to warmly welcome you to the city of Minna the capital of the *POWER STATE.* It is a great honour to have you in the beautiful campus of Federal University of Technology Minna, Nigeria. I am aware of the great sacrifices made by many of you to be present in this occasion and I will definitely not overlook the long distances some of you have had to cover to get to the conference venue. We genuinely appreciate all your efforts. It is our singular hope and desire that this 2nd edition of the conference (SETIC 2018) meets your expectations and gives you unquantifiable experience and tremendous developmental networking opportunities for a life fulfilling career.

We are grateful for the presence of the Vice Chancellor of the Federal University of Technology Minna Professor Abdullahi Bala whose leadership and distinguished academic career has served as inspiration and encouragement to many academics within and outside Nigeria. His desire to continue on the path of greatness for this Humble University of ours has seen the University become a destination for International conferences, Public lectures, Book Development, Presentations and Seminars that meet International standards. We are happy to have you as the Chief host to declare the conference open and deliver the welcome address.

We are grateful to the former Dean of School of Environmental Technology, Federal University of Technology Prof A.M. Junaid and the Ag. Dean of School of Environmental Technology Prof. S.N. Zubairu for providing the healthy platform, academic backing, management and guidance for the organisation of the conference. You increased the level of challenge from 2016 and provided the required resources, direction, energy and strategies for achieving its success, it is a great honour of having the opportunity to work closely with you and learning never to give up.

I wish to thank also all the special guests particularly leaders of the Industry, Built Environment and Academia.

A special thanks goes to the Bursar of Federal University of Technology, Mrs. Hajara Kuso for the timely responses to all our requests regarding the financial aspects of access to funds for the conference.

SETIC is beginning at the foundation this year and for this I wish to thank all those who have supported us through various forms of participation. Specifically I wish to thank the delegates and the partners for contributing significantly to the conferences. I wish to thank Prof. S.N. Zubairu Prof. A.M. Junaid, Prof. O. O. Morenikeji and Prof. Y.A Sanusi, who all genuinely and consistently monitored the progress of the conference preparations. My desire in 2016 was for SETIC to become a constant feature in the calendar of the University and global conference listings, am a happy person today seeing this desire fulfilled with the SETIC 2018 edition.

Delegates to SETIC 2018 are from different academic and research institutions that are spread across different countries. This offers participants a wonderful opportunity for exchange of cultural, social and academic ideas during the conference periods. It is also an opportunity to create awareness about programmes and events at the participants' individual institutions. I encourage you all to make good use of the networking opportunities that are available.

In this 2nd edition we received 258 abstract submissions because we had a wide distribution outlet as compared to the 1st edition which is an indication of growth. Using a rapid review system we accepted a total of 209 abstracts and the authors were communicated on what issues they were to examine while developing the full papers based on their titles and aim of the paper. Two hundred (200) full papers were received and reviewed. We sent back the reviewed papers and reviewers comments forms to each of the prospective authors to assist

in the preparation of the revised papers. It was after this rigorous and time consuming process that we were able to accept 172 papers for presentation at the conference. It gives me great joy therefore to congratulate all the authors whose papers made it to the conference. It is my sincere believe that the presentation of the different ideas in your paper would go a long way in improving the knowledge of the participants and also generate meaningful discussions over the tea beaks, lunch and beyond.

I wish to express my utmost gratitude to each of the Seventy-three (73) reviewers for a wonderful job done well and for tolerating our deadlines and Oliver Twist syndrome. It is your dedication and expertise that has ensured that the conference is a success.

Special thanks to all our keynote speakers, Arc. Umaru Aliyu, (ficiArb, fnia, ppnia) (*President, Architects Registration Council of Nigeria (ARCON)*, Prof. Stella N. Zubairu (*Former Dean Postgraduate School, Federal University of Technology Minna*), Dr. Julius A. Fapohunda, (*Editor-in-Chief: International Journal of Sustainable Energy Development & Leader: Sustainable Building and Urban Growth Research Unit, Cape Peninsula University of Technology).*

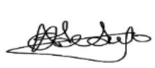
It is important to appreciate the roles and efforts of the following people for their selfless and very significant contributions made towards the successful organization of the conference: Oyetola Stephen, Alonge Olubunmi, Lynda Odine, Adedokun John, Idowu Oqua, Bamidele Eunice and Muhina Lami (for being available to run around at very short notice),

The organisation of this conference would not have been this easy without dedicated individuals offering to serve. My heartfelt gratitude goes to Dr. Taibat Lawanson, Dr. R.A. Jimoh, Dr. L.O. Oyewobi, Dr. N.I. Popoola, Dr. Lekan Sanni, Dr. I.B. Muhammad, Dr. A.A. Shittu and Dr. A. Saka for their unflinching support all through the process.

It is our sincere hope that this conference will serve as a forum for the advancement of research in the urban sphere towards achieving a sustainable environment. It is our sincere believe that academics and professionals in practices will continually participate in this forum.

Worthy thanks goes to the members of the Local Organising Committee for the tireless effort. The success of the conference goes to these wonderful people. You have made SETIC 2018 to ROCK.

Once again I wish to thank you all for creating time out of your busy schedule to attend this conference. Please do enjoy your stay at Federal University of Technology Minna, and the city as a whole. Ensure that you make use of the different fora created throughout the conference to build new relationships for the future and strengthen existing relationships. I look forward to seeing you all in future.



Olatunde Folaranmi ADEDAYO
SETIC 2018 LOC Chairperson
APRIL 2018

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ANALYSIS OF ENERGY POVERTY IN RAFI LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA

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Energy access is an essential tool for social and economic development of any nation. The energy that most people in developed countries enjoy is usually out of the reach of most people in the developing countries, especially Nigeria. Energy access in Nigeria has urban and rural dimension; the situation is even worse in rural areas than the urban centres. This study, therefore, examines energy access (EA) and its determinant in Rafi LGA of Niger State. The objective of the study is as follows; to assess resident access to electricity and clean cooking energy, measure energy poverty and assess the determinant of energy poverty. Energy access was measured using a multi-tier approach to energy access measurement developed by Nicolina Angelou for Energy Sector Management Assistant Programme (ESMAP, 2014). Energy access in Rafi LGA was examined in ten (10) selected communities, one from each of the ten (10) wards of the LGA. Households, enterprise, and community institution forms the three (3) tiers of the community energy access levels, using graduated measurement rather than binary measurement. A total of 447 copies of questionnaires was administered. The data collected are analysed by using descriptive and inferential statistics. Regression analysis was employed as an analytical tool to identify the determinants of energy poverty in the study area. The study shows that electricity access from the three (3) tiers of the communities varies; households energy access index is (0.53), Enterprise (0.31), community institution (0.23), while the energy poverty for Rafi LGA stands at (0.29). The poor performance of energy access is occasioned by poor access to clean cooking fuel (0.05) at household level. The regression analysis shows that 65.4% of energy access in Rafi LGA can be explained by years spent in school, age of marriage, age of household head, household size and the income of the household head. The study concludes that access to clean cooking fuel is by far the most pressing challenge to energy access in rural communities of Rafi LGA. Therefore, the study recommends that clean and affordable cooking fuel should be made available across the study area with proper awareness creation on the benefits of using clean cooking fuel. If energy access at the rural areas must be tackled, education and livelihood of the people must also be improved.

Keyword: *Energy, Energy Access, Energy Access Index, Energy Poverty*

INTRODUCTION

Poverty is undoubtedly one of the world's most pressing issues, which requires immediate attention. Over the years, the term "poverty" has been conceptualized in various ways by many authors (Foster *et al*., 2003; International Energy Agency (IEA) 2010a; United Nation Development Programme (UNDP, 2012); Practical Action (PA, 2010). Poverty is conceptualized in economic terms through the use of income, or in social terms, which involves lack of access to basic human needs (food, water, clothing, shelter, sanitation, healthcare and education). There is also the energy dimension of poverty; popularly termed energy poverty. There is no doubt that quite a number of concepts and definitions of energy poverty abound in both policy and academic literatures. The extant literature review has shown that there is no consensus as to how best to define and measure energy poverty (Reddy et al., 2000; IEA, *et al.*, 2010b; Asian Development Bank (ADB, 2013).

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However, even with the multiplicity of energy poverty definitions, it is evident that most scholars are in agreement over two indicators; access to electricity and access to clean cooking fuel (United Nations, 2005; IEA, 2010b, ADB, 2013). Therefore the Asian Development Bank (ADB, 2013) definition of energy poverty was adopted for the study. The definition is stated thus "*absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally benign energy services to support economic and human development*."

Despite Africa's endowment in energy resources, it remains the least in terms of energy access amongst all other regions of the world (IEA, 2016). There is a sharp contrast in energy access between the northern Sahara and the Sub-Saharan countries (Moulot, 2005). Electricity access in the northern Sahara is estimated to be 95% as against 23% in the sub-Saharan Africa, which drops considerably to as low as 1% in some countries (UN, 2005). UN (2005) asserted that in Sub-Saharan African countries with the exception of South Africa, 80% of the inhabitants depend on traditional biomass for their energy use; hence it is fair to posit that access to modern energy services (electricity and clean cooking fuel) is by far the most pressing challenge facing the continent. Globally, it is estimated that about 3 billion people are currently living in the rural areas, many of who do not have access to clean energy services (Sumiya, 2016). It is also estimated that about one-third of humanity cannot access modern energy forms and services (IEA 2009).

The situation of energy poverty in Nigeria is not different from that of the region. Ogwumike and Ozughalu (2015) estimated that energy poverty in Nigeria stands at 75%. Further study carried out by Apere *et al*., (2014) shows an increase in energy poverty in Nigeria to as high as 95%. Energy poverty across the states in the south-south zone is as high as 96.7% in Cross River State and 60.1% in Edo. Edoumiekumo *et al.,* (2013) also suggested that energy poverty has a rural dimension; energy poverty in the rural area was estimated to be 98%, and is more severe in the rural areas than the urban areas. Sanusi and Owoyele (2016) estimated that access to clean cooking energy in Nigeria is as low as 0.38% in Zamfara State; while the highest is recorded in Abuja the Federal Capital with just 12.76% of the inhabitants having access to clean cooking fuel. Despite the abundance of energy resources in Nigeria, an estimated 113 million people, representing about 70% of the population, lack access to electricity, while the remaining 30% have only intermittent and unreliable access (Adedeji, 2016). IEA (2016) estimated that electricity access in Nigeria stands at 45%, 55% in the urban areas and 36% in the rural areas, while it is estimated that 134 million people rely on traditional biomass for energy use accounting for 76% of the population.

Several studies have been directed toward addressing the issue of energy poverty in Nigeria; (Sunday, 2011; Stephen et al., 2011; Edoumiekumo *et al*., 2013; Apere, 2014; Sanusi and Owoyele, 2016). Most of the studies on energy poverty dwell more on estimating energy poverty at national, zonal or state level. Studies on energy poverty in Nigeria concentrate on national level estimations, ignoring disaggregated information on energy access at the local level. Furthermore, there is little or no studies on energy poverty and access that shows the spatial disparities of energy access in the rural areas of the country; Sanusi and Owoyele (2016) mapped out the spatial disparity in energy poverty at state level, thereby neglecting the rural areas where poverty levels are higher and dependency on traditional fuels is noticeably great (Sanusi and Owoyele, 2016). In Nigeria, studies on energy poverty have dwelled more on the composite indicator approach using Multidimensional Energy Poverty Index (MEPI), Total Energy Access (TEA), or Energy Development Index (EDI) (Edoumiekumo *et al*., 2013; Apere *et al*., 2014; Ogwumike and Ozughalu, 2015; Sanusi and Owoyele, 2016) which considers indicators on binary metric (Access or No Access) rather than measuring access base on graduated level of its capacity, duration, reliability, quality, affordability, legality and convenience as proposed by the Multi-Tier energy poverty measurement approach.

By these studies, there are two major research gaps. First is the dearth of local level study, especially at the level of rural settlements and secondly, there is a methodological gap in the current approach to measuring energy poverty. This study intends to fill this gap by focusing on rural communities and by employing Multi-Tier energy poverty measurement approach. This was achieved through the following objectives; assess energy access, measure energy poverty using multi-tier approach and identify the determinant of energy poverty in Rafi LGA.

Energy and Human Wellbeing

Energy is a central aspect of human life as it affects agricultural productivity, environmental sustainability, health care, and job creation. More than a need, energy per se is absolutely essential to deliver adequate living conditions, food, water, health care, education, shelter and employment (Najam *et al*., 2003). Poverty comes in different dimensions; and hence energy is a dimension of poverty. When there is energy poverty; it simply implies that one of the bundles of product needed to maintain a good life is missing (Sanusi *and Owoyele*, 2016). Energy is one of the basic human needs that play a crucial role in improving human well being (Global Network on Energy for Sustainable Development (GNESD), 2013). Human wellbeing, poverty reduction, social inclusion, and economic improvement cannot be advanced without access to electricity and clean cooking fuel (Karkezi *et al*., 2012).

Renewable Energy Policy Network for the 21^{st} century (REN21, 2005) noted that the only available and affordable energy for the world's poor is "traditional biomass" which includes animal waste, fuel wood, and crop residue. Practical Action (2010) cited in Sanusi and Owoyele (2016), highlighted three (3) mechanism that relates energy access to wellbeing, they are; creating new earning opportunity, improving existing earning activities and reducing cost, drudgery and releasing time to enable new earning opportunity. Presently energy is one of the most essential ingredients for poverty alleviation as it is a vital input for people's livelihood. At the most basic level, energy is needed for cooking, heating and cooling (Clancy *et al.*, 2003). UNDP (2004) suggested that the deprivations arising from energy poverty on human development are far more significant than energy poverty itself; because it does not only reflect energy poverty but human poverty. There are various deprivations that arise from energy poverty (Ramani, 2004; Modi *et al*., 2006).

Although basic educational services and literacy can be achieved without the use of cleaner energy input, yet, there is a link between access to energy and education services. Access to cleaner energy option can improve the quality and availability of educational services and increases the likelihood that children will attend and complete school (IEA, 2010a; UNDP, 2005; UN, 2005). Mapako (2010) posited that access to cleaner, affordable and modern energy can help to induce a more child friendly environment that encourage school attendance and reduce the significant dropout rate experienced in many low income countries. It can enhance access to clean water, sanitation, lighting, space heating/cooling, and energy for cooking in the case of boarding schools. Access to clean energy can provide quality lighting for both the boys and girls for comfortable night studying (Mapako, 2010); as it also helps to reduce the risk to child's eyesight (Eva and World Health Organization, 2006).

There is an equity dimension to energy poverty, richer household can afford cleaner and qualitative energy services and fuel than the poorer households (Clancy *et al.*, 2003; Cecelski, 2004). Women from poorer households tends to suffer from large health problems, spend more time collecting firewood and hence pay a higher price per unit of energy (Reddy 2000). The health dimension to energy poverty also exists; as poor households do not boil water and eat less cooked food, thereby inducing health problems which hinder effective women participation in economic and social activities, hence affecting their general wellbeing (Clancy *et al.*, 2003).

Most of the poor people in the world get their daily caloric intake from grains, such as rice, corn, millet, and wheat. Aside from the fact that these grains require energy for cooking before consumption, it also requires energy for their production, harvest and processing as well as for it cultivation, irrigation, transportation and preservation for some food crops especially the perishable crops. Food and Agricultural Organization (FAO, 2011) asserted that through the facilitation of irrigation, food security can be enhanced through access to cleaner energy options. Energy can play a vital role in enhancing food security among the poor by adopting technologies that can be used for irrigation and water pumping.

All production activities from the simplest to the most complex requires energy, be it electricity or fuel. It is an essential input of production and hence has a major effect on the cost of the final product (Modi e*t al.,* 2006; UN Energy, 2005). In its simplest form it can be animal or human energy for doing manual work or transporting goods, while with the introduction of high degree of technology in the production process comes the application of different forms of energy. Formal and informal sector employment is positively correlated to access to cleaner energy options such and electricity and Liquified Petroleum Gas (LPG) (Modi et al., 2006). Transformation of economies is also linked to access to clean energy; it is an important factor in transforming from an agrarian economy to an industrial based economy. Conversely, economies with record of low clean energy use tend to show high contribution of agriculture to Gross Domestic Product (GDP) which is as a result of poor development of the industrial sector (Modi et al., 2006; UNDP, 2005; UN, 2005).

Although energy itself is not a basic human need, it is critical for the fulfilment of all needs. Lack of access to diverse and affordable energy services means that the basic needs of many people are not being met (Adria and Bethge, 2013). Figure 2.1 shows the graphical presentation of the conceptual framework for this study, indicating how access to modern, clean, and affordable energy can impact positively on the general wellbeing of individual and the community at large.

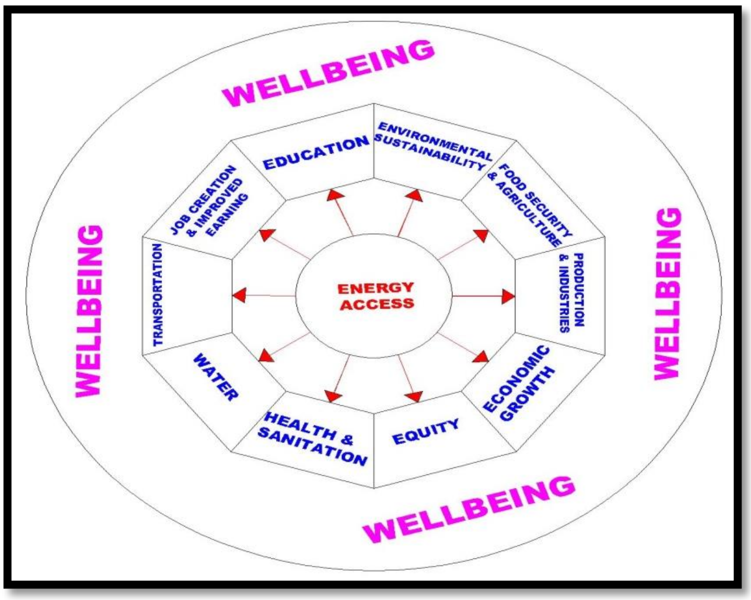

Figure 2.1: Conceptual Framework.
Source: Akande (2017)

Concept of Energy Poverty

Numerous concepts of energy poverty abound in development literatures, yet there is no universally accepted or adopted concept of energy poverty. Although, popular conceptualizations of energy poverty are usually based on minimum physical levels of basic energy needs, the minimum energy expenditure required and maximum proportion of energy expenditure in relation to total disposable income or expenditure. In the case of poverty itself, researchers have to rely on various indicators to capture the depth of poverty from diverse measurements. However, the realities of energy poverty differ across the globe. Phenomena of energy poverty diverge considerably between developed and developing, between rich and poor countries, as well as between different climatic zones.

Energy poverty and fuel poverty are sometimes used interchangeably by some authors; some sccholars consider energy poverty as a concept highlighting problems in developing countries, while fuel poverty is seen to be prevalent in the Organization for Economic Cooperation and Development (OECD) countries. British definition of fuel poverty from 2000/2001 is expressed as “adequate standard warmth” or not being able “to keep a home warm at reasonable cost” (Schuessler, 2014). Boardman (2009) offered a broader definition according to which a household is energy poor if it cannot attain adequate energy services for less than 10 percent of its net income. In simple term energy poverty refers to poverty in terms of access and consumption of energy. Traditionally poverty is measured in terms of monetary income or expenditure. With the time, the ways of measuring poverty have been changed. In Modern days poverty is directly linked to deprivation. Therefore we can simply identify energy poverty as constraints in energy services for households (Tennakoon, 2008).World Economic Forum (WEF, 2013) conceptualizes energy poverty as: “The lack of access to sustainable modern energy services and products”. Energy poverty is defined as a situation where the absence of sufficient choice of accessing adequate, reliable, affordable, safe and environmentally suitable energy services is found (ADB, 2013). In simple words, energy poverty is the lack of access to sustainable and modern energy services and products (kerosene, liquefied petroleum, gas etc).

Energy poverty definitions are based on different indicators, some of which was highlighted by ADB (2013) as follows: Minimum amount of physical energy that meets cooking, lighting, heating, and other basic needs (Barnes *et al*., 2010); Type and amount of energy used by households at or below the poverty line (Barnes *et al*., 2010); Household energy spending beyond a certain percentage of the household budget (Barnes *et al*., 2010); Income level sufficient only to sustain the bare minimum energy needs (below that, energy use or energy expenditure remains the same) (Barnes *et al*., 2010);

Poverty and lack of access to modern forms of energy (Modi *et al*. 2006); or Lack of access to energy services (Pachauri *et al.*, 2004). However, even with the multiplicity of energy poverty definitions, it is evident that most scholars are in agreement over two indicators; access to electricity and access to clean cooking fuel (UN, 2005; IEA, *et al*. 2010, ADB, 2013).

Concept of Energy Access

The concept of energy access does not lend itself to an easy definition. In the past, access to energy usually was considered synonymous with household access to electricity. It has been defined variously as, household electricity connection, an electric pole in the village, and an electric bulb in the house. However, these definitions do not take into account the quantity and quality of electricity provided. The global agenda on energy poverty has arose various debate and argument on what constitute energy access by scholars, international organizations and research groups across the globe (IEA, 2009, Energy Sector Management Assistant Programme (ESMAP), 2014). It is important to have a working definition of energy access prior to the development of metrics or indicators for measuring energy access. IEA (2011) conceptualizes energy access in three (3) incremental steps, they are as follows; (i) basic human needs (electricity for lighting, health, education and communication) approximately 50 – 100 Kw per person per year and approximately 50-100 goe of modern cooking fuel or improved biomass cooking stove (ii) Productive uses; electricity and modern cooking fuel for agriculture (pumping of water for irrigation, mechanized tilling), electricity for commercial agricultural processing, cottage industry and other light industries and electricity and modern fuel for transportation e.g. electric train (iii) Modern Society Needs; Modern energy services for many more domestic appliances, increase requirement for cooling and heating (Space and Water) private transportation. Electricity usage is approximately around 2000Kwh per person per year

In 2010, in a report published by the UN Secretary-General's Advisory Group on Climate Change (AGECC, 2010), energy access was conceptualized as "a basic minimum threshold of modern energy services for both consumption and productive uses, that is reliable and affordable, sustainable and where feasible, from low Green House Gas (GHG)]-emitting energy sources."The international development charity Practical Action (2012), in its Poor People's Energy Outlook, uses the term "energy access" to mean the "use of modern energy services by un-served and underserved people." IEA (2012) defines energy access as being without access to electricity and without access to clean cooking facilities. Access to energy is the ability to avail energy that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy & safe, for all required energy services across household, productive and community uses (ESMAP, 2014). International Institute for Applied System Analysis (IIASA, 2012) define energy access to include access to three forms of energy, each of which provides distinct but essential benefits for economic and social development: less polluting household energy for cooking and heating; electricity for powering appliances and lights in households and public; and mechanical power from either electricity or other energy sources that improve the productivity of labour.

Going by the various definitions of energy access highlighted by international organizations and scholars, it is obvious that there is no single internationally-accepted and internationally-adopted definition of modern energy access. Yet significant commonality exists across definitions, including; Minimum level of electricity access by household; Access to sustainable and safe cooking and heating fuels and stoves; Access to modern energy that enables productive economic activity, (mechanical power for agriculture, textile and other industries); Access to modern energy for public services, e.g. electricity for health facilities, schools and street lighting.

All of these elements are crucial to economic and social development, as are a number of related issues that are sometimes referred to collectively as "quality of supply", such as technical availability, adequacy, reliability, convenience, safety and affordability.

Measurement of Energy Poverty

If the gap between policy and action on energy poverty must be bridged, there is a need for the development for an all in one metrics for measuring the state of energy access. Although, quite a number of metrics exist for measuring energy poverty; this study will provide an insight into four common measurement approach of energy poverty as highlighted below:

Energy Poverty Line & Minimum Energy Require to Satisfy Basic Needs (Energy Threshold)

This measurement approach is deduced from the conventional income or expenditure poverty measure. Energy poverty is determined by estimating energy use as a function of income or expenditure and by estimating the average level of energy use that correspond to the amount of expenditure or income specified by the official income or expenditure poverty line (Pachauri, and Spreng, 2003). Although this approach to energy poverty measurement is easy to compute and useful in determining headcount of energy poverty, it is often criticized on the grounds that it only provides a single energy or fuel poverty line and does not provide an insight by way of suggesting the factors responsible for the low spend or low consumption by households (Jain, *et al*., 2015).

This approach to energy poverty measurement uses estimate to determine the amount of energy required to satisfy basic need (Pachauri & Spreng, 2003; Practical Action, 2010). Modi, *et al.*, (2005) has recently proposed an alternative and less data intensive way to estimate the energy required for basic needs. Unlike the poverty line approach, two poverty line must be exceeded; the first is the minimum amount of final energy used in the form of modern fuel and the second is the minimum amount of electricity for all other services excluding heating and mobility (Jain, *et al*., 2015)

The income poverty line and minimum energy required estimate approach are uni-dimensional and normative in nature. Ascertaining the minimum level of energy required for basic needs is the problem with setting the normative threshold, which is usually due to the significant inter-country and regional differences in cooking practices and heating requirement (Jain, *et al*., 2015). Khandker, *et al*., (2010) argued that energy requirement and consumption is location specific which is due to difference in climatic condition and cultural practices. The minimum needs for physical quantities of energy (for specific tasks) are chosen somewhat arbitrarily. In the opinion of Nussbaumer *et.al* (2011), modern energy services have a higher service quality, hence it reduces household expenditure and increase resource efficiency simultaneously. It therefore implies that as technology improves in energy wise, these metrics (and thresholds) require to be updated constantly and often lose their utility over time.

In the bid to overcome the drawback of these two approaches, Khandker, *et al*., (2010) empirically determine an energy poverty threshold based on estimation of final and end-use energy consumption. The threshold is defined as the income decile where energy consumption is significantly different from the consumption in the first decile. In this approach, the threshold represents the point at which energy demand becomes insensitive to income changes as threshold below the point can only consume a bare minimum of energy (Jain, *et al*., 2015). This metric provides the basic understanding of the difference that exist between income and energy poverty. Nonetheless, it is often criticized for not providing insight into the factors that keep households from meeting the threshold energy consumption. Furthermore, the approach fails to highlight that energy consumption is elastic even among the poor (Bensch, 2013).

Multidimensional Energy Poverty Index

The availability of datasets that provide necessary data for both the developed and developing countries coincided with the notion of poverty as a multidimensional phenomenon (Deaton, 2010). Multidimensional Energy Poverty Index (MEPI) is a child of the Multidimensional Poverty Index (MPI) and it was presented by Nussbaumer, (2012). This approach proposes dual cutoff instead of a single poverty cutoff to define threshold in two steps; weight is attached to each sub-dimensions so that the final head count of energy poverty that is defined incorporates the importance that is attached to all the dimensions. The authors were of the opinion that attainment in all the six sub-dimensions are important and are expressed as dummy equalling one (Jain, *et al*., 2015).

MEPI has been criticized on the basis that the proxies used in defining energy access quality in this approach are not robust enough. Jain, *et al*., (2015) argued that possession or mere consumption of a quantum of these assets does not translate to energy access for households. Just like It was noted by KandehYumkella, the then Director-General of the UN Industrial Development Organization, and UN Secretary-General Ban Ki-moon's that "*the provision of one light to poor people does nothing more than shine a light on poverty*". Therefore, it can be said that energy access transcends mere possession of modern energy assets and consumption of small quantum of energy. Fuel stacking, which is a common phenomenon especially in developing countries is not fully accounted for or penalized.

Total Energy Access Standard (TEA)

In the light of the criticism of MEPI, an alternative multi-dimensional approach was proposed by the Practical Action (PA, 2012) in United Kingdom (UK). This approach was developed in cooperation with the International Energy Agency (IEA), World Bank, The Global Alliance for clean cooking stoves and the National Development Cooperation Agencies. This approach is called the Total Energy Access Standard (TEA). The TEA corresponds to the headcount ratio of energy poverty, the major point of departure from MEPI is in intensity as it considers the intensity of deprivation as irrelevant. Even with the numerous dimensions captured in the TEA, some areas exist with intractable field data and some areas exist where the definition is just to define the absolute bare minimum threshold of energy consumption. Jain, et al., 2015 argued that even though TEA is dimensionally extensive, it has a binary view of energy access.

It is clear that existing metrics fail on several grounds to provide a nuanced view of energy access. More importantly, they do not dwell on the factors that preclude access. The key point is that energy access is not only multi – dimensional, but also multi-tiered. In other words, households are distributed on an energy consumption spectrum, rather than a binary classification of having and not having access to energy and the services thereof. In the submission of Bensch (2014), he argued that MEPI and TEA are two composite indices which deliver quite distinct results mainly depending on normative judgment inherent in the two indices. MEPI allows for a certain degree of deprivation (e.g. a household maybe energy non-poor). The TEA is far more restrictive in that everybody is considered energy poor, when a household is deprived in any of the six sub-dimensions of the TEA

Multi-Tier Energy Poverty Index

The recent attempt at understanding the subtle difference in energy poverty is that of the Global Tracking Framework (GTF). They combined multi-dimensionality of energy poverty with multi-tiers. This implies that all the facet of the community is captured in terms of the households or community energy access, productive energy access for agricultural processing and enterprises for economic activities. The multi-tier energy poverty measurement approach was developed by Nicolina Angelou who is an Energy economist for Energy Sector Management Assistance Programme (ESMAP) in 2014. This method of energy poverty measures energy poverty based on energy access as a continuum of improvement, based on the performance of the energy supply which includes; Capacity, Duration/Availability, Reliability, Quality, Affordability, Legality, Convenience, and Health & Safety. It is a composite energy poverty approach and it is expressed mathematically as $\Sigma(Pi \times K)$. The multi-tier energy captures all the dimensions of energy poverty from different tiers of the community. Multi-tier framework does not only measure the consumption of energy services, but also measures the quality, reliability, affordability, safety and adequacy of energy access. The method has since been applied and completed by ESMAP in five countries, namely, DRC, Uganda, India, Ethiopia, and Malawi. The multi-dimensionality and the composite measurement approach of the multi-tier energy poverty measurement approach is a good improvement to the existing multidimensional energy poverty measurement approach.

Related Studies

Edoumiekumo *et al.*, (2013) carried out a study on multidimensional energy poverty in the south-south geo-political zone of Nigeria, using the Multidimensional energy poverty index developed by Nussbaumer *et al.*, (2011). The study revealed that 83% of the inhabitants in the south-south are energy poor and are deprived of 90.3% of the weighted indicators, while at the state level, Akwa-Ibom, Bayelsa, Cross-Rivers, Delta, Edo, and Rivers were energy poor at 92.1%, 96.7%, 76.8%, 60.1%, and 83.1% respectively. Energy poverty in the south-south geo-political zone was found to have a rural-urban, educational attainment and occupational dimensions.

Apere *et al.* (2014) carried out a similar study on multidimensional energy poverty in Nigeria, with focus on national and zonal levels. Using similar data set and MEPI by Nussbaumer *et al.*, (2011), the study established that 95% of Nigerians are energy poor, while deprivations stands at 74% of the weighted indicators and a MEPI score of 70%. Furthermore, MEPI methodology and NLSS data 2009-2010 was also employed by

Edoumiekumo and Karimo, (2014) to determine energy poverty at state level in Bayelsa State and its implication for sustainable development. The study shows that energy poverty and deprivations stands at 96% and 82% respectively in Bayelsa State. The study also reveals that energy poverty cut across all sectors in Bayelsa State. The studies (Edoumiekumo and Karimo, 2014; Edoumiekumo *et al*., 2013; Apere *et al*., 2014) on multi-dimensional energy poverty at state, zonal and national level in the country focus more on estimating the level of energy poverty without examining the determinant of energy poverty.

Sanusi and Owoyele (2016) examined energy poverty and its spatial differences in Nigeria. Energy development index approach to measuring energy poverty was adopted along with regression analysis to establish the relationship between energy poverty and factors of energy access. The study shows that most of the state performed fairly well with the highest access rate recorded in Lagos State with 99.3% and the lowest recorded in Taraba State with a 10.9%. However, in respect to cooking fuel, the performance is quite poor with the highest rate recorded in Lagos State with a 10% of her household using clean energy for cooking. Generally 55.6% have access to electricity while only 2.7% cooks with clean cooking fuel. Lagos State recorded the highest EDI of 0.613, of all the 36 state only Lagos and the FCT are having fair energy wellbeing, while others are poor. The study also shows that there is disparity in energy access between the northern and the southern states; the former are poorer in terms of energy access.

Adedeji (2016) in his study on the “spatial exploration and analysis of electricity poverty in Nigeria” posited that access is not a problem in Nigeria’s urban areas, but rather inadequacies and unreliability of electric supply in substantial quantity and reliable quality. The study establishes that huge infrastructural deficit and metering gap are the major challenges bedevilling the electricity access in the country urban area. The study recommends a total overhauling, maintenance, upgrading and expansion of grid network infrastructure and adequate supply of natural gas to power generation plants to ensure adequate provision of reliable electricity to households.

Metaksa (2016) carried out a study on multidimensional household measure of energy poverty and its determinants in Ethiopia; using MEPI and data from Ethiopian socio-economic survey of 2011 and 2014. Four dimensions and five variables of energy poverty was captured for rural and small towns in Ethiopia, while the static random effect and logit model was used to examine the determinant of energy poverty. Energy poverty in rural and small towns of Ethiopia was found to be severe with about 74% and 73% of the inhabitant found to be multi-dimensionally energy poor in 2011 and 2014 respectively. Furthermore, family size, rural-urban, and household head where found to be the determinant of energy poverty in Ethiopia, while age of household head, number of rooms, and total expenditure were the determinant of poverty. The study recommends that reduction in energy poverty should be handled simultaneously with poverty reduction policies, promotion of rural energy and energy efficient technologies and appropriate energy source pricing mixes.

Madobi (2016) carried out a study on energy poverty in at Marondera urban area of Zimbabwe; 120 respondents were sampled from three residential areas using a multi-stage sampling technique of purposive and random sampling technique. Survey design, interview and documentary analysis were used to collect data; the study was able to establish that resident of Marondera are energy poor with limited energy options, because in the absence of electricity they are forced to rely on traditional energy sources (biomass). The study, therefore, recommends that energy and other related policies be pro-poor and that research in the line of energy sources be done to increase energy options for both rural and urban dwellers.

RESEARCH METHOD

The study adopted a non-experimental research design approach. This implies that it is empirical as it involves a field survey. The study relies on quantitative data. Primary and secondary data were collected and analysed. A total of 500 copies of questionnaires were administered using simple random sampling technique, and 447 copies were returned completed. The data collected were analysed using descriptive and inferential statistics. Regression analysis was employed as an analytical tool to identify the determinants of energy poverty in the study area. The unit of measurement for the sample is household; the sample population for the study was estimated at 3885 households. The sample size for the study was determined using Sallant and Dilmann (1997) sample size formular to arrive at 500. Table 1 shows the sample population and sample size for the study.

Table 1: Sample Size for the Study

S/N	Name (Rafi LGA)	Households	Sample Size (500)
1	Sihonna	283	34
2	Inga Gari	321	39
3	Kukogi	392	47
4	Guwa	297	36
5	Pangungari	369	44
6	Yakila	709	85
7	Maikujeri	465	56
8	Garun Gabbas	582	70
9	Gidi Gori	294	35
10	Kundu	456	55
	Total	**3885**	**500**

Source: Authors Computation (2017)

Multi-tier energy poverty measurement approach was adapted to estimate energy poverty in the selected rural areas of Rafi LGA of Niger State. This method of energy poverty measures energy poverty based on energy access as a continuum of improvement, based on the performance of the energy supply which includes; Capacity, Duration/Availability, Reliability, Quality, Affordability, Legality, Convenience, and Health & Safety. It is a composite energy poverty approach and it is expressed mathematically as $\Sigma(Pi \times K)$, where Pi = Proportion of households at the k^{th} tier; K = Tier number {0,1,2,3,4,5}

RESULTS AND DISCUSSION

Electricity Connection and Duration of Access

Connection to the public electricity grid was assessed, and the rate of electricity connection in the study area is presented in Table 1. The result shows that electricity connection at household level is 80%, 75% at institutional level, and 49% at the enterprise level. The overall connection rate in the communities is estimated at 68%. The result shows that the entire community tier performed above average, except for institutional tier that records a low connection rate. The result also shows that all the communities are connected to the public electricity grid, except for Sihonna village.

The average daily duration of electricity access in the study area is depicted in Table 2. The analysis shows that the average electricity duration at household level in Rafi LGA is 5.3 hours, 1.9 hours at institutional level, 4.3 hours at the enterprises level.. On the average the communities enjoy 3.8 hours of electricity per day. This shows that although electricity connection rate is high, duration of electricity access is low.

Table 1 Electricity Connection Rate

Communities	Household	Institution	Enterprises	Overall
Garun Gabbas	100	67	89	85
Gidi Gori	87	50	100	79
Guwa	77	0	100	59
Inga Gari	86	50	100	79
Kukogi	93	50	100	81
Kundu	100	50	88	79
Maikujeri	88	50	83	74
Pangungari	70	100	0	57
Sihonna	0	0	0	0
Yakila	100	75	86	87
Rafi LGA	**80**	**49**	**75**	**68**

Source: Author's Fieldwork (2017)

Table 2: Average Daily Duration of Electricity Access

Communities	Household	Institution	Enterprise	Overall
Garun Gabbas	16.8	5.7	9.5	10.7
Gidi Gori	2.3	0	3.4	1.9
Guwa	3.3	0	3	2.1
Inga Gari	6.3	2.5	3.7	4.2
Kukogi	7.3	2.5	4	4.6
Kundu	3.1	0.5	1.5	1.7
Maikujeri	3.6	3	3.7	3.4
Pangungari	2.3	1	-	1.6
Sihonna	0.0	0	-	0.0
Yakila	8.5	3.8	5.4	5.9
RAFI LGA	**5.3**	**1.9**	**4.3**	**3.8**

Source: Author's Fieldwork (2017)

Reliability of Electricity Access

The reliability of electricity access was assessed based on number and duration of electricity outages. The result on average number of daily electricity outages is presented in Table 3. At household level, an average of 2.6 daily outages is recorded, 2.4 outages for enterprise, and 1.5 daily outages for institutions. The low number of outages recorded at institutional level may be as a result of hours spent at such institutional areas compared to enterprise and household.

The duration of daily outages was also assessed, and the result is depicted in Table 4. The result shows that daily power outage in Rafi LGA last for an average of 4.7 hours. The highest average duration of outages was recorded at household level (5.9 hours), enterprise 3.6 hours, and institutions 3.3 hours.

Table 3: Average Number of Daily Outages

Communities	H	E	I	Overall
Garun Gabbas	0.9	1.7	1	**1.2**
Gidi Gori	2.5	3.4	2	**2.6**
Guwa	3.2	2	0	**1.7**
Inga Gari	3.4	4	1.5	**3.0**
Kukogi	4.8	3	2	**3.3**
Kundu	3.6	3.4	1	**2.7**
Maikujeri	2.7	3.3	3	**3.0**
Pangungari	2.1	0	3	**1.7**
Sihonna	0.0	0	0	**0.0**
Yakila	3.3	2.9	1.75	**2.7**
LGA Level	**2.6**	**2.4**	**1.5**	**2.2**

Source: Author's Fieldwork (2017)

Table 4: Average Duration of Daily Outages

Communities	H	E	I	Overall
Garun Gabbas	0.5	0.8	0.83	0.7
Gidi Gori	3.7	4.4	4	4.0
Guwa	4.7	4	0	4.4
Inga Gari	6.1	4	2.5	4.2
Kukogi	6.3	4.7	3.5	4.8
Kundu	16.2	9.3	11	12.2
Maikujeri	3.9	4.2	3.5	3.9
Pangungari	14.3	0	5	9.7
Sihonna	0	0	0	0
Yakila	3.5	4.1	3	3.5
RAFI LGA	**5.9**	**3.6**	**3.3**	**4.7**

Source: Author's Fieldwork (2017)

Quality of Electricity Access

The quality of electricity accessed was analysed based on the proportion of respondents from various tiers that experience electricity fluctuation and the duration of fluctuation. The result as presented in Table 5 shows that only 19.6% of the respondents experience power fluctuation. Enterprise recorded the highest proportion of respondents that experience power fluctuation. This may be due to the nature of machines and tools used by enterprises, especially the grinders and welders. Furthermore, the communities experience an average of 8.8 minutes of power fluctuation, while at household level, the average duration of fluctuation is 9.1 minutes, enterprise 8.6 minutes, and institution 10 minutes (Table 6).

Table 5: Electricity Fluctuation by Communities

Communities	H (%)	E (%)	I (%)	Overall
	Yes	**Yes**	**Yes**	**Yes**
Garun Gabbas	3.3	44.4	0	**16**
Gidi Gori	6.3	60	50	**39**
Guwa	0.0	0	-	**0**
Inga Gari	2.9	66.7	0	**23**
Kukogi	9.8	66.7	50	**42**
Kundu	7.8	37.5	0	**15**
Maikujeri	10.2	50	0	**20**
Pangungari	8.1	--	0	**4**

Sihonna	-	-	-	
Yakila	6.8	42.9	0	**17**
LGA Level	**6.3**	**45.4**	**11**	**19.6**

Source: Author's Fieldwork (2017)

Table 6 Average Duration of Fluctuation

Communities	H	E	I	Overall
Garun Gabbas	10	10	0	10
Gidi Gori	7.5	8.3	10	8.6
Guwa	0	0	0	0
Inga Gari	10	7.5	0	8.8
Kukogi	6.7	7.5	10	8.1
Kundu	8.3	10	0	9.2
Maikujeri	10	8.3	0	9.2
Pangungari	5	0	0	5
Sihonna	-	-	-	-
Yakila	15	8.3	0	11.7
Rafi LGA	**9.1**	**8.6**	**10**	**8.8**

Source: Author's Fieldwork (2017)

Household Access to Clean Cooking Energy Distance Covered and Rate of Distance Change in Search of Cooking Energy

The study reveals that all the households rely on firewood as the primary source of cooking energy. Therefore, the study assessed the distance covered by households in search of firewood in the last five years and in recent time. The result is presented in Figure 1. The result shows that the average distance covered by household in search of firewood is 2.5km in the last five years, while presently households cover an average of 4.5km in search of firewood. In recent time, the highest average distance covered in search of firewood is recorded in Yakila (5.9km), while the lowest is recorded in Guwa 3.6km.

The rate of distance change within five years is computed and presented in Table 7. The result shows the distance covered in search of firewood increases at 9.2% per annum in Rafi LGA. The lowest rate of distance change per annum is recorded in Garun Gabbas 6.7%, while the highest is recorded in Maikujeri 13.1%. This is an indication that there is high rate of distance change per annum, which may result to energy stress.

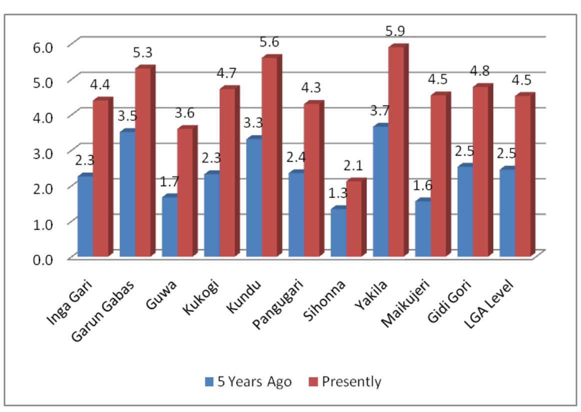

Figure 1: Distance Covered in Search of Firewood
Source: Authors Fieldwork (2017)

Table 7: Change in Distance Covered in Search of Firewood

Community	Change in Dist (Km)	Rate of Change/Annum
Garun Gabbas	1.8	6.7
Gidi Gori	2.3	9.4
Guwa	1.9	10.7
Inga Gari	2.1	9.7
Kukogi	2.4	10.2
Kundu	2.3	8.2
Maikujeri	2.9	13.1
Pangungari	1.9	9.1
Sihonna	0.8	7.4
Yakila	2.2	7.6
LGA Level	**2.0**	9.2

Source: Authors Fieldwork (2017)

Similarly, Figure 2 shows the time spent by households in search of firewood. The analysis shows that, on the average, households spend about 3.22 hours in search of firewood in Rafi LGA. Yakila recorded the most hours spent in search of cooking fuel, while the least is recorded in Sihonna. This shows that households spend more than 30 minutes in search of firewood as stated by

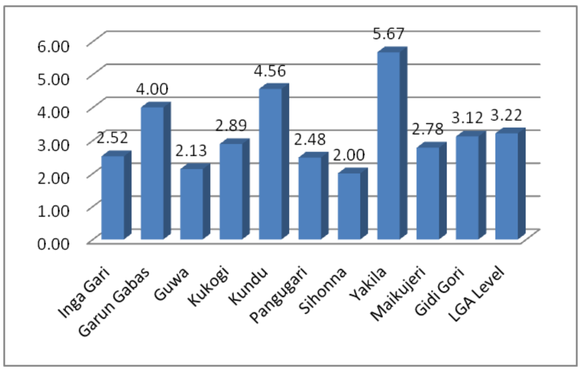

Figure 2: Time Spent in Search of Firewood
Source: Authors Fieldwork (2017)

Energy Poverty in Rafi LGA

Energy poverty in Rafi LGA was computed using the Multi-tier energy poverty measurement index. Electricity poverty index across the three levels of the community (Household, Enterprise, and Institutions) and household access to clean cooking energy forms the basis of the energy poverty assessment. Access to electricity and clean cooking energy was also computed across dimensions at various community levels.

Electricity access index in Rafi LGA is depicted in Table 8. The result shows that all the communities are electricity poor, except Garun Gabbas that is medial electricity poor. The communities recorded a poverty index of less than 0.50. Households recorded electricity access index of 0.55 (medial poor), while enterprises and institution are electricity poor with electricity access index of 0.31 and 0.25 respectively. Households perform better than enterprise and community institution in terms of electricity access.

Table 8: Electricity Access Index by Tier

Community	**H**	**E**	**I**	**EAI**	Remark
G/Gabbas	0.85	0.44	0.41	0.57	**Medial Energy Poor**
G/Gori	0.53	0.33	0	0.29	**Energy Poor**
Guwa	0.61	0.50	0	0.39	**Energy Poor**
Inga Gari	0.60	0.35	0.40	0.45	**Energy Poor**
Kukogi	0.59	0.35	0.28	0.41	**Energy Poor**
Kundu	0.48	0.38	0.38	0.41	**Energy Poor**
Maikujeri	0.58	0.35	0.40	0.44	**Energy Poor**
Pangungari	0.48	0	0	0.16	**Energy Poor**
Sihonna	0	0	0	0	**Energy Poor**
Yakila	0.59	0.36	0.46	0.47	**Energy Poor**
Rafi LGA	0.53	0.31	0.23	0.36	**Energy Poor**
Remark	**MEP**	**EP**	**EP**		

Source: Authors Fieldwork (2017)
Note: H=Household; E=Enterprise; I=Institutions;

Table 9: Electricity Access Index by Dimensions

Communities	**C.I**	**D.I**	**R.I**	**Q.I**	**A.I**
Garun Gabbas	0.83	0.24	0	0.58	0.49
Gidi Gori	0.6	0.2	0.04	0.48	0.53
Guwa	0.67	0.05	0	0.67	0.9
Inga Gari	0.83	0.15	0.02	0.77	0.69
Kukogi	0.83	0.24	0	0.58	0.49
Kundu	0.79	0.01	0.03	0.85	0.35
Maikujeri	0.78	0.16	0.04	0.8	0.61
Pangungari	0.33	0	0.05	0.31	0.11
Sihonna	0	0	0	0	0
Yakila	0.82	0.25	0	0.83	0.45
Rafi	**0.65**	**0.13**	**0.02**	**0.59**	**0.46**
Remark	**MEP**	**EP**	**EP**	**MEP**	**EP**

Source: Authors Fieldwork (2017)

Electricity access index across sub-dimensions of access is presented in Table 9. The result shows that Rafi LGA is medial electricity poor by the dimension of electricity connection (0.65) and quality (0.59). Electricity poverty is experienced from the dimension of duration of access (0.13), reliability of access (0.02) and affordability of access (0.46) in Rafi LGA. This shows that electricity reliability, duration and affordability remains a major challenge to electricity access in the rural communities. The spatial distribution pattern of electricity access is depicted in Figure 3.

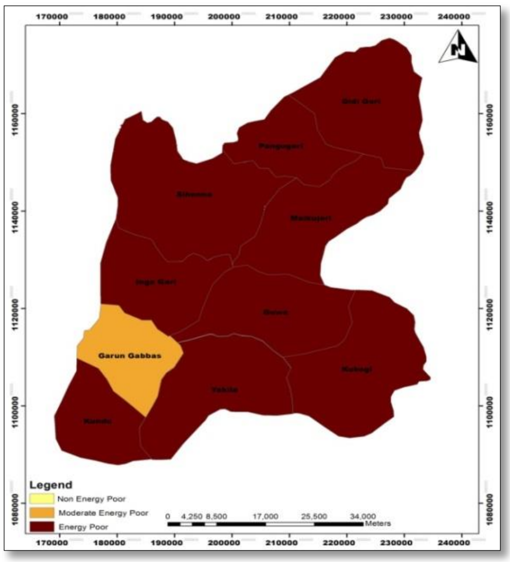

Figure 3: Spatial Distribution Pattern of Electricity Access
Source: Authors Fieldwork (2017)

Household Access to Clean Cooking Energy

Household access to clean cooking energy was examined from three dimensions; cleanliness, quality and convenience of access. The household clean energy access index is presented in Table 10. The result shows that all the communities are energy poor. The poor performance of the households in access to clean cooking fuel is occasioned by the type of primary cooking fuel, distance and time spent in search of cooking energy. The spatial distribution pattern of access to clean cooking energy is depicted in Figure 4.

Table 10: Access to Clean Cooking Energy

Communities	C.I	Q.I	CVI	CEAI	Rank
G/Gabbas	0	0	0.38	0.13	**EP**
Gidi Gori	0	0	0.34	0.11	**EP**
Guwa	0	0	0.5	0.17	**EP**
Inga Gari	0	0	0.36	0.12	**EP**
Kukogi	0	0	0.37	0.12	**EP**
Kundu	0	0	0.3	0.10	**EP**
Maikujeri	0	0	0.43	0.14	**EP**
Pangungari	0	0	0.41	0.14	**EP**
Sihonna	0	0	0.45	0.15	**EP**
Yakila	0	0	0.38	0.13	**EP**
Rafi	**0**	**0**	**0.39**	0.13	**EP**
Remark	**EP**	**EP**	**EP**		

Source: Authors Fieldwork (2017)

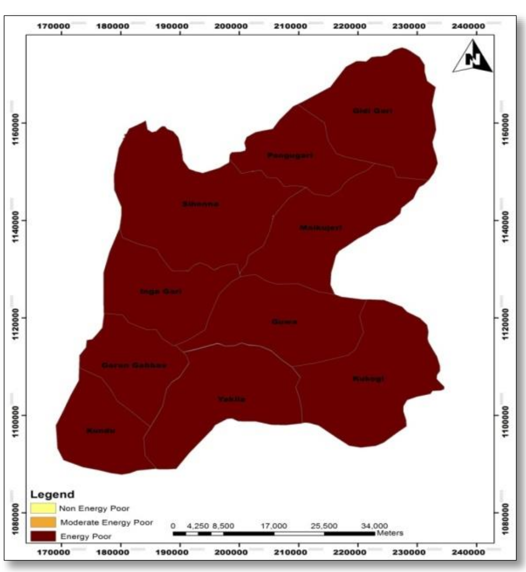

Figure 4: Spatial Distribution Pattern of Access to Cooking Energy
Source: Authors Fieldwork (2017)

Energy Poverty in Rafi LGA

The energy poverty index for the communities was computed based on access to electricity and access to clean modern cooking energy. The result shows that all the communities are energy poor. That is, they record an index of less than 0.5. The best energy poverty index is recorded in Garun Gabbas (0.45), followed by Inga Gari and Maikujeri (0.37) respectively (Table 11). The least is recorded in Sihonna (0.03), which is occasioned by the total absence of electricity connectivity in the community. The spatial distribution pattern of energy poverty in Rafi LGA is presented in Figure 5.

Table 11: Energy Poverty Index

Communities	**EPI**	Remark	**Rank**
Garun Gabbas	0.45	EP	1
Gidi Gori	0.22	EP	8
Guwa	0.30	EP	7
Inga Gari	0.37	EP	3
Kukogi	0.33	EP	6
Kundu	0.35	EP	5
Maikujeri	0.37	EP	3
Pangungari	0.10	EP	9
Sihonna	0.03	EP	10
Yakila	0.39	EP	2
LGA Level	0.29	EP	

Source: Authors Fieldwork (2017)

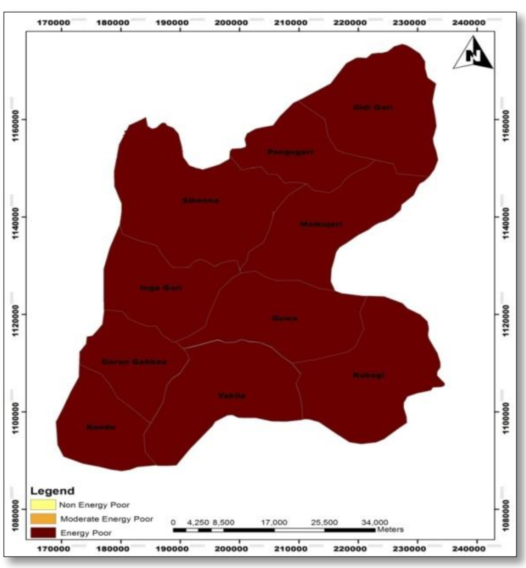

Figure 5: Spatial Distribution Pattern of Energy Poverty
Source: Authors Fieldwork (2017)

Energy Poverty and the Determinant

In other to identify the determinant of energy poverty; regression analysis was carried out between energy poverty and socio-economic variables in Rafi LGA. The operational variables for the regression analysis are: energy poverty, age of household head, Age of marriage, household size, years spent in school and monthly income. The dependent variable of the regression analysis is “energy poverty”, while the socio-economic variables are the independent variables. The result of the regression analysis is presented in Table 12(a-c). Table 12a shows the regression model summary; the regression analysis recorded an R^2 value of 65.4%. The F-statistics of the regression model is 41.990 and a p-value of (0.00), significant at 95% confidence level. It therefore implies that socio-economic variables account for 65.4% of the energy poverty, while the balance (37.3%) is determined by other variables not considered for the study. The coefficient of the regression model is presented in Table 12c.

Table 12a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.809[a]	.654	.639	.09656

a. Predictors: (Constant), Monthly Income, Years in School

Table 12b: ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1.957	5	.391	41.990	.000[b]
Residual	1.035	111	.009		
Total	2.992	116			

Dependent Variable: Energy Poverty
Predictors: (Constant), Monthly Income, Years in School, Age of Marriage, Household Size, Age of Household Head

Table 12c: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.137	.082		-1.667	.098
Age of Household Head	.004	.002	.240	1.736	.085
Age of Marriage	-.004	.002	-.212	-1.532	.128
Household Size	.005	.005	.063	.969	.335
Years Spent in School	.026	.002	.753	12.587	.000
Average Monthly Income	3.079E-6	.000	.208	3.564	.001

a. Dependent Variable: Energy Poverty
Source: Authors Analysis (2017)

The model for the study as derived from the regression model is stated as follows:

$Y=a +b_i x_i +b_{ii} x_{ii}$……………………………………………………..…………..bnxn….Equation (1)

Where Y= energy poverty a= Intercept b= slope X= explanatory variables (x_{i}=age of household head, x_{ii}=age of marriage, x_{iii}=Household Size, x_{iv}=years spent in school, x_{v}=average monthly income)

$Y= -0.137 + 0.004(x_i)-0.004(x_{ii}) +0.005(x_{iii}) + 0.026 (x_{iv}) + 0.000003079(x_v)$....Equation (2)

The model for the determinant of energy poverty as presented in equation (2) shows that all the variables except age of marriage contributes positively to energy poverty, while age of marriage has an inverse relationship with energy poverty. This implies that an increase in the age of household head, household size, years spent in school and average monthly income leads to a corresponding increase in the value of energy poverty value, while a decrease in age of marriage by a factor of the -0.04 implies an increase in energy poverty.

CONCLUSION AND RECOMMENDATION

Electrification (connection to national grid) in the rural communities of Rafi LGA is quite impressive; which is as a result of government effort towards connecting rural community to public electricity through rural electrification programme across the LGA and the state at large. The quality of electricity enjoyed by the rural communities is also commendable; this may be due to the relatively low population of the communities and absence of heavy machines and equipment which may cause overloading and other electrical problem. However, complete access to electricity is still far from the reach of the rural populace, which stem from the low duration of daily electricity supply especially at nights, and the reliability of the access which is usually subject to unannounced interruption that could last for hours, all these are some of the challenges to electricity access in the rural communities of Rafi LGA..

Access to clean cooking energy in the rural areas is a major challenge and a major contributing factor to energy poverty. It is likely that easy access to trees within and around the environment makes the use of firewood handy and convenient. The availability of fire wood in abundant quantity, and at relatively no cost coupled with the ease of use is among the factor responsible for household choice of cooking energy.

The study therefore, recommends that, access to electricity in the rural areas in terms of connection and quality of access must be matched with reasonable hours of electricity access. Outages and duration of outages must also be reduced. Until this is achieved, Rafi LGA is still far from achieving electricity access. Concerted effort must be directed towards providing clean cooking energy in Rafi LGA. The use of fuel wood as cooking fuel must be discouraged systematically, through the provision of alternative cooking energy at affordable prices across the LGA. Residence must also be sensitized on the health and environmental implication of fuel wood as primary cooking energy. Electrification in the rural areas must not be restricted to households alone. Other facet of the rural community (enterprise and institution) should also be connected to the electric grid for optimum access. Until the entire community facet is connected to electricity, energy access in the rural areas will remain a mirage.

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