ADOPTION OF SOLAR ENERGY AS AN ALTERNATIVE POWER SOURCE AMONG RESIDENTS OF MINNA METROPOLIS, NIGER STATE.

BY

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2014/1/49871TI

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SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

JULY, 2021

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A RESEARCH PROJECT SUMMITTED TO THE DEPARTMENT OF INDUSTRAL AND TECHNOLOGY EDUCATIONSCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION,FEDERAL UNIVERSITY OF TECHNOLOGY,MINNA, NIGER STATE.

IN PARITIAL FULFILMENT OF THE REQUIREMENT FORTHE AWARD OF BACHELOR OF TECHNOLOGY (B. TECH) ININDUSTRIAL AND TECHNOLOGY EDUCATION

JULY, 2021.

DECLARATION

I Umah,BenedetteImoh, matriculation number 2014/1/49871TI an undergraduate student of the Department of Industrial and Technology Education certify that the work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other University.

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Signature and Date

CERTIFICATION

This project has been read and approved as meeting the requirement for the award of B. Tech degree in Industrial and Technology Education, School Science of Technology Education, Federal University of Technology,Minna.

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External Examiner

Signature and Date

DEDICATION

The researcher gratefully dedicates this project to Almighty God, the Most Sovereign God, in his infinite mercies and protection, I am privilege to complete my degree program, and you deserve my worship. This work is also dedicated to my wonderful parents, Mr.& Mrs. Umah who have been constant source of support and encouragement during the challenges of graduate school and life. To my only sibling Mildred Umah who have loved me unconditionally and whose good advice have taught me to work hard for the things that I aspire to achieve. I also dedicate this work to Psalm Umoh, who has encouraged me all the way through.Thank you to my supervisor Dr. S. A.Owodunni who guided me in this process, and kept me on track. God bless you.

ACKNOWLEDGEMENTS

The researcher would like to express my sincere gratitude to several individuals for supporting me throughout my graduate study. First and foremost, praise and thanks be to God, the almighty, for His showers of blessings throughout this research work to complete the research successfully.

The researcher would like to express my deep and sincere gratitude to the researcher's research supervisor Dr. S. A.Owodunni, for his enthusiasm, patience, helpful information, practical advice and unceasing ideas that have helped tremendously at all times in this research and realization of this project. The researcher's gratitude goes to the project coordinator Dr. A.M. Hassan, the H.O.D. of the Department of Industrial and Technology Education Dr. I. Y. Umaruand all other lecturers in the Department, for their intellectual support. A Big thanks! May God bless you all and renew your strength and wisdom.

Any attempt at any level cannot be satisfactorily completed without the support and guidance of the researcher's parents Mr. and Mrs. ImohUmah,their full support financially, academically, spiritually and morally. You have given me the opportunity to rank among the intellectual people in this world. May God grant you long life and prosperity to enjoy the fruit of your labour. (Amen.)

Finally, researcher appreciate all my relatives and friends, Mildred Umah, Psalm Umoh, Juliet Ita my friends and colleagues, youall contributed positively during the period of my study, God in His infinite mercy will bless you all. All your effort will be noted with thanks.

ABSTRACT

The study used descriptive survey design through structured questionnaire to the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State. The population of the study was 90 in the small and medium scale enterprises and residential building owners. The sampling technique used for this study was simple random sampling. A random sampling was adopted for this study which consists of small and medium scale enterprises and residential building owners; it includes 30 small and medium scale enterprises and 60 residential house owners. A 30 item structured questionnaire was used for collecting data for the study. The instrument for the study was validated by three experts. Mean and standard deviation was used to answer the research questions while z-test was used to test the null hypotheses at 0.05 level of significance. The finding revealed that it is evident that Nigeria in general and Minna to be precise have huge potential as far as the generation of clean energy is concerned. It is, however, disappointing to note that solar power which is the most the efficient and readily available resource is least utilized with most countries covered having below one percent solar generation. Due to those reasons; Lack of knowledge about solar technologies, improper use and poor maintenance, High cost of the solar pv modules and high installation by the adopters, Cost of the power produced by solar over a period of time is too much because of maintenance cost and the Cost of the power produced by solar over a period of time more efficient a panel is, the more expensive it is to produce and how contractors develop a market strategies for marketing their product in order for residential building to adopt it. The findings on the hypotheses revealed that there was no significant difference between the mean responses of small and medium scale enterprises and residential house ownersin adoption of solar energy as an alternative power source among residential housein Minna. Therefore the null hypotheses are accepted. Consequently, it was recommended among others, that there is need for every staff to have a written procedure guiding his or her schedule of duty.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Nigeria is naturally endowed with abundant renewable energy resources especially solar irradiation. A lot of potentials exist which can be adequately harnessed into useful energy. Moreover, a large percentage of the Nigerian populace lives in rural areas with very little energy access. This translates to absence of basic social amenities and the resultant effect being a constant exodus from such areas to urban centers where there are social amenities. This drift occurs in every part of the country. However, this trend is not economically healthy to our country as the urban areas tend to be over populated and over stretched in their facilities with other attendant consequences whereas the rural areas, where basic or primary production takes place is depleted in population leading to a drop in this aspect of production, with the greatest sector affected being the agricultural sector.

Consequently, renewable energy technologies can be adopted and applied in the rural areas where the national grid has not yet been extended to. Rural electrification, community water projects and other things can be achieved with the use of renewable energy technologies. This will increase energy access in such areas and improve the standard of living thereby discouraging and curbing migration from such places to the urban areas. Furthermore, the adoption of renewable energy technologies like solar energy does not only increase energy access and aid in providing social amenities, it also has capacity to generate employment opportunities which will culminate in curbing rural-urban drift in Nigeria. Solar energy is the term used for the heat and light which the sunlight contains. Sunlight reaches the earth in the form of photons. Photons are energy packets that contain light in it. Solar energy is considered as a renewable energy source because it does not destroy our ecological system and is present

naturally in the environment. There are basically three ways that we can use the sun's energy. The first is by solar cells in which photovoltaic or photoelectric cells are used to convert light directly into electricity. The second is solar water heating in which the heat from the sun is used to warm the water in glass panels on the roof therefore no longer requiring gas or electricity to heat the water. The third is solar furnaces which use mirrors to capture the sun's energy into a congested place to produce high temperatures.

Solar radiation incident on the earth's surface varies in intensity with location**,** season, day of the month, time of day, instantaneous cloud cover and other environmental factors. The incorporation of efficient storage devices in solar energy conversion systems will take care of this intermittent nature of the availability of solar radiation. Nigeria lies within a high sunshine belt and, within the country; solar radiation is fairly well distributed. The annual average of total solar radiation varies from about 12.6- 28MJ/m2-day in the coastal latitudes to about 25.2 MJ/m2-day. In the far North, Solar energy is renewable and its utilization is environmentally friendly. Consequently, when the availability and environmental costs of the utilization of other forms of energy are considered, the competitiveness of solar energy in comparison with these other forms becomes very evident, particularly for low to medium power applications. Solar radiation conversion technologies are generally either of the solar-thermal type (solar heating, cooling, drying, thermal power plant, etc.) or of the photovoltaic type (direct conversion to electricity). Areas of application of solar thermal technologies are crop drying, house heating, heating of process water for industries, hospitals etc, air-conditioning, preservation of foods and drugs, power generation, etc. Photo-voltaic (PV) power may be utilized in low to medium power applications and in remote areas, in such uses as communication stations, rural television and radio, water pumping, refrigeration etc, which require power of the order of 1-10 kW. It may also be used for power supply to remote villages not connected to the national grid. It is also possible to generate PV power for feeding

into the national grid. Most solar-thermal technologies can be supported by the technical expertise existing within the country.

In Nigeria, most solar PV projects are designed for street lighting, water pumping and general stand-alone/mini grid rural electrifications. However, several solar PV projects being installed in various parts of this country fail to meet the minimum life-span due to a number of limiting factors. These include poor or improper fundamental design, use of sub-standard components, adoption of poor installation procedure by inexperienced personnel, bad construction/civil works among other factors. This has become a problem in the country and many are beginning to feel disgusted with solar PV projects as the heavy investments in such projects do not seem to be commensurate with their performances and satisfactions derivable. We believe that if power projects are designed and executed properly by experienced technical experts, using the appropriate components and best technical procedures, standard PV projects with maximum performance output could be achieved. It is over eleven decades ago since electricity was introduced into Nigeria. The country has an installed generating capacity of about 6000MW from 60kW within this period but only about 40% of the population has access to grid-connected electricity supply. A per capita electricity consumption of 72kwh per annum was estimated in the year2000. Utilization of the existing generation capacity has also been estimated at 30% to40% for the same year. The supply of electricity in the country is sparse and inadequate; the spread favors the urban areas with about 80% accessibility by households in 1992.

Most rural grid-connected households have blackouts of up to 20 hours a day. The current approach to involve independent power producers in boosting grid electricity supply via thermal plants has also been focused to cities and towns in the country with rural areas alienated. As of year, 2000, less than 10% of electricity generated in the country goes to the

rural area which is rather too inadequate to meet the developmental objective of the rural areas of Nigeria.

Since the availability of energy is an important precondition for developing the rural economy and improving the people's living standards, it is imperative therefore that the extent to which the country could meet the growing demands for energy in the rural areas in a sustainable way will significantly affect its economic growth and well-being of its rural dwellers. It is therefore essential to access what alternatives exist for supplying electricity in a sustainable manner to rural households to meet their energy requirement. And potentially, one of such options is solar energy photovoltaic device. This paper therefore reveals the importance of using solar power to Improve Energy Access inrural areas and also contributes to the industrial and economic growth of Nigeria.

In a nation of diverse topographies, many regions across the Nigeria vast rural landscapes have expressed support for the current administration's policies. At the same time, these rural areas have displayed a slow acceptance to the low energy supplies. In an effort to reduce government oversight and bring jobs back to rural communities struggling from high unemployment, the current administration has promised to lower environmental regulations and inflate the price of fuel extraction with little regard to what the outcome could be. Consequently, the Nigeria finds itself immersed in a rhetoric promoting a revival of solar energy and other practices proven to negative impact the environment which includes the potential environmental impacts associated with solar power such as land use and habitat loss, water use, and the use of hazardous material in manufacturing can vary greatly depending on the technology, which includes two broad categories like photovoltaic (PC) solar cells or concentrating solar thermal plants (CSP). All the while, rural residents ignore job opportunities for skilled workers and increased revenues for their local communities, both of which could result from advancing solar photovoltaic (PV) technology in these areas.

Compounding the challenge of increased solar adoption in rural areas of the Minna metropolis, existing research has predominantly focused on major urban areas or large scale RETs like wind power. Few studies have explored the barriers and motivations of adopting solar technology in rural areas of the Minna.

Nigeria has 12,500 MW of installed generation capacity, being largely dependent on hydropower sources; 12.5% and 87.5% respectively. Although it is important to note that currently only 3,500 MW to 5,000 MW is typically available for onward transmission

1.2 Statement of the Problem

An adequate and reliable power supply system is essential for any developing country like Nigeria. The supply of electricity is insufficient and unreliable to the over 170millionpeople living in Nigeria. Nigeria Only 40 percent of the country's population has access to electricity leaving the remaining 60 percent without access to electricity. Many Nigerians have resorted to sources like generating set which is too expensive to maintain the unsustainable energy practices of today which need to be reformed if the national developmental goals for a sustainable future will be met. As at today, Nigeria has 12,500 MW of installed generation capacity, being largely dependent on hydropower and fossil (gas) thermal power sources; 12.5% and 87.5% respectively. Although it is important to note that currently only 3,500 MW to 5,000 MW is typically available for onward transmission to the final consumer. Based on this scenario the country’s energy sector could be deemed as being in crisis, with the extensive losses attributable to non-availability of the installed capacity and a very high occurrence of significant technical and non-technical issues through the power supply value chain. The supplied electricity is delivered to Nigerians connected to the grid, though these customers suffer from extensive power outages a situation that results in annual consumption of electricity per capita being amongst the lowest in Africa, estimated at less than 150 kWh.

Against this backdrop a significant number of businesses operational in the country possess standby generators; statistics on this captive generation capacity are not readily available however estimates are as high as 14-20 GW.

Societies which must achieve sustainable energy in the future must strive to achieve these three objectives as:

1. improve energy efficiency to reduce demand increase
2. replace oil
3. Increase carbon-free energy sources. Randolph and Masters (2008).

Infuse these adoptions of solar energy as one of the means to achieve these objectives. As at today, there is no single solution that addresses all three objectives, however renewable energy sources and their associated technologies present a solution that is able to address some of these objectives. This research will be seeking to:

a. Identify the barriers and drivers of the adoption of solar photovoltaic system among home owners and organizations in Nigeria.
b. Identify the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems.

In response to this situation the Government of Nigeria in 2013 completed an extensive nine year-long process of power sector reforms centered on the privatization of the country's main generation, distribution assets and also using other means of other electricity supply like solar energy. In addition, to tackle the supply and distribution crisis, fifteen (15) governments owned generation and distribution companies were sold to private owners in 2015.

1.3 Purpose of the Study

The purpose of the study is to explore strategies in overcoming barriers for the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

The specific objectives of this study are to:

1. Find out the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
2. Find out the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
3. Identity possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

1.4 Significance of the Study

Given the shortages of electricity experienced in Nigeria both by rural and urban dwellers, individuals and businesses turn to other sources to provide electricity for themselves, with the most common being generating sets which mostly use petrol and diesel. The research will be of great effect to the electrical contractor, engineer, technicians, specialist or consultant, client, and student on industrial training, apprentice and everyone who work in the electrical field and own a residential building. Since it will uncover all the barriers preventing individual from adopting solar energy in their work place and client house which are alternative source of energy for residential houses. This research will likewise be of great advantage to practicing managers, employees, educationists, safety and health practitioners,

technologists, engineers, and general public that are interested in getting information in the field of life. It will reveal the mistakes other contractors made when installing solar panels in the work environment and the possible solution.

The study will prepare the technician and client with significant consciousness of how to adopt solar energy as an alternative power source. For the academic it opens them to the practices in solar energy execution in an efficient manner and furthermore what the electrical contractors ought to do.

1.5 Research Questions

In order to achieve the objectives, the following research questions have been formulated to guide the research:

1. What are the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State?
2. What are the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State?
3. Identifying possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

1.6 Null Hypotheses

1. There is no significant difference in the mean responses between small and medium scale enterprises and residential building owners on the most common barriers and

drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

2. There is no significant difference in the mean responses between small and medium scale enterprises and residential building owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
3. There is no significant difference in the mean responses between small and medium scale enterprises and residential building owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

1.7 Scope of the Study

The researcher chose the Minna metropolis, Niger State. Because of the significant lack of research on solar adoption outside of large metropolitan areas in states other than those with large concentrations of solar power like Abuja and other Southwestern states. Based on research completed as part of a pilot study, it was apparent that focus data collection from residential building owners and government agencies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of Renewable Energy

The high energy demands have brought up the need for at least ten terawatts of carbon free power by the mid-century to the world (Armstrong, 2003). In other words, although the energy intensities have declined, the need will increase to about two-fold by the middle of 21st century is undeniable (Apajalahti *et al.*, 2015.).This increase in energy demands (up to about 2-3% per year) is generally due to the high population and economy growth (Lund, 2011.). Additionally, the rapid increasing of renewable energies attention is happening and the knowledge about their environmental effects are very limited (Armstrong, 2003). As a result, the renewable energies (e.g. solar or wind energies) will play a vital role in the future because it is well accepted by environmental friendly industries.

Renewable energy is useful energy that is collected from renewable resources, which are naturally replenished on a human timescale, including carbon neutral sources like Sunlight, wind, rain, tides, waves and geothermal heat. Furthermore, the fuel-based sources are not less reliable from environmental point of but also will last soon. The statistical studies show that the energy demand will increase about 40% between2009 and 2035(IEA, 2011). This increase will get contributions from solar energy, hydropower, biomass and waste, and 'other' renewable energies. These sources are predicted to increase by 70%, 55% and 600%, respectively (IEA, 2011). As an expanding source wind power has grown tremendously. An extraordinary growth of about 238GW happened to wind power growth between 2010 and 2011. Additionally, solar photovoltaic (PV) technology demonstrated a growth rate of 74%, which was the highest rate among all energy sources in 2011(Armstrong *et al.*, 2016).

Renewable energy often provides energy in four important areas; electricity generation, air and water heating/cooling, transportation, and rural energy service. Many renewable projects are large-scale, renewable technologies are also suited to rural and remote areas and developing counties, where energy is often crucial in human development. As most of renewable energy technologies provide electricity, it deployment is often applied in conjunction with further electrification, which has several benefits; electricity can be converted to heat, can be converted to mechanical energy with high efficiency and it is clean at the point of consumption. In addition, electrification with renewable energy is more efficient and therefore leads to significant reductions in primary energy requirement.

2.2. Solar Energy

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. It is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

The large magnitude of solar energy available makes it a highly appealing source of electricity. The United Nations Development Program in its 2000 World Energy Assessment found that the annual potential of solar energy was 1,575–49,837 exajoules (EJ). This is several times larger than the total world energy consumption, which was 559.8 EJ in 2012. In 2011, the International Energy Agency said that "the development of affordable, inexhaustible

and clean solar energy technologies will have huge longer-term benefits. It will increase energy security through reliance on an indigenous, inexhaustible, and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared".

2.3 Potential of Solar Energy

The Earth receives 174 peta watts (PW) of incoming solar radiation (insulation) at the upper atmosphere. Approximately 30% is reflected in space while hetaerist is absorbed by clouds, oceans and landmasses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Most of the world's population lives in areas with insulation levels of 150–300 watts/m2, or 3.5–7.0 kWh/m2 per day.

Solar radiation is absorbed by the Earth's land surface, oceans – which cover about 71% of the globe and atmosphere. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anticyclones. Sunlight absorbed by the oceans and landmasses keeps the surface at an average temperature of 14 °C. By photosynthesis, green plants convert solar energy into chemically stored energy, which produces food, wood and the biomass from which fossil fuels are derived.

The total solar energy absorbed by Earth's atmosphere, oceans and landmasses are approximately 3,850,000 exajoules (EJ) per year. In 2002, this was more energy in one hour

than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

S/N	Yearly solar fluxes & human consumption	
1	Solar	3,850,000
2	Wind	2,250
3	Biomass potential	~200
4	Primary energy use	539
5	Electricity	~67

The potential solar energy that could be used by humans differs from the amount of solar energy present near the surface of the planet because factors such as geography, time variation, cloud cover, and the land available to humans limit the amount of solar energy that we can acquire. Geography affects solar energy potential because areas that are closer to the equator have a higher amount of solar radiation. However, the use of photo voltaic that can follow the position of the Sun can significantly increase the solar energy potential in areas that are farther from the equator. Time variation affects the potential of solar energy because, during the nighttime, there is little solar radiation on the surface of the Earth for solar panels to absorb. This limits the amount of energy that solar panels can absorb in one day. Cloud cover can affect the potential of solar panels because clouds block incoming light from the Sun and reduce the light available for solar cells.

Besides, land availability has a large effect on the available solar energy because solar panels can only be set up on land that is otherwise unused and suitable for solar panels. Roofs are a suitable place for solar cells, as many people have discovered that they can collect energy directly from their homes this way. Other areas that are suitable for solar cells are lands that are not being used for businesses where solar plants can be established. Solar technologies are characterized as either passive or active depending on the way they capture, convert and distribute sunlight and enable solar energy to be harnessed at different levels around the world, mostly depending on the distance from the equator. Although solar energy refers primarily to the use of solar radiation for practical ends, all renewable energies, other than geothermal power and Tidal power, derive their energy either directly or indirectly from the Sun.

Active solar techniques use photovoltaic's, concentrated solar power, solar thermal collectors, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand-side technologies. In 2000, the United Nations Development Program, UN Department of Economic and Social Affairs, and World Energy Council published an estimate of the potential solar energy that could be used by humans each year that took into account factors such as insulation, cloud cover, and the land that is usable by humans. The estimate found that solar energy has a global potential of 1,600 to 49,800 exajoules (4.4×1014 to 1.4×1016 kWh) per year.

2.4 Types of Solar Energy

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect. Solar power is anticipated to become the world's largest source of electricity by 2050, with solar photovoltaic and concentrated solar power contributing 16 and 11 percent to the global overall consumption, respectively. In 2016, after another year of rapid growth, solar generated 1.3% of global power.

Commercial concentrated solar power plants were first developed in the 1980s. The 392 MW Ivanpah Solar Power Facility, in the Mojave Desert of California, is the largest solar power plant in the world. Other large concentrated solar power plants include the 150 MW Sol nova Solar Power Station and the 100 MW Andasol solar power station, both in Spain. The 250 MW Agua Caliente Solar Project, in the United States, and the 221 MW Charanka Solar Park in India, are the world's largest photovoltaic plants. Solar projects exceeding 1 GW are being developed, but most of the deployed photovoltaic are in small rooftop arrays of less than 5 kW, which are connected to the grid using net metering or a feed-in tariff.

- **Photovoltaic**

  In the last two decades, photovoltaic (PV), also known as solar PV, has evolved from a pure niche market of small scale applications towards becoming a mainstream electricity source. A solar cell is a device that converts light directly into electricity using the photoelectric effect. The first solar cell was constructed by Charles Fritts in the 1880s. In 1931 a German engineer, Dr Bruno Lange, developed a photo cell using silver selenide in place of copper oxide. Although the prototype selenium cells converted less than 1% of incident light into electricity, both Ernst Werner von

Siemens and James Clerk Maxwell recognized the importance of this discovery. Following the work of Russell Ohl in the 1940s, researchers Gerald Pearson, Calvin Fuller and Daryl Chapin created the crystalline silicon solar cell in 1954. These early solar cells cost US$286/watt and reached efficiencies of 4.5–6%. By 2012 available efficiencies exceeded 20%, and the maximum efficiency of research photovoltaic was in excess of 40%.

- **Concentrated solar power**

  Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear fresnel reflector, the Stirling dish, and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage. Designs need to account for the risk of a dust storm, hail, or another extreme weather event that can damage the fine glass surfaces of solar power plants. Metal grills would allow a high percentage of sunlight to enter the mirrors and solar panels while also preventing most damage.

2.5 Common Barriers and Drivers Preventing Individuals from the Adoption of Solar Energy as an Alternative Power Source among Residential Houses.

Residents and businesses around the world are increasingly installing solar photovoltaic (PV) panels and battery storage systems, satisfying not just their interest in clean energy, but also taking advantage of reduced technology costs and mitigating against future electricity price rises.

Solar PV panels coupled with storage systems present an opportunity to move towards a resilient, affordable, flexible and secure electricity network.

Nigeria provides a unique set of conditions (isolated network, high solar radiation, and rising electricity prices), which has contributed to the rapid uptake of solar PV's in the state. Yet, a number of issues are still obstructing the transition to renewable.

Using Minna as a case study, this paper investigates the barriers inhibiting the network transformation and explores the role that solar PV and storage can play as a disruptive threat to the incumbent, centralized service model of electricity utilities.

These barriers are identified and qualified through a series of interviews with several Nigerians energy market participants. If policy makers intend to enable widespread adoption of solar PV and storage, they will need to address barriers to support these emerging technologies. In parallel, market participants must work with policy makers to drive flexibility in regulatory frameworks and progress the evolution towards innovative and sustainable electricity networks of the future. Research on increasing the adoption of solar PV systems has a long heritage, beginning in the 1980s and with research literature continuing today, profiling the advancement of PV technologies from socio technical (Müggenburg *et al.*, 2012; Dewald and Truffer, 2012), economic (Lund, 2011) and political perspectives (Jacobsson and Lauber, 2006).This research shows that the barriers to increased uptake of solar PV typically relates to a similar set of areas including socio-technical, management, economic, or policy (Karakaya and Sriwannawit, 2015; Balcombe *et al.*, 2014). Although specific research investigating the barriers from a Nigeria context was not found, barriers are expected to be similar, albeit with varying levels of priority, and encompassing issues including cost, environmental concerns, self-generation, policy uncertainty, inertia and inconvenience and aesthetic impacts (Ratinen, 2014; Strupeit, 2015; Balcombe et al, 2014; Sandberg and Aarikka-Stenroos, 2014; Suzuki, 2015; Luthra *et a.*,, 2014). For ease of classification, barriers

have been regrouped under three main headings: technological, institutional, and financial. Each barrier is discussed in more detail below;

Technological

- **Fore casting capability**

Forecasting inaccuracies are infamously known to drive poor decision-making across any industry, but forecasting has become embedded into the centralized model of electricity provision. In minna, actual demand growth has been far below forecasts made at the time the Wholesale Electricity Market in minna was designed. As a result there is now a substantial excess of capacity in the market, imposing a significant cost to electricity consumers as there is a Capacity Market that pays for the capacity of all generators, even if they simply provide back-up services and are rarely if ever called on to generate electricity. In conjunction, the market mechanism designed to reduce this cost over time is not functioning at all – failing to incentivize generators to mothball or retire redundant capacity. Poor forecasting by the Independent Market Operator (as Nigerians system operator), Government authorities, and the Economic Regulation Authority, has now resulted in a situation where consumers have to pay for the costly errors and

Un-needed infrastructure investments in the market. Whilst the impact of additional costs imposed by poor forecasting might provide residents with additional incentive to go 'off-grid' or install solar PV and storage units, at a business level, electricity generators, networks and retailers have a reduced need for additional capacity and can already secure long term power contracts at long-term average costs.

- **Constraints of existing technology**

The transformation of electricity systems requires technological innovation in order to implement services and products to consumers in an affordable and accessible way (Suzuki, 2015). The quality and reliability of solar PV and storage systems is therefore critical for their

increased adoption and barriers exist relating to the uncertainty of the technical performance of solar and storage systems (Zahedi, 2011; Luthra et al, 2014). Adoption rates in China provide an example where high levels of dissatisfaction with the low performance of solar home systems (whether caused by improper usage or not) has reportedly prevented other potential adopters from purchasing systems (Karakaya and Sriwannawit, 2015; YuanEt al, 2011). Similarly, studies in the US indicated that consumers were also likely to hesitate from adopting solar PV systems due to the perceived risks of unknown technologies and associated complexities (Druryetal,2012).As part of the Government led electricity marketer forms in Nigeria, the local network utility responsible for grid connections for the SWIS, Western Power, has begun reviewing its processes and technical standards for distributed generation connection in order to reduce system connection costs. Nigeria will also require the adoption of smart meters, sensors and advanced communication networks in order to realize the full benefits of new technology such as solar PV and storage systems. For example, new control systems will have to be developed to deal with the bi-directional power flows inherent in a fully developed distributed market. As existing networks evolve to become 'smart grids', utilities will also need to grapple with the complexities of data ownership, cyber security and data privacy (Luthra *et al.*, 2014).Market participants and smart-meter providers interviewed for this research noted that engaging within recumbent utilities in Nigeria was still a slow and often unsuccessful process, with network utilities (Western Power and Horizon Power) and Government owned retailer (Synergy), still applying existing centralized business models (Participant 15, 2016) Trials being conducted by both companies (e.g. at the Alkimos Beach energy storage trial, a fringe of grid development on the outskirts of Perth).

- **Network capacity and access**

Integrating solar PV systems (with or without storage) also raises technical challenges in regards to network stability, reliability and power quality. Western Power is responsible for

following technical rules and regulations in order to safeguard and maintain its network assets. Therefore, as the gatekeeper to network access, Nigeria Power is extremely interested in the potential impacts of new connections. While individual residential solar PV customers introducing 1 or 2kW into the system may have only a minor impact, when aggregated across the interconnected system, or when concentrated in areas with existing network constraints or older infrastructure, network impacts may be more pronounced.

Given the rapid uptake of solar PV that has already occurred across the state, network access barriers appear to have been minimal over the last few years. Going forward may present a different situation, however, particularly as the penetration rates rise from less than 20 per cent of customers on the network to estimates far above 50 per cent in the next decade. The unknown disruptive component in all of this is of course the impact that residential storage systems will play across both supply and demand side management. Although the connection of small-scale residential batteries received a promising start in 2015, when the Nigeria Energy Minister facilitated the removal of regulations prohibiting homes with battery storage from feeding electricity back into the grid.

Institutional

- **Psychological will –increasing motivation to embrace innovation**

A 2013 study of the German energy market by Richter (2013), found that not only were German utilities yet to react to solar, but the majority of managers interviewed saw no future for solar PV within their organizations (at that time). This was driven by the view of solar PV as a relatively small-scale technology, with relatively high costs and therefore a strong reliance on government subsidies to remain competitive (Richter, 2013). This view may be particularly prevalent for companies without established capabilities in solar or storage technologies (most incumbents), who have a greater reluctance to embrace these technologies than comparable companies with some previous experience (Markard and Truffer, 2006;

Stenzel and Frenzel, 2008; Luthra *et al.*, 2014).This places most incumbent electricity utilities (particularly the dominant government owned entities in Nigeria) in a position where they may be inclined to rely more on their beliefs than facts when formulating business strategies and predicting future market outcomes (Henderson and Clark, 1990).Alternatively, as Storbacka et al. (2009) note, companies may just be 'stuck' in their mindset and identify the structures and players of the energy market as being "given and unchangeable". In contrast, and three years on, all Nigeria stakeholders interviewed now see solar PV as a 'disruptive innovation' given its potential (particularly in combination with residential storage systems) to challenge the entrenched, centralized models of electricity generation and the opportunities it presents to the electricity market going forward . Further, the growth potential in the expanding solar market and building new customer relationships would be additional opportunities for utilities; and long term contracts for solar PV provided by the utility would also facilitate customer retention. Within this new perspective, solar PV could then be viewed as a stepping stone into promoting other 'green energy' initiatives, such as energy efficiency and battery system offerings (Richter, 2013). In the Minna context, many stakeholders agreed with the vast opportunities that 'new energy' offerings provide, but various views were expressed on the timing of when these opportunities would be pursued

- **Organizational management - is listening to customers a bad thing?**

Interviewees also cited a general belief that lack of management expertise has acted as a central barrier to increasing adoption of solar PV and storage systems in Nigeria. Unlike the conventional type of value chains in the centralized energy industry (i.e. generators wholesale to distributors and retailers), in the distributed generation model, participants need to develop different types of business models that cooperates across multiple fronts with multiple actors (Karakaya and Sriwannawit, 2015.). The question then becomes how these new models will be developed. Research on disruptive technology's impacts on existing markets has

highlighted the inability for incumbent firms to recognize the true nature of threats to existing business models (Christensen, 1997). A study by Christensen and Raynor (2013) found that the primary reason incumbent firms are resistant to innovating product sis because of an over-reliance on listening to what customers are asking for. According to the study, the average customer is blind to any potential benefits from new and innovative products prior to their Commercialization, and therefore rather than driving any form of radical innovation, customer preferences simply lead businesses to make gradual improvements on existing products and services (Christensen and Raynor, 2013). Apajalahti et al. (2015) identified a further institutional barrier; the inherent complexity faced by utilities attempting to unbundle and split their business

Units along service offering lines. Two interviewees also raised the important issue of culture for utility businesses and suggested that whilst in Government hands, WA utilities such as Horizon Power and Western Power would be more resistant to embrace innovation and would inhibit any form of lasting institutional change. One interviewee argued that unless Government-owned enterprises continued to provide secure and stable returns via traditional business models, they would be acting outside their mandate as they could then be seen as first movers and take on the risks of unproven technologies.

Financial

- **Sunk network costs- network design inertia**

Sunk costs in existing network infrastructure are a significant hurdle that is central to the transformation of centralized grids towards more sustainable, distributed platforms for energy trading. A Commonwealth of Australia Governmental led investigation, the Senate's Select Committee on Electricity Prices (Select Committee, 2012), found that network design, connection and cost barriers were the main impediments to increasing embedded generation in Australia's electricity grids.

As per the current design model, customers pay for the sunk costs of electricity poles and wires (whether they want to use them or not) based on levels of spending pre-approved by economic regulators (in Western Power's case, this has been the Economic Regulation Authority). This model has provided very limited incentive to shift these electricity utilities away from their reliance on the regulated asset base (which allows for a more certain revenue stream). In effect, this model propagates old, centralized electricity service business models which are framed to see residential solar and storage generation units as a threat, rather than as an opportunity for new business (Parkinson, 2015B).

One interviewee suggested the immediate focus should be on:

"Applications where it already makes more economic sense to have solar and storage technologies, particularly when considering any large capital heavy projects on the electricity network - such as fringe of grid, new developments, undergrounding power lines, or replacing damaged power lines.

Indeed, for the Nigeria context, this appears to be the approach now being followed by the Government and government-owned utilities. The aforementioned trial in Alkimos beach, combines community scale battery energy storage, high penetration solar PV and energy management, and will test the feasibility of new energy retail models (ARENA, 2016).

- **Upfront system costs**

The high cost of solar PV systems is usually cited as the most common (and largest) economic

barrier to increased adoption – specifically the high initial capital costs, high repair costs, and long payback period (Zhang et al, 2012; Balcombe et al, 2014; Allen et al, 2008; Ravindranath and Balachandra, 2009). It should also be noted that it is important to consider this cost in relation to the cost of substitutable energy sources available (Karakaya and Sriwannawit, 2015; Sarzynski et al, 2012).

2.6 Challenges Faced by Large-scale and Small-scale Suppliers of Solar Photovoltaic Systems in Adopting of Solar Energy as an Alternative Power Source among Residential Houses.

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available. Solar technologies can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use. However, solar still faces a number of obstacles before it can really replace fossil fuels for power generation. There are many unexpected challenges with solar electrification that entrepreneurs are learning about while doing business in these developing countries.

The Levelized Cost of Solar Power

Levelized cost of Solar Power is a term which describes the cost of the power produced by solar over a period of time, typically the warranted life of the system. It is the capital cost for solar power plants which is high initially. Moreover, there are on-going maintenance costs for both types and the cost of financing any loans.

- **Intensity of Solar Radiation**

Intensity of solar radiation is one of the main obstacles to the extensive application of solar power. It varies with different locations of the world. The amount of useful solar energy incident in any particular location is highly dependent on latitude and climate. The equator receives the most annual solar energy and the poles receive the least. Dry climates receive more solar energy than those with cloud cover.

- **Required Land Space**

A good amount of land space is required for solar farms, as power generation is directly proportional to the surface area covered. Therefore, the largest solar farms in the world are built in deserts and huge open spaces. However, this is not feasible in smaller countries with limited landmass, or even for larger countries where a land compromise develops restricting the use of agricultural land for developing solar farm.

- **Transmission**

Sufficient transmission is required to transport the power to urban load centres. Intermittent resources like solar can pose distinctive problems in transmission planning and in efficient operation of transmission infrastructure, causing in higher transmission costs, increased congestion, and even generation limitations when sufficient transmission capacity is not available. Due to potential transmission barriers, solar project developers will need to evaluate the economic trade-off of locating where the resource is best versus locating nearer to loads where transmission barriers are less possible.

- **Reliability**

Reliability is one major problem with solar power. A solar panel can produce electricity for maximum 12 hours a day and a panel can only reach peak output for a short period around noon. Solar panels with tracker can track the sun spreading the major generation period fairly, but it still means that panels employ very little of the day producing at maximum capacity. During peak generation, storage batteries can be charged by solar panels which help to supply a dribble of power at night. But they can be costly, contain toxic materials and wear out rapidly due to frequent charging and discharging cycles.

- **Efficiency of Solar Panel**

Photovoltaic efficiency is another obstacle. In the desert area, a single square meter of solar panel could receive the equivalent of more than 6 kilowatt-hours of energy in the course of a single day. But a solar panel cannot convert that much of energy to electricity. The efficiency of a solar panel regulates usable power. Most commercial solar panels have efficiency less than 25%. The more efficient a panel is, the more expensive it is to produce.

- **Environmental Issues**

Though generating power from solar is free from carbon emission, manufacturing of solar panels and associated technologies can comprise some environmentally unfriendly elements. Nitrogen tri-fluoride is a common by product of electronics manufacture; including those used in solar cells, and it is a greenhouse gas 17,000 times more potent than carbon dioxide. Moreover, many solar cells contain small amounts of the toxic metal cadmium, and the batteries required to store generated electricity can contain a host of other heavy metals and dangerous substances. As solar technology improves, manufacturers may be able to move away from these potentially dangerous substances, but for now, they ruin the otherwise notable environmental benefits solar power offers.

2.7 Related Empirical Studies.

Tarek (2019) carried out a study on solar energy policies and impact on residential houses from the contractors and owners' perspectives. This study was designed specifically to introducing the adoption of solar energy among many countries from the contractors and owners' perspectives and there polices that played a crucial role in helping countries to shift from one conventional energy to solar energy by overcoming the barriers face by the issues of lack of electricity. The four research questions and one hypothesis were formulated and tested

at 0.05 level of significance. The research designed used for this study was the survey method as it involved the use of questionnaires to elicit opinions from respondents. The study was conducted in Osun State building Odo-otin local government, purposeful sampled techniques was used. 40 owners and 70 contractors. The designed questionnaires were administered to the respondents and had 100% returned rate. Four point scales was used. The data collected for this study was analyzed using mean, standard deviation and analysis of variance (z-test). The findings emerged from the study among others are on economic growth, job creation, welfare, CO2 emissions, electricity prices, and fuel imports. Based on these findings it was recommended among others Contracting companies that the policies used were essential to shift to renewable energy substantially reduced carbon emission, and the majority concluded that renewable energy has a positive correlation with economic growth, job creation and welfare.

The similarity between this study and the current study is that the study is based on the adoption of solar energy and the questionnaire where used in collecting data while the difference is that it is carried out in Osun State while the current study is carried out in Minna, Niger State and another difference is in terms of research population and respondent.

Karakaya (2015) carried out a study on Barriers to the adoption of photovoltaic systems in Imo state as a case study in Imo state. This study was designed specifically to evaluate the Barriers to the adoption of photovoltaic systems and identifies key barriers and their effects on the adoption of solar energy. There were three research questions and three hypotheses were formulated and tested at 0.05 level of significance. The research designed used for this study was the survey method and interview as it involved the use of questionnaires to elicit opinions from respondents. The study was conducted in Imo State building, purposeful sampled techniques was used was which are registered and practicing solar energy engineers and people of imo state which have which consist of 150 registered electrical technician, 45

residential houses, 110 registered electrical engineers, 120 registered suppliers engineers, 28 registered structural engineers, and 30 registered Builders, making it a total of 484. The designed questionnaires were administered to the respondents and had 97% returned rate. Scales was used. The data collected for this study was analyzed using a system of rank scaling was used and chi-test as a statistical technique is used in testing of hypothesis.

The findings emerged from the study among others are the cost and schedule development process was inefficient in many the adoption of solar energy and led to inaccurate estimates that later negatively affected solar performance. The complexity and risk of building solar panel is increasing by the day as more ideas are emerging. According to findings in this research, despite the rapid development and maturity of the technology during the past few years, the adoption of PV systems still faces several barriers. The wide adoption of PV systems either as a substitute for other electricity power generation systems in urban areas or for rural electrification is a challenging process. Our results show that the barriers are evident for both low and high income economies, encompassing four dimensions: socio technical, management, economic, and policy. Although the barriers vary across context, the lessons learned from one study can be valuable to others. The involvement to fall stake holders' adopters, local communities, firms, international organizations, financial institutions, and government is crucial to foster the adoption.

The similarity between this study and the current study is that the study is based on adoption of solar and the questionnaire where used in collecting data while the difference is that it is carried out in Imo State while the current study is carried out in Minna, Niger State and another difference is in terms of research population and respondent.

2.8 Summary of Literature Reviewed.

The literature review presented an overview of the adoption of solar energy as an alternative power source among residential house. The concept of renewable in the context of solar energy option was that the high energy demand have brought up the need for at least ten terawatt of carbon free, there is need for the adoption solar energy were highlighted. Also, included in the literature was the types of solar energy, common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house, challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house, roles of clients and contractor in adopting solar energy in residential houses**.**

In the literature review, it was implicit that whilst barriers were often discussed in isolation, it is in fact their interaction and combined impact, which has the most significant effect on the deployment and uptake of solar PV and storage systems in Nigeria. Further, some of the barriers identified do not fit neatly into just one category and feed into multiple themes. For example, one interviewee provided a unique insight into a potential barrier that straddles both financial and technological classifications, relating to Nigeria relatively small size in the global markets. In their view, since Nigeria offers a significantly smaller market than those found in Asia, North America and Europe, Australian consumers with strong preferences for solar and storage products will likely be left waiting in line behind the larger markets. This is likely to be more noticeable in relation to storage products, which have limited supply chains. Therefore, the present study is interested in investigating the barriers inhibiting the network transformation and explores the role of adoption of solar PV and storage can play as a disruptive threat to the incumbent, centralized service model of electricity utilities.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

In this chapter, an explanation of research design, area of study, population of study, sample and sampling technique, instrument for data collection, validity of the instrument, administration of the instrument, method of data analysis and decision rule.

3.1 Research Design

Research design refers to the whole technique for the study, from recognizing the problem to discover the designs for data collection. For this study a survey design was used because; it uses a structure to seek for the perspective on the respondent on the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State.

3.2 Area of Study

The study was conducted among the residential building owners and small and medium scale enterprises in Minna metropolis which consist of Bosso local government and Chanchaga local government, Niger state.

3.3 Population of the Study

The target populations for the study are professionals in the small and medium scale enterprises and the residential house owners. This research will comprise of 90 respondents both the solar energy installer and the customers.

3.4 Sampling and Sampling Techniques

A random sampling will be adopted for this study which consists of all respondents in Minna Metropolis. It includes 30 small and medium scale enterprises and 60 residential house owners.

3.5 Instrument of Data Collection

The instrument for data collection is a well-designed questionnaire developed by the researcher for the purpose of this study. The questionnaire consists of two parts. Part A contains the information of the respondent and part B was divided two sections.

Section A; deal with most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State which consists of 10 items.

Section B deal with the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State which consist of 10 items.

Section C deal with the Identification of possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

3.6 Validation of Instrument

The instrument was validated by three lecturers in the Department of Industrial and Technology Education, Federal University of Technology, Minna. This validation will be done in other to check the instrument of the relevant items to be added and the items that are not relevant to be remove, their correction and suggestion will be reflected in the final copy of the instrument.

3.7 Administration of Instrument

The instrument used was administered through the researcher and assistance of two other personal that are specialized on the study. The instrument was administered to the respondent

that very moment and their response which is the data was collected and was analyzed, the administration and the collection of the questionnaire was conducted that same day, their response were collected immediately after they responded to the questionnaire or the instrument.

3.8 Method of Data Analysis

The data collected by the researcher will be analyzed using mean, standard deviation and z-test. The mean and standard deviation will be used for item for the research question while z-test will be to test the hypotheses formulated for the study.

The research instrument (questionnaire) will be rated using the following four point rating scale below.

Strongly agreed	(S.A)	4 points
Agreed	(A)	3 points
Disagreed	(D)	2 points
Strongly disagreed	(S.D)	1 point

3.9 Decision Rule

To determine the acceptance level, a mean score of 2.50 and above was chosen as decision point. Therefore, a mean score of the 2.50 and above will be accepted as a decision point for agreed, while below 2.49 will be considered disagreed.

For testing the hypotheses, any item that has the calculated t-value (t-cal) less than t-table value (t-crit) (±1.99) was accepted, while any item that has the calculated t-value (t-cal) equal or greater than z-table value (t-crit) was rejected.

CHAPTER FOUR

4. 0 RESULTS AND DISCUSSION

This chapter is devoted to the presentation, analysis and interpretation of the data collected in the course of this study. The data are based on the number of copies of the questionnaire completed and returned by the respondents. The data are presented in tables and the analysis is done using the z-test.

4.1 Research Question One

What are the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among small and medium scale enterprises and residential house owners in Minna metropolises, Niger State?

Table 4.1: Mean responses of solar energy small and medium scale enterprises on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

N1=20 N2=70

S/N	ITEMS	X_1	X_2	X_t	REMARK
1	Lack of knowledge about solar technologies	3.40	3.40	3.40	Agreed
2	Improper use and poor maintenance by the adopters	2.85	3.12	2.98	Agreed
3	Climate conditions and architectural constraints	3.35	2.99	3.33	Agreed
4	Inconsistence between policy measures.	2.90	3.38	3.14	Agreed
5	Low income and high income business strategies	3.40	2.96	3.18	Agreed
6	Inappropriate differentiation between rural and urban	2.10	3.02	2.56	Agreed
7	Lack of policy backing	3.66	3.35	3.25	Agreed
8	High cost of the solar PV modules and high installation.	3.25	3.14	3.20	Agreed
9	Maintenance and repair cost.	3.25	3.17	3.21	Agreed
10	Lack of national infrastructure.	2.90	3.29	3.09	Agreed
11.	Economic Barriers.	3.40	3.40	3.40	Agreed
12.	Socio-technical barriers	2.10	3.02	2.56	Agreed

Key: X1 mean of small and medium scale enterprises, X2=mean of residential house owners, N1= number of small and medium enterprises, N2= number of residential house owners, Xt= average of respondents.

The data presented in the table 1 above show that the mean values of all the items above the cut-off point of 2.50. These indicate that all the respondents agreed with items on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

4.2 Research Question Two

What are the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State?

Table 4.2: Mean responses of small and medium scale enterprises and residential house owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

N_1=20 N_2=70

S/N	ITEMS	X_1	X_2	X_t	REMARK
1	Cost of the power produced by solar over a period of time	3.35	3.21	3.28	Agreed
2	Maintenance costs.	2.90	2.99	2.94	Agreed
3	Intensity of solar radiation	2.90	3.00	2.95	Agreed
4	Required Land Space	3.15	3.21	3.18	Agreed
5	Insufficient transmission	3.25	3.26	3.25	Agreed
6	Unreliability.	3.45	3.21	3.33	Agreed
7	Costly, contain toxic materials and wear out rapidly.	2.90	3.11	3.01	Agreed
8	The Cost of the power produced by solar over a period of time more efficient a panel is; the more expensive it is to produce.	3.35	3.21	3.28	Agreed
9	Environmental issues.	3.20	3.10	3.15	Agreed
10	Photovoltaic efficiency is another obstacle.	3.15	3.11	3.13	Agreed
11.	Performance	3.45	3.27	3.36	Agreed
12.	Manufacturability	3.60	3.29	3.39	Agreed

Key: X1 mean of small and medium scale enterprise, X2=mean of residential house owners, N1= number of small and medium scale enterprises, N2= number of residential house owners, Xt= average of respondents.

The data presented in the table 2 above shows that the mean values of all the items above the cut-off point of 2.50. These indicate that all the respondents agreed with items on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

4.3 Research Question Three

Identity possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

Table 4.3: Mean responses of small and medium scale enterprises and residential house owners on possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

N1=20 N2=70

S/N	ITEMS	X_1	X_2	X_t	REMARK
1	Low-income carve out in community to solar legislation.	3.45	3.50	3.48	Agreed
2	Community development block grant.	3.45	3.27	3.36	Agreed
3	Bank funding.	3.15	3.29	3.22	Agreed
4	Adequate skilled personnel.	3.15	3.24	3.20	Agreed
5	Proper maintenance.	3.75	3.46	3.60	Agreed
6	Sufficient funds.	3.60	3.29	3.39	Agreed
7	Proper communication and policy making.	3.65	3.49	3.57	Agreed
8	Market strategy.	3.30	3.16	3.22	Agreed
9	Proper understanding of technical.	3.25	3.44	3.35	Agreed
10	Creating awareness.	3.15	3.11	3.13	Agreed
11.	Policy backing/long-term policies.	2.85	3.12	2.98	Agreed
12.	Creating communication mechanism to reach institutional policy makers for legal backings.	2.90	3.38	3.14	Agreed

Key: X1 mean of solar energy contractor, X2=mean of client, N1= number of small and medium scale enterprises, N2= number of residential house owners, Xt= average of respondents.

The data presented in the table 4 above shows that the mean values of all the items above the cut-off point of 2.50. These indicate that all the respondents agreed with items on possible solutions to the most common barriers and drivers preventing individuals from the adoption of

solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

4.4Hypothesis One

Ho1: There is no significance difference in the mean responses between small and medium scale enterprises and residential building owners on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

Table 4.4: The mean standard deviation and t-test analysis of the response of small and medium scale enterprises and residential building owners on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

S/N	ITEMS	X_1	X_2	SD_1	SD_2	t-cal	REMARK
1	Lack of knowledge about solar technologies	3.40	3.40	0.82	0.82	0.00	NS
2	Improper use and poor maintenance by the adopters	2.85	3.12	1.14	0.74	-1.04	NS
3	Climate conditions and architectural constraints	3.35	2.99	0.93	0.88	1.62	NS
4	Inconsistence between policy measures.	2.90	3.38	0.72	0.64	-2.73	S
5	Low income and high income business strategies	3.40	2.96	0.50	0.85	2.20	S
6	Inappropriate differentiation between rural and urban	2.10	3.02	1.12	0.99	-3.59	S
7	Lack of policy backing	3.66	3.35	1.02	0.61	-0.03	NS
8	High cost of the solar PV modules and high installation.	3.25	3.14	0.91	0.86	0.49	NS
9	Maintenance and repair cost.	3.25	3.17	1.02	0.87	0.34	NS
10	Lack of national infrastructure.	2.90	3.29	0.85	0.54	-2.44	S
11.	Economic Barriers.	3.40	3.40	0.82	0.82	0.00	NS
12.	Socio-technical Barriers.	2.10	3.02	1.12	0.99	-3.59	S

KEY: S.D1=Standard deviation of the small and medium scale enterprises, S.D=Standard deviation of the residential house owners, T-test= t-test calculated, S= significance difference, NS= No significance difference

The result of the analysis in the table 5 shows that items 1,2, 3, 7, 8, and 9 had their calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (±1.99), which implies that there is no significance difference in the mean response of clients and contractors on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, while item 4, 5, 6, and 10 had their calculated t-value (t-cal) obtained from the t-test analysis greater than the t-table value (±1.99), which implies that there is significance difference in between the mean response of clients and contractors on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential housse in Minna metropolises, Niger State. Because the ratio of those items with no significant difference is higher than the items with significance difference, therefore the null hypothesis is accepted.

4.5Hypothesis Two

Ho1: There is no significant difference in the mean responses between small and medium scale enterprises and residential building owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

Table 4.5: The mean standard deviation and t-test analysis of the response of small and medium scale enterprises and residential building owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

S/N	ITEMS	X_1	X_2	SD_1	SD_2	t-cal	REMARK
1	Cost of the power produced by solar over a period of time.	3.35	3.21	0.93	0.51	0.62	NS
2	Maintenance costs.	2.90	2.99	1.07	0.77	-0.40	NS
3	Intensity of solar radiation	2.90	3.00	1.07	0.83	-0.44	NS
4	Required Land Space	3.15	3.21	0.87	0.77	-0.32	NS
5	Insufficient transmission	3.25	3.26	0.91	0.79	-0.03	NS
6	Unreliability.	3.45	3.21	0.94	0.72	1.20	NS
7	Costly, contain toxic materials and wear out rapidly.	2.90	3.11	0.72	0.94	-0.94	NS
8	The more efficient a panel is, the more expensive it is to produce.	3.35	3.21	0.93	0.51	0.86	NS
9	Environmental issues.	3.20	3.10	0.89	0.88	0.62	NS
10	Photovoltaic efficiency is another obstacle.	3.15	3.11	0.99	0.79	0.17	NS
11.	Performance	3.45	3.27	0.95	0.61	0.8	NS
12.	Manufacturability.	2.90	3.38	0.72	0.64	-2.73	S

KEY: S.D1=Standard deviation of the small and medium scale enterprises, S.D=Standard deviation of the residential house owners, T-test= t-test calculated, S= significance difference, NS= No significance difference

The result of the analysis in the table 6 shows that the calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (t-crit) (±1.99), which implies that there is no significance difference in the mean response of clients and contractors on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house in Minna metropolises, Niger State, Therefore the null hypotheses are accepted.

4.6 Hypothesis Three

Ho1: There is no significance difference in the mean responses between small and medium scale enterprises and residential building owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

Table 4.6: The mean standard deviation and t-test analysis of the response of small and medium scale enterprises and residential building owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

S/N	ITEMS	X_1	X_2	SD_1	SD_2	t-cal	REMARK
1	Low-income carve out in community to solar legislation.	3.45	3.50	0.95	0.58	-0.23	NS
2	Community development block grant.	3.45	3.27	0.95	0.61	0.80	NS
3	Bank funding.	3.15	3.29	1.18	0.68	-0.49	NS
4	Adequate skilled personnel.	3.15	3.24	0.87	0.73	-0.48	NS
5	Proper maintenance.	3.75	3.46	0.44	0.58	2.42	S
6	Sufficient funds.	3.60	3.29	1.05	0.85	0.94	NS
7	Proper communication and policy making.	3.65	3.49	0.48	0.72	1.18	NS
8	Market strategy.	3.30	3.16	0.47	0.69	0.86	NS
9	Proper understanding of technical.	3.25	3.44	0.91	0.83	-0.90	NS
10	Creating awareness.	3.35	3.21	0.49	0.66	0.86	NS
11.	Policy backing/long-term policies.	2.85	3.12	1.14	0.74	-1.04	NS
12.	Creating communication mechanism to reach institutional policy makers for legal backings.	2.90	3.38	0.72	0.64	-2.73	S

KEY: S.D1=Standard deviation of the small and medium scale enterprises, S.D=Standard deviation of the residential house owners, T-test= t-test calculated, S= significance difference, NS= No significance difference

The result of the analysis in the table 7 shows that items 1, 2, 3, 4, 6, 7, 8, 9 and 10 had their calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (±1.99), which implies that there is no significance difference in the mean response of small and medium scale enterprise and residential house owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State, while item 5 had is calculated t-value (t-cal) obtained from the t-test analysis greater than the t-table value (±1.99), which implies that there is significance difference in between the mean response of small and medium scale enterprises and residential house owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State. Because the ratio of those items with no significant difference is higher than the items with significance difference, therefore the null hypothesis is accepted.

4.7 Findings of the Study

Based on the data collected and analyzed, the following findings emerged:

1. The most common barriers and drivers preventing individuals from the adoption of solar energy such as; Lack of knowledge about solar technologies, Improper use and poor maintenance by the adopters, Climate conditions and architectural constraints, High cost of the solar PV modules and high installation, Maintenance and repair cost, was moderately preventing the consumers by the respondents.
2. The challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems such as: Cost of the power produced by solar over a period of time,

Maintenance costs, Required Land Space, The Cost of the power produced by solar over a period of time more efficient a panel is, the more expensive it is to produce, was highly practices. The respondents moderately talked that the cost of solar PV can be costly, contain toxic materials and wear out rapidly due to frequent charging and discharging cycles.

3. Identify possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy such as: A sufficient fund, proper maintenance, market strategy, creating awareness, adequate skilled personnel was moderately practiced by the respondents.
4. There was no significance difference in the mean responses between small and medium scale enterprises and residential building owners on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
5. There was no significance difference in the mean responses between small and medium scale enterprises and residential building owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house in Minna metropolises, Niger State
6. There was no significance difference in the mean responses between small and medium enterprises and residential building owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State.

4.8 Discussion of Findings

The findings in Table 1 contained the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, the findings of the study reveal that the Lack of knowledge about solar technologies, improper use and poor maintenance, High cost of the solar PV modules and high installation by the adopters between client and contractors which means that contractors supply defective materials due to lack of knowledge about the solar PV and to execute the contract there should be a proper maintenance to manage a contract. According to (Harris &McCaffer, 2010;)it can be expressed as an exposure to economic loss or gain arising from involvement in the contract process. Therefore, there should be proper knowledge about the adoption of PV from client and contractors. Because it will aid the project move faster and be able to be delivered at the appointed time.

The findings in Table 2 contained the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, the findings of the study reveal that the Cost of the power produced by solar over a period of time is too much because of maintenance cost and the Cost of the power produced by solar over a period of time more efficient a panel is, the more expensive it is to produce.. The researcher observed that there in order to maintain solar PV there should be adequate fund to do that.

The findings in Table 3 contained the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, the findings of the study reveal that Contractors should develop a market strategies for marketing their product in order for residential building to adopt it. There are certain circumstances where there should be

awareness about adoption of solar energy among the building. Moreover, the researcher observed that contractor should be possessing adequate knowledge about the job.

Finding from hypothesis 1 it show that there is no significance difference in the mean responses between small and medium scale enterprises and residential building owners on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, the result of the analysis shows that items 1,2, 3, 7, 8, and 9 had their calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (±1.99), which implies that there is no significant difference in the mean response of clients and contractors on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, while item 4, 5, 6, and 10 had their calculated t-value (t-cal) obtained from the t-test analysis greater than the t-table value (±1.99), which implies that there is significant difference in between the mean response of clients and contractors on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State. Because the ratio of those items with no significant difference is higher than the items with significance difference, therefore, the null hypothesis is accepted. This affirms the study of (Yusuf, 2014) who analyzes the most barriers and drivers preventing the adoption of solar energy in Ghana, when he acknowledges that there are no there are no significant difference in the mean responses of electrical contractors and clients on the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house.

Finding from the hypothesis 2 it show that there is no significance difference in the mean responses of small and medium scale enterprises and residential house owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in

adopting of solar energy as an alternative power source among residential house in Minna metropolises, Niger State, the result of the analysis shows that the calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (t-crit) (±1.99), which implies that there is no significance difference in the mean response of small and medium scale enterprises and residential house owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State. Therefore the null hypotheses are accepted. This confirm the study of (Adwoa, 2015) who analyzes the risk management practices in Ghana, when he acknowledges that there are no there are no significance difference in the mean responses of small and medium scale enterprises and residential house owners on the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house.

Finding from the hypothesis 3 it show that there is no significance difference in the mean responses of small and medium scale enterprises and residential house owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State, the result of the analysis shows that items 1, 2, 3, 4, 6, 7, 8, 9 and 10 had their calculated t-value (t-cal) obtained from the t-test analysis less than the t-table value (±1.99), which implies that there is no significance difference in the mean response of small and medium scale enterprises and residential house owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State, while item 5 had is calculated t-value (t-cal) obtained from the t-test analysis greater than the t-table value (±1.99), which implies that there is significance difference in between the mean response of small and medium scale enterprises and residential house owners on the possible

solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State. Because the ratio of those items with no significance difference is higher than the items with significance difference, therefore the null hypothesis is accepted. This confirm the study of (Boadua, 2015) who analyzes the risk management practices in Ghana, when he accept that there are no there are no significance difference in the mean responses of small and medium scale enterprises and residential house owners on the possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Summary of the Study

The aim of the study is to explore strategies in overcoming barriers for the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State. The objective of the study was to find out the most barriers and drivers, the challenges faced by large-scale and small-scale suppliers, and to identity possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State. The statement of the problem, purpose, significance, and scope of the study, research question and hypotheses were well stated, tested and discussed appropriately in line with the topic. Related literatures were review under the following sub-headings; concept of renewable energy, solar energy, types of solar energy, common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house, challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house, related empirical studies and summary of literature reviewed.

The instrument used for data collection was the questionnaire. The questionnaire was administered to by the researcher to a total population of ninety (90) selected in Minna metropolis, Niger state. This consists of 30 small and medium scale enterprises and 60 residential house owners. In analyzing the data collected the research made use of mean, standard deviation, and t-test to determine the degree of agreement and disagreement, and acceptance or rejection as the case may be. Therefore, the research question and hypotheses were discussed based on the findings.

The finding revealed that it is evident that Nigeria in general and Minna to be precise have huge potential as far as the generation of clean energy is concerned. It is, however, disappointing to note that solar power which is the most the efficient and readily available resource is least utilized with most countries covered having below one percent solar generation. Due to those reasons; Lack of knowledge about solar technologies, improper use and poor maintenance, High cost of the solar PV modules and high installation by the adopters, Cost of the power produced by solar over a period of time is too much because of maintenance cost and the Cost of the power produced by solar over a period of time more efficient a panel is, the more expensive it is to produce and how contractors develop a market strategies for marketing their product in order for residential building to adopt it

5.2 Implication of the Study

The findings of this study have certain implication on electrical contractor, engineer, technicians, specialist or consultant, client, student on industrial training, apprentice and everyone who work in the electrical field. This studying has provided information on how to explore strategies in overcoming barriers for the adoption of solar energy. The researcher comes up with the implication of this study that;

Findings equally revealed that contractors and clients, if they don't have adequate knowledge about solar PV it will result to loss of capital and for proper maintenance there should be adequate fund. From the findings it also revealed that if contractors should come up with marketing strategies through proper awareness to make resident builder to adopt this new innovation.

5.3 Conclusions

Nigeria has not taken advantages of its potential in the renewable energy generation. Given the large amount of incident radiation, the country can greatly benefit if the necessary

resource are committed toward subsidized opportunity for socio economic development. It is, therefore, imperative upon the stake holders to put in place policies that will create an enabling environment for solar production. There be an institution to impact knowledge about solar PV it will result to loss of capital and for proper maintenance there should be adequate fund. From the findings it also revealed that if contractors should come up with marketing strategies through proper awareness.

5.4 Recommendations

1. As far as the improvement of solar energy adoption in Minna concerned, contractors should create an awareness of the adoption solar energy.
2. Government should also introduce in the country learning institutions courses on the handling of solar panels.
3. A special fund should also be put in place to subsidize the raw materials needed for the installation and production of solar PV.
4. Stakeholders should conduct continuous training programme with cooperation to advance managerial and financial practices to explain the adoption of solar energy among residential building owners.

5.5 Suggestion for Further Research

1. Strategies to improve adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
2. Assessment of worker toward adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
3. Benefits of adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

4. The Level of Awareness Electrical contractors on adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.
5. Factors affecting implementation of adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

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APPENDICES

ON

THE ADOPTION OF SOLAR ENRGY AS AN ALTERNATIVE POWER SOURCE AMONG RESIDENTIAL HOUSE IN MINNA METROPOLIS, NIGER STATE.

SECTION A

INTRODUCTION: Please complete this questionnaire faithfully as possible and sincerely tick

[✓] the column that best represents your perception about the above topic. The questionnaire for research purpose and your view will be treated confidentially.

PERSONAL DATA

Respondent

Small and medium scale enterprises [ ] Residential Building Owners [ ]

INTRODUCTION: A five point rating scale is used to indicate your opinion, tick the word which best describe your agreement as shown below.

1. Strongly agreed (S.A) 4 points
2. Agreed (A) 3 points
3. Disagreed (D) 2 points
4. Strongly disagreed (S.D) 1 point

SECTION B

1. What are the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential house in Minna metropolises, Niger State?

S/N	ITEMS	SA	A	D	SD
1	Lack of knowledge about solar technologies				
2	Improper use and poor maintenance by the adopters				
3	Climate conditions and architectural constraints				
4	Inconsistence between policy measures.				
5	Low income and high income business strategies.				
6	Inappropriate differentiation between rural and urban.				
7	Lack of policy backing.				
8	High cost of the solar PV modules and high installation.				
9	Maintenance and repair cost.				
10	Lack of national infrastructure.				
11	Economic Barriers.				
12	Socio-technical.				

2. What are the challenges faced by large-scale and small-scale suppliers of solar photovoltaic systems in adopting of solar energy as an alternative power source among residential house in Minna metropolises, Niger State?

S/N	ITEMS	SA	A	D	SD
1	Cost of the power produced by solar over a period of time				
2	Maintenance costs.				
3	Intensity of solar radiation				
4	Required Land Space				
5	Insufficient transmission				
6	Unreliability.				
7	Costly, contain toxic materials and wear out rapidly.				
8	The Cost of the power produced by solar over a period of time more efficient a panel is the more expensive it is to produce.				
9	Environmental issues.				
10	Photovoltaic efficiency is another obstacle.				
11	Performance.				
12	Manufacturability.				

3. Identity possible solutions to the most common barriers and drivers preventing individuals from the adoption of solar energy as an alternative power source among residential houses in Minna metropolises, Niger State.

S/N	ITEMS	SA	A	D	SD
1	Low-income carve out in community to solar legislation.				
2	Community development block grant.				
3	Bank funding.				
4	Adequate skilled personnel.				
5	Proper maintenance.				
6	Sufficient funds.				
7	Proper communication and policy making.				
8	Market strategy.				
9	Proper understanding of technical.				
10	Creating awareness.				
11	Policy backing/long-term policies.				
12	Creating communication mechanism to reach institutional policy makers for legal backings.				