Beuth University of
Applied Science

Master's Thesis

Analysis of Innovative Solar Financing Models And Possible Support Schemes For Distributed Generation/ Hybrid Power Plants In Nigeria

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Prepared for the degree of

MBA Renewables

Ankara, 2017

ACKNOWLEDGMENTS

This master's thesis project would not have been possible without the support of many people. Many thanks to my supervisor, Mr. Alexander Boensch who read my revisions and helped to make some sense out of the confusion, and RENAC team to let me cope with this study. Also thanks to my evaluator, Prof. Dr. rer. pol. Detlev Stock, who accepted evaluation, guidance and support for my master's thesis. Thanks to Beuth University for awarding me an MBA Renewables completion fellowship, and highly distinguished personnel; Silja Krösche, Caroline Weiland, Tina Büttner and others for providing me with the administrative means of support by heart to complete this project. And finally, thanks to my wife Özlem Muhtaroglu for her enduring patience and love, my son and daughter who always give me energy and enthusiasm throughout my study; thanks to my parents, my brother, my sister and numerous relatives and friends who helped for this long process being with me, always offering support.

DECLARATION

I, Ömer Muhtaroğlu, hereby declare on oath that this master's thesis is a presentation of my original research work and that it has not been submitted anywhere for any award. Wherever external contribution and other sources were implied, every attempt was made to emphasize this clearly by indicating references to the literature.

ANKARA 10,08,2017

Place, Date

Signature

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Abbreviations

AfDb	African Development Bank
BOT	Build Own Transfer
BPE	Bureau of Public Enterprises
CBN	Central Bank of Nigeria
CTF	Clean Technology Funds
DFI	Development Finance Institution
DISCO	Distribution Company
EASE	Energising Access to Sustainable Energy
ECA	Export Credit Agency
ECOWAS	Economic Community of West African States
EPA	Economic Partnership Agreement
EPSRA	Electric Power Sector Reform Act
FEC	Federal Executive Council
FGN	Federal Government of Nigeria
FIT	Feed-in-tariff
FMP	Federal Ministry of Power (Nigeria)
FX	Foreign Exchange
GENCO	Generation Company
GENSET	Generator Set
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HPS	High Pressure Sodium
IEA	International Energy Agency

IFC	**International Finance Corporation**
IFI	**International Finance Institution**
IPP	**Independent Power Plant / Independent Power Producer**
JV	**Joint Venture**
KWH	**Kilowatt hour**
LCOE	**Levelized Cost of Energy/Electricity**
LED	**Light Emitting Diode**
M2M	**Machine-to-machine**
MFB	**Micro Finance Banks**
MIGA	**Multilateral Investment Guarantee Agency**
MW	**Megawatt**
MYTO	**Multi Year Tariff Order**
NAPTIN	**National Power Training Institute of Nigeria**
NBET	**Nigeria Bulk Energy Trading**
NEMSF	**Nigeria Electricity Market Stabilization Facility**
NEPA	**National Electric Power Authority (Nigeria)**
NEPP	**National Electric Power Policy (Nigeria)**
NERC	**Nigerian Electricity Regulatory Commission**
NESI	**Nigerian Electricity Supply Industry**
NESP	**Nigerian Energy Support Program**
NIPC	**Nigerian Investment Promotion Commission**
NGN	**Nigerian Naira**
NPV	**Net Present Value**
NREEP	**National Renewable Energy and Energy Efficiency Policy (Nigeria)**
OPIC	**Overseas Private Investment Corporation (USA)**

PAYG Pay-As-You-Go

PHCN Power Holding Company of Nigeria

PPA Power Purchase Agreement

PPP Public Private Partnership

PRI Political Risk Insurance

PSRP Power Sector Recovery Program (Nigeria)

PV Photovoltaic

PWC Pricewaterhouse Coopers

RE Renewable Energy

REA Rural Electrification Agency (Nigeria)

REAN Renewable Energy Association of Nigeria

REF Rural Electrification Fund

REFIT Regulations on Feed-in Tariff

RESP Rural Electrification Strategy and Plan

SAS Stand Alone System

SHS Solar Home System

SME Small and Medium Scale Enterprise

SSA Sub-Saharan Africa

TCN Transmission Company of Nigeria

TWH Terawatt Hour

WAPP West African Power Pool

WB World Bank

Table of Content

1. Introduction

All around the world the price of solar PV system has significantly come down in the last ten years and there are a lot of ways to pay for a system in today's world. Among various available financing options there are certain methods to be analyzed with their structure and appropriateness to increase the access to energy in Nigeria. The Analysis of innovative solar financing models and possible support schemes for distributed generation/ hybrid power plants in Nigeria investigates the best finance models and possible support schemes for distributed generation and hybrid power plants in Nigeria. The study covers Nigerian energy sector from an electricity demand and supply perspective with off-grid rural electrification focus respective to the financial modelling and supportive structure review which includes a survey report to address the research question. The study does not cover technical considerations related to PV system siting, installation and connection to grid; nor does it deal with all local market considerations that may influence financing a system and/or approaches that can be studied state wise.

This study is structured as follows. First, the paper provides an explanation of the background information for this thesis subject (Section 1.1) and the methodology applied (Section 1.2). The report then explores the Nigeria country review on energy continued by Nigeria electricity supply industry and the design of the new energy market. Chapter 2 compares solar electricity and diesel power generation to clarify a combination of a solar-diesel-hybrid distributed generation system with these two resources. Chapter 3 looks at the topics of policy process, regulations and Incentives in energy sector of Nigeria. In chapter 4 and 5, the analysis of finance models is considered to highlight viability and applicability of solar-diesel-hybrid distributed generation system. In chapter 6 the research broadened with an interviewer administrated survey with random samples from Nigerian citizens to apply the public point of view to the financial formula with a realistic approach. Chapter 7 and 8 are designed in a manner to assess the results of the survey with impact measurement and suggest possible support schemes for solar-

diesel hybrid distributed generation in light of the survey results again. Chapter 9 is the final part to address the research question, research objective and research gap that have been filled with the conclusions of this study. The last part, chapter 10 is for literature regarding the referencing of the resources used. In this study Harvard referencing is used for in-text citation and also for the literature review which is primarily used by university students, to cite information sources (Cite This For Me, 2017).

1.1 Background

Access to Energy in Nigeria is a very crucial must for the development of a healthy future for the society. Nigeria is blessed with a variety of fossil fuels such as oil, natural gas and coal. However; these are certainly not promising a lot for public when it comes to the distribution of energy access to use it. Nigerian energy sector has faced serious challenges and still trying to adopt into an oil centered economy together with the diversification with hydropower, other renewables and coal. No matter oil and natural gas was found in this country, there is the staring problem of refining and making it usable. The country would like to grow its economy but this growth process doesn't necessarily be entitled to fossil fuels. Alternatively; solar irradiation levels prove that one of the most important energy resources is the solar PV energy with high irradiation levels.

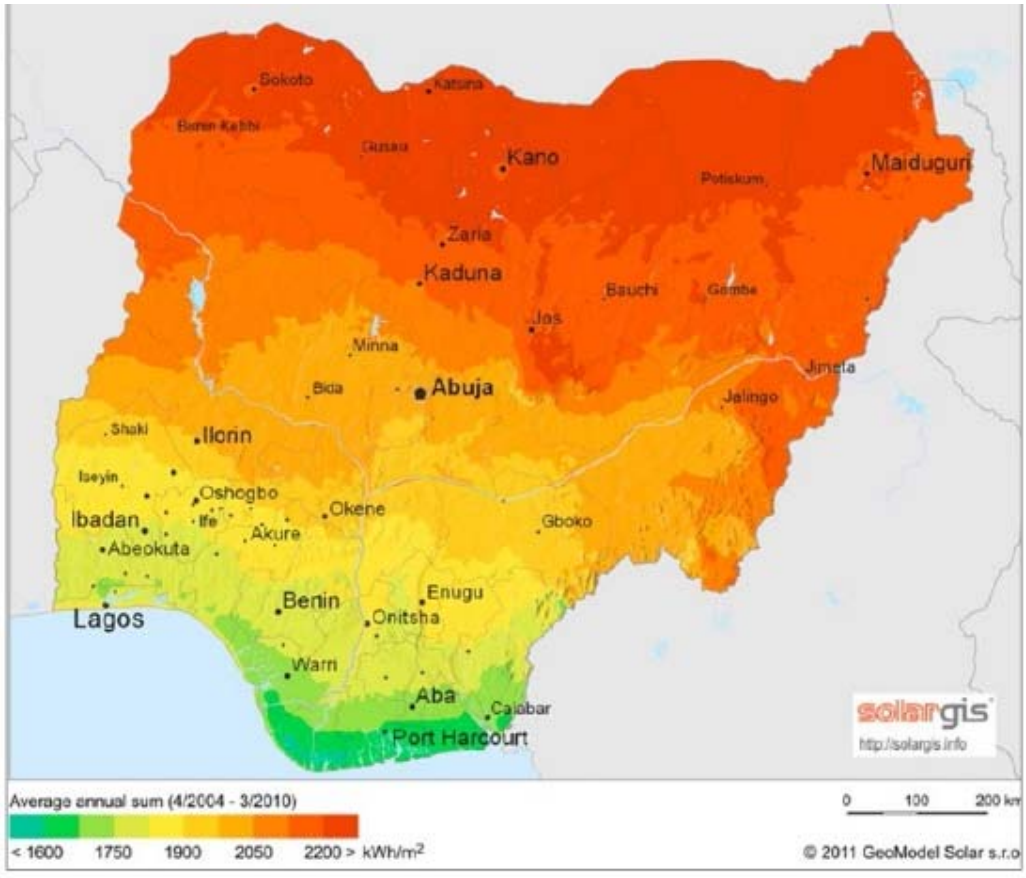

Figure.1 Solar Irradiation levels in Nigeria, GHI (Source: Solargis)

Nigeria has a potential for electricity production from Solar PV technology in the range of 207,000 GWh per year if theoretically only 1% of the land area (e.g. 920 km^2 = 920*106 m^2) were covered with state-of-the-art poly-crystalline PV modules, with an electricity yield of 1,500 Wh/Wp per year. This figure is tenfold the total electricity production of Nigeria in 2011 (GIZ; 2015, p.85). Specifically, the World Bank recommends in this context that off-grid solutions be developed using renewable energy sources, commenting that *"PV and hybrid systems are already economically competitive for many off-grid applications. Gasoline and diesel generators produce power at levelised cost of energy (LCOE) between US$ 0.23 and $0.42/kWh. The cost of electricity from PV and hybrid PV-wind diesel systems are in the range of $0.30/kWh and $0.22/kWh, respectively. As the costs of renewables continue down the learning curve, and fossil fuel prices in Nigeria revert to global market prices ("export parity"), the economic advantages of renewables will become ever greater" (GIZ, 2015, p.15).*

The existing literature research shows that the generation of electricity from solar resources has been dealt but those studied are mostly focusing on the technical side consisting the validation of the resource as reliable. However, besides availability of the solar resource, solar finance models do not have an in depth analysis; and not utilized with innovative solar finance methods to be analyzed with the support of the public and private opinion or surveys. Our study focuses to fill this gap with a public opinion survey on Access to Electricity in Nigeria from a financial point of view.

1.2 Methodology

In order to specify the research question of the "Analysis of Innovative Solar Financing Models and Possible Support Schemes for Distributed Generation/ Hybrid Power Plants in Nigeria" two research methods were followed. The first research method obtain data about research subject as a documentary analysis to cover each historical experience, background and the context of the topic that revealed by the documents in which they emerged. This method consists of data gathered from existing studies, newspaper articles, government databases, internet sources, surveys and financial tables, reports and institutional data. The clarification of a theoretical framework prepared by documentary analysis between chapter 1 and 5. Due to limitations such as lack of data or limitations to obtain broader up-to-date information that might affect the outcome of this study the research extended with a survey as a second method of support that help us to see which possible support schemes are suitable for public. The survey questionnaire design is exclusively based on and prepared for this study and prepared according to Harvard University program on survey research tips with questions as precise as possible to keep the respondents answer the questions that apply to them (Harrison; 2007). Most of the questions kept with single Yes/No answer to make sure the choices are unique and some of the questions are extended with anticipation of all possible answers to be made properly. The words chosen for the survey are simple and easily understood to avoid complex jargons and sentence misunderstanding (Bradburn et al, 2004; p283ff).

The survey on "Access to Electricity in Nigeria" with 23 questions are interviewer administered questionnaire survey with response rates and answer percentages recorded from the answers of 100 participants randomly selected on the streets of Nigeria with the help of the partners of Depar Energie GmbH. To obtain a good sampling and objective data, the respondents were picked randomly from various backgrounds and financial conditions that we use the collected data from a portion of a population and use this sampling statistics to generalize our findings. The survey was conducted between 5th of June to 25th of July in 4 geographical

locations; Lagos as the biggest metropolitan city, Abuja as the capital city of Nigeria; Anambra, Enugu, Port Harcourt, Delta and Imo States from southern regions and Kaduna, Kano from Northern states. These regions compose a mix of social, political and financial background nature in Nigeria as well as a mix of different solar irradiation levels and geographical conditions. Expectations are met with this way as target population to have an optimum sampling of the population in Nigeria. The aim of the survey is to analyze and understand the financial situation of public side and to compare to the governmental, institutional and private investor sides to contribute and fill the gap in our analysis of financial models of solar-diesel-hybrid distributed generation systems and possible support schemes. The secondary aim is to attract policy-makers' attention in solar-diesel-hybrid distributed generation systems, offering energy and infrastructure stakeholders an alternative scheme to support electrification in rural scale micro or mini-grid systems based on renewable energy hybridization. The research question was analyzed with 23 unique survey questions to collect both standardized and comparable data from 100 people and their characteristics. The questions in survey were picked carefully to have both qualitative and quantitative data set. The survey is tried to be well-suited for our research question to clearly point out what people think and how they react on our analysis seeking to measure parameters of Nigerian citizens on access to electricity in the country. The limitation for the survey is that some people do not reply their exact answer or they sometimes tend to change the answer because of their feelings. This is the nature of survey and we must rely on the existing data. The methodology of the survey is separately explained in detail in chapter 6 onwards.

The documentary analysis and survey research analysis then combined in a result to fill the research gap on the financial models that are used by government and institutions and which models can be configured better based on the survey results on Access to Electricity in Nigeria and particularly the solar finance models that can be applied for solar-diesel-hybrid distributed generation and to create possible support

schemes for the system. From government or institutions in charge of rural electrification planning, electrification funds or donor agencies, as well as private stakeholders, readers will find within the document valuable information for decision making when considering solar-diesel-hybrid systems from a financial perspective as well as a public point of view to address rural electrification needs.

1.3 Nigeria Country Review on Energy Sector

To incentivize the private-sector investment in the power sector, the government has privatized the generation and distribution sections in two waves. The proceeds are sensibly being dedicated to infrastructure expansion and, in the case of the second wave, a large part of the revenue has been planned for expansion of the country's hydropower plants. However, the process of privatization is still ongoing. At present, it is impossible to say with any certainty whether the independent power producers who now form the backbone of the Nigerian power sector will be commercially viable. As part of the process, however, the government has started to encourage investments in both renewable energy and energy efficiency. Nigeria is also part of the West African Power Pool (WAPP), a specialized institution of ECOWAS, Economic Community of West African States. The target of WAPP is to ensure regional power system integration and realization of a regional electricity market. It covers public and private generation, transmission and distribution companies (GIZ, 2015; p.28).

Past researches on the topic has identified that, yet another problem for Nigeria is the distribution of energy, namely the transmission of energy with High or Medium voltage electricity lines respective to the distance between fossil fuel power plant and the urban or rural places where energy is needed. It is now investigated that only some 35% of the rural Nigeria has electricity. This means every 65 people out of 100 in rural places doesn't have access to electric, light and very simple devices. There is a definite need of a more distributed energy and hybrid power

plants working for a better distributed energy generation and transmission, especially for rural electrification. According to a PricewaterhouseCoopers (PWC) survey report most people see local energy systems as developing alongside rather than replacing existing centralized generation. As it is depicted "whether the market vision is focused on centralized large-scale systems, nearly three-fifths (59%) of the survey participants expect new entrants to play a big part. These will include more independent power producers (IPPs) as traditional generation expands and a variety of entrants in the case of local systems and off-grid solutions'' (PWC, 2015; p.17).

One of the widest studies published by the Federal Government of Nigeria (FGN) is the "Power Sector Recovery Program" (PSRP) report which clearly states the challenges, action plan and pathway for the energy sector recovery in the country. As stated, the program is a series of carefully thought out policy actions, operational and financial interventions to be implemented by FGN to attain financial viability of the power sector and reset the Nigerian electricity supply industry (NESI). One of the key points of the program states that the power sector in Nigeria is in transition from government to private-sector owned and operated (PSRP; 2017; p7). Second key point is the sector shortfall with low tariff levels and due to the lack of tariff increase, the shortfall grows. Third key point to mention is that the national economy is losing $29.3 billion annually due to the lack of adequate power. These three key points among others are enough to state that there is a certain need for effective reforms and a good action plan (PSRP, 2017; p.8).

PSRP mentions that the power sector's reforms started with the publication of the national electric power policy in 2001, followed by the electric power sector reform act of 2005 (EPSR Act) that unbundled the National Electric Power Authority (NEPA) and created eighteen corporate entities, six Gencos (Generation Companies), eleven Discos (Distribution Companies) and TCN, Transmission Company of Nigeria. The report also mentions that amongst others, two key new institutions were established:

the Nigerian electricity regulatory commission (NERC, created in 2005) and Nigerian bulk electricity trading company (NBET, created in 2010) as the bulk electricity trader. The privatization of Discos and Gencos was completed in 2013 and TCN remained under the control of the Ministry of Power Nigeria (PSRP, 2017; p11). This organizational behavior was set in such a manner that the authorities saw the sector was in a state of emergency which could cause further deterioration in power supply and the failure of the PSRP, which will severely constrain the country's ability to revive growth and restore confidence for private investments. The Ministries of Power and Finance believe that urgent, deliberate and decisive actions are needed to get the sector back on track. The two ministries also acknowledge that most of the Gencos and Discos may essentially be insolvent (PSRP; 2017; p11).

The condition of the power sector in Nigeria face with serious challenges as key objectives are emphasized by PSRP as follows:

(I) To improve power supply reliability to meet growing demand;

(II) To strengthen the sector's institutional framework and increase transparency;

(III) To implement clear policies that promote and encourage investor confidence in the sector;
and

(IV) To establish a contract-based electricity market.
(See PSRP, 2017; p12)

Apart from the objectives the key deliverables are also among the titles of this program entitled as follows:

- Dimensioning accumulated deficit (2015, 2016) and future shortfall (2017-2021),
- Developing mechanisms for settlement of accumulated debt,
- Developing interventions to minimize subsidy going forward,
- Restoring energy sector financial viability,

- Ensuring Disco loss reductions,
- Identifying funding sources,
- Addressing infrastructure gaps,
- Addressing gas pipeline vandalism,
- Enabling electricity market business continuity,
- Developing a communications strategy for stakeholders.

The PSRP program unveils the efforts of FGN on energy sector. Similarly, according to Nigeria country fact sheet; "Power Africa" program of the US government, in association with Guarantco, partnered with Standard Chartered Bank to make critical lending available to the privatized Discos and Gencos for capital expenditures to reduce energy losses and improve operational efficiencies (Nigeria Fact Sheet, US Government, usaid.gov). This is yet another sign that there have been tremendous efforts by institutions as well to increase efficiency and access to energy but the recent condition of the power sector in the country shows that these efforts are not enough and new models has to be urged.

FGN see the most important solution to the shortfall as tariff increase, which might be inevitable. The interventions required to minimize subsidy going forward are also including aggressive loss reduction, transparency on revenues and costs, enforcement of market regulations and fully funded "Project Finance" approach. However; as the solar irradiation potential of the country is obvious, this research paper focuses on "renewable solutions and rural electrification with renewables" as the most promising intervention required to minimize subsidy going forward. Rural mini-grids and/or micro-grids can serve, with certain qualities and reliable technologies and systems such as solar-diesel-hybrid distributed generation, electrification to unserved and under-served areas that have high economic potential. The focus will be on solar-based micro or mini-grids which can be implemented quickly and later be integrated with Discos (PSRP, 2017; p.26). Addressing solar-diesel-hybrid distributed generation as the most influential tool for access to energy and rural electrification, this research intends to point out

policy process and financial schemes together with the public opinion as all these go together to bring a bottom-up solution in terms of both policy process and innovative solar financing models.

1.4 Nigeria Electricity Supply Industry (NESI)

The positive movement started right after the privatizations in 2013 and in a short period of time from being an investment destination, the Nigeria electricity supply industry (NESI) has fallen out of favor. The program reports that a bold turnaround plan is now required to utilize current assets and resources optimally, and to restore investor confidence in the sector, required to deliver the planned sector reforms. This is a loss of investment appetite for NESI (PSRP, 2017; p.20).

The Nigerian electricity regulatory commission (NERC) approved regulations regarding feed-in-tariffs for renewable energy sourced electricity. Electricity distribution companies are now required to source 50% of their supplied electricity from renewable energy sources. The legislation stresses the regulatory institutions' ambitions to reach the set targets within the next couple of years (Solarplaza, 2017; p.17ff). The power sector in Nigeria is seen by many analysts as the key constraint on economic development. Assessing the ease of getting electricity, the World Bank ranked Nigeria 187th of 189 countries in the 2015 edition of its "Doing Business" report. For a business in Lagos, to obtain permanent electricity connection takes 260 days (World Bank, 2014). Once connected to the electricity provider, Nigerian businesses' biggest reported problem is the erratic power supply. About 83% of all managers surveyed considered electricity outages to be a serious problem – more than any other constraint. Firms of all sizes, in all states and sectors, report average power outages equivalent to eight hours per day. The average firm claims outage related losses equivalent to more than 4% of sales. No peer country experiences such severe business losses related to the power supply (World Bank, 2011).

1.5 The Design of the New Energy Market

1.5.1 Barriers in Front of Support for Solar

Despite allowing IPPs since 2005, attractive renewables feed-in-tariffs (FiTs), several incentives and abundant sunshine (5.08 x 1012 kWh of energy per day from the sun), there has been limited interest by private investors in renewable energy technologies. Now, there are no utility-scale solar energy power plants in Nigeria and installed renewable capacity is less than 1 MW (excluding hydro). Specifically, to the deployment of Solar PV plants in Nigeria, private investors are required to overcome several barriers such as high development costs of a non-proven technology in the local market as well as higher first-mover costs. Furthermore, there are several country risk factors related to proper legal and regulatory frameworks. These barriers lead to prohibitive risk-return profiles for private investors. These barriers can be addressed in different ways depending on the timing of an intervention but may include providing concessional financing to subsidize development costs via the public sector at a pre-investment stage or directly through the private sector. Given the small share of development costs to the total investment needs of solar PV power plants, these projects may still require further concessionality to ensure commercial viability at tariff levels that are, on one side, reasonable to the off-taker, and on the other that allow to cover for capital expenditures, operational and maintenance costs, debt servicing and cash distribution to shareholders. To address value-chain issues, initiate pathways for public-private sector processes, and deploy market-based mechanisms to mitigate risks to attract private sector investors, ensuring the sustainability of the sector and this model of financing over time there has been studies by some institutions such as clean technology fund (CTF) investment plan (WB, 2104).

1.5.2 Energy Consumption by Sectors

With a share of about 78%, the residential sector accounts for most of the final energy consumption in Nigeria, followed by industrial use, whereby the latter only amounts to approx. 9%, followed by the rapidly expanding transport sector. (GIZ, 2015; p.28)

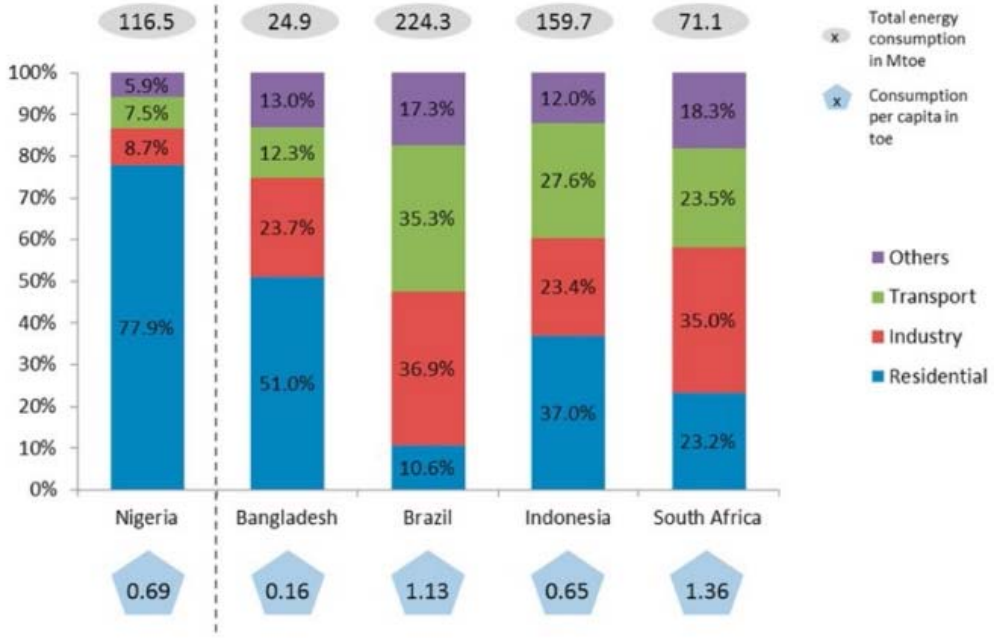

Figure.2 Total Energy Consumption by Economic Sectors (Source: IEA)

The country comparison on the figure reveals that in percentage terms energy consumption in Nigeria is skewed firmly towards the residential sector. All other countries show a much lower share of residential energy consumption. In addition, a shortfall in transportation infrastructure can be deducted. The country comparison also highlights the problems the Nigerian industry faces, as residential energy consumption outstrips that for industry by a factor of almost nine. Given the substantial proportion of the population that lives in rural areas, electricity generation to drive industrialization and rural electrification are both policy imperatives (GIZ, 2015; p.28).

Based on data from the International Energy Agency, residential usage accounts for almost 58% of the final electricity consumption in Nigeria. Likewise, it is the residential sector (households) where the increase over the ten-year period depicted in Figure 3 is most pronounced (GIZ, 2015; p.38).

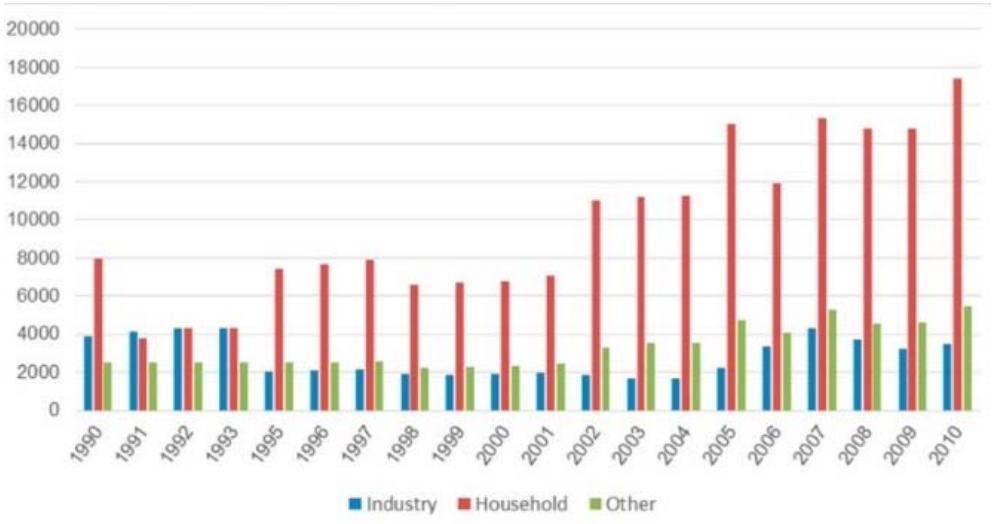

Figure.3 Nigerian Electricity Consumption (Million KWH) (Source: UN Stats)

1.5.3 The Overview of Electricity Demand

With a fast population and economic growth, electricity demand is generally expected to increase in the future. The World Bank's demand forecast is illustrated in Figure 4 (WB; 2013). Fifteen years by now it is projected to be increased by four times in comparison to today's demand. Figure 4 shows a strong increase in the yearly electricity demand, mainly driven by on-grid demand and from 2020 onwards – also from off-grid demand (blue area, no grid access).

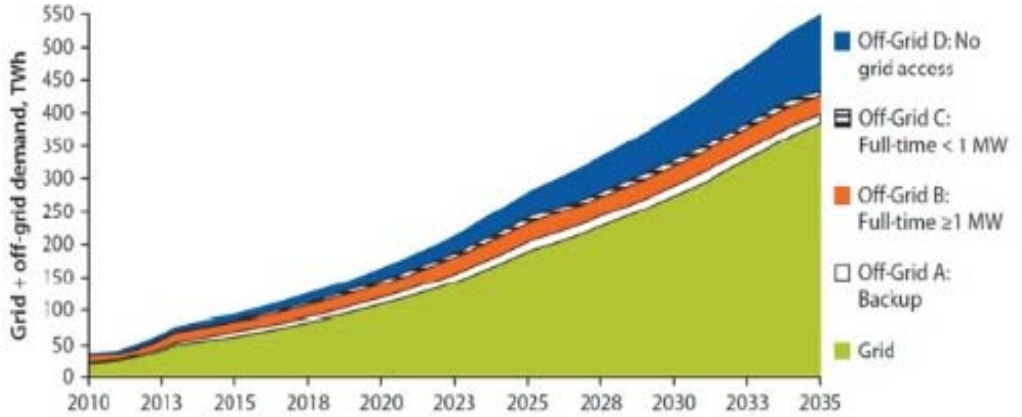

Figure.4 Projected Grid and Off-Grid Electricity Demand in TWH (Source: FMP and Power Holding Company; and UN 2010 Data)

According to the World Bank's projection, electricity demand is to grow by a factor of over 5 until 2035 up to almost 530TWh. This demand could be satisfied by generators with a capacity of ~63 GW, which would have to run throughout the year at maximum output level. Since 100% utilization of all power plants is unrealistic and transmission losses as well as peak power demand are not considered yet, even higher generation capacity is necessary for ensuring sufficient supply, if the World Bank's scenario holds true (GIZ, 2015; p.38ff).

1.5.4 Rural Electrification Facts in Nigeria

Nigeria's rural electrification program was launched back in the days in 1981 aimed to connect all local government headquarters and selected neighboring towns and villages to the national grid. The Federal Ministry of Power and Steel in collaboration with the Power Holding Company of Nigeria (PHCN) handled the rural electrification activities centered on grid extensions. They were substituted by the Rural Electrification Agency (REA), which was established in 2006 as part of the electric power sector reform act (EPSRA) (GIZ, 2015; p.51). Since 2013, REA's role is transitioning from centrally managed and government-funded projects, towards a demand-driven (yet still centrally coordinated) market approach. The REA does not have any regulatory mandate (GIZ, 2105; p.52).

The draft rural electrification strategy and plan prepared by the FMP (Federal Ministry of Power) clearly point outs targets for rural electrification on the part of the federal government: *"In the National Electric Power Policy and the more recent Rural Electrification Policy, the FGN has set an ambitious target: to make reliable electricity available to 75% and 90 % of the population (rural or urban) by 2020 and 2030 and at least 10% of renewable energy mix by 2025."* In order to gauge the plans for roll-out of rural electrification schemes, the magnitude of the challenge must be considered. At present, the FMP estimates that perhaps as many as 70,000,000 Nigerians in rural areas lack access to reliable electricity supply. The FMP puts this in the context of its overall electrification targets and suggests that *"only if by 2020 urban electrification reaches 95% and rural electrification reaches 60%"* will it prove possible to reach the national target of 75% electrification. It goes on to say that *"this will only happen by connecting more than 10,000,000 additional rural households. The new generating capacity required serving the additional domestic and non-domestic rural demand is around 6,000 MW. This is more than the current capacity of the entire Nigerian power system. Achieving this would take the rural electrification rate to 60%."* (GIZ, 2015) The electrification rate calculated by the World Bank for 2011 was 48.0%. The enormity of the task of rural electrification at hand is thus adequately described. Plans based on this will entail huge costs that would place strain on the national budget (GIZ, 2015; p.118).

Reasons for lack of electricity access and frequent blackouts in Nigeria are reported in the General Household Survey of 2010/2011. Over 60% of rural households sampled during the survey attributed the reason for a lack of electricity access to frequent blackouts and high connection cost. Unreliability of service was also reported as one of the reasons for lack of electricity in Nigeria (GIZ, 2015; p.41).

Region	Sub-Saharan Africa	Nigeria
Population without electricity	612 million	93 million
Overall Electrification rate (%)	32	45
Urban Electrification rate (%)	59	55
Rural Electrification Rate (%)	16	35

Table.1 Electrification Rates in Nigeria and Sub-Saharan Africa (Source: IEA, 2014).

According to the latest available data (Table.1) the overall electrification rate for Nigeria is just 45 % compared to 32 % average electrification rate in Sub-Saharan Africa. As further detailed this cannot disguise the fact that there is a sharp discrepancy between cities and rural areas, as the rate of urban electrification in Nigeria is 55 % as compared to only 35 % for rural electrification. Going forward the government plans to achieve an overall electrification rate of 75% by 2025, as emphasized in the "Vision 20:20" and the draft rural electrification strategy and plan (GIZ, 2015).

1.5.5 Rural Electrification Market in Nigeria

The process of rural electrification has long been a focus of Nigerian policymakers. However, the sheer scale of the undertaking and the attendant impact on budgets has prevented successive administrations from fielding decisive solutions to meet the target of electrifying 75% of the population with Vision 20:2020 as being the core stimulant which is a target vision plan set by FGN.

In general, this can be achieved by:

- Expanding the national electricity grid to rural areas,
- Using mini- or off-grid systems,
- Stand-alone systems like solar home systems (SHS).

The focus is on the latter two options. With the emergence of renewable energy sources, the opportunities to achieve rural

electrification using standalone and off-grid systems have improved markedly. For this reason alone, the sector is being revisited by the government, in line with its commitment to *"facilitate the extension of electricity services to all Nigerians, irrespective of where they live and work."* The electrification rate calculated by the World Bank for 2011 was 48.0%. According to UNESCO and IEA, the electrification rate in Nigeria in 2009 was 50.6%, while triangulation of available data suggests that total grid access to electricity hovers around 35 – 40 % (GIZ, 2015).

State of Residence	Have Electricity	No Electricity	Missing	Number of hh surveyed
North Central	**48.7**	**51.2**	**0.1**	**5,942**
FCT-Abuja	77.7	22.0	0.3	361
Benue	22.1	77.9	0.0	1,365
Kogi	62.9	37.1	0.0	876
Kwara	90.6	9.1	0.3	617
Nasarawa	33.2	66.5	0.3	550
Niger	51.7	48.2	0.1	1,504
Plateau	36.3	63.7	0.0	669
North East	**29.3**	**70.4**	**0.3**	**5,115**
Adamawa	37.4	62.2	0.7	726
Bauchi	29.3	70.3	0.4	932
Borno	33.0	66.5	0.5	1,560
Gombe	48.1	51.8	0.1	464
Taraba	10.9	88.8	0.3	634
Yobe	18.1	81.7	0.2	799
North West	**42.2**	**57.7**	**0.1**	**9,992**
Jigawa	26.0	74.0	0.0	1,152
Kaduna	53.5	46.2	0.3	1,915
Kano	52.1	47.9	0.0	2,606
Katsina	31.3	68.5	0.2	1,267
Kebbi	44.4	55.6	0.0	1,069
Sokoto	30.9	69.0	0.2	890
Zamfara	29.1	70.6	0.3	1,096
South East	**66.4**	**33.6**	**0.0**	**4,687**
Abia	81.7	18.3	0.0	644
Anambra	88.1	11.8	0.1	1,050
Ebonyi	39.2	60.7	0.1	970
Enugu	55.4	44.6	0.0	920
Imo	69.9	30.1	0.0	1,096
South South	**68.3**	**31.3**	**0.4**	**5,239**
Akwa Ibom	68.0	31.8	0.2	892
Bayelsa	52.5	47.3	0.2	322
Cross River	57.4	41.4	1.2	848
Delta	78.3	21.6	0.1	946
Edo	82.4	17.5	0.1	702
Rivers	66.1	34.5	0.4	1,529
South West	**81.1**	**18.8**	**0.1**	**7,546**
Ekiti	92.7	7.3	0.0	376
Lagos	99.3	0.5	0.2	2,240
Ogun	72.0	27.9	0.1	1,355
Ondo	66.3	33.7	0.0	920
Osun	89.4	10.6	0.0	853
Oyo	66.6	33.3	0.1	1,802
Total	**55.6**	**44.2**	**0.2**	**38,522**

Table.2 *Household Electrification Rate by Geopolitical Zone and Federal States in Nigeria (Source: NBS, 2014)*

The differing data show the difficulty to define and calculate the access rate, but the tendency is in the same range. However, it bares noting that many more households might be technically connected to the grid (state government officials regularly mention figures of 80% of grid coverage), which however don't receive or only get a very limited amount of electricity – hence it should be kept in mind that access to electricity and grid coverage are two different issues in Nigeria. However, data reflect the considerable extent of self-provision and backup generation of electricity in Nigeria; in form of large generators in industry and by many big commercial establishments. At the other end of the spectrum there are the ubiquitous small portable generators used by households and shops to supply electricity at very high unit cost. The extent of self-provision is a function of the sector's inefficient performance in delivery of affordable and reliable access. Table.2 displays the household electrification rate by geopolitical zone and federal states, whereby according to this data set (National Bureau of Statistics), the electrification rate sits at 55.6% (GIZ, 2015; p.118).

Reporting current off-grid capacity and generation is undoubtedly challenging. Even when generators of 1 MW or more must be registered with the Federal Ministry of Power (FMP) only limited actual data is available. There is an estimated installed capacity of 8 – 14 GW off-grid diesel and gasoline generators the majority of which is installed by individual people in urban areas to cover power outages from the national grid. Households in rural areas usually cannot afford to buy and operate gensets. For renewable energy sources, there is no difference in principle between the potential for rural projects than those for grid-connected utility-scale projects, other than the fact that economies of scale may make the rural projects more expensive. However, off-grid renewable energies are economically more interesting in case of remote areas with poor accessibility and hence high alternative fuel costs (GIZ, 2015). According to a research it is reported that solar energy had been neglected due to the availability of fossil fuels that were more affordable

and available (Nkpeebo, 2013; p.12). This situation will likely to change in very near future.

1.5.6 The Analysis of Off-Grid Electricity Prices in Nigeria

As per our study on rural electrification and distributed generation, it is better to have a focus on rural electrification prices and omit on-grid electricity to make our point clear. In the present set-up of the Nigerian electricity market, off-grid generation based on medium sized diesel gensets is by nature far more expensive for the consumer than on-grid supply of electricity. The World Bank estimates the cost for generation with medium-sized diesel gensets at approx. 250 US$/MWh (US$0.25/kWh). This is significantly higher than the electricity charges for residential usage and higher than electricity charges of US$ 0.124 – 0.185 /kWh for industrial usage, purchased from the Discos based on MYTO 2.1 (multi-year tariff order) (GIZ, 2015). Small scale businesses and families spend an average of NGN 3.5 trillion (US$ 21.8 billion) yearly to power their generating sets with diesel and petrol due to unstable supply of electricity (Vanguard, 2013).

2. Solar vs Diesel or Solar-Diesel-Hybrid in Nigeria?

2.1 Diesel Power Generation in Nigeria

According to a 2013 survey, approx. 80% of the Nigerians use alternate sources of electricity supply such as generators or solar inverters. Estimates suggest that between 8 and 14 GW of decentralized diesel generator capacity is currently installed in the country. About 86% of the companies in Nigeria own or share a generator and about 48% of their total electricity demand is covered by these private generators (GIZ, 2015). With several millions of privately installed diesel generators, Nigeria leads Africa as a generator importer and is one of the highest importers worldwide, with the total annual import figure being NGN 17.9 billion (US$ 112 million) (GIZ, 2015; p.36). The generator whether diesel or gasoline is seen as a life saver and respected a lot because of the lack of sufficient grid. This can be seen in Figure.5, an advertisement flag in

Lagos, Nigeria photoshoot by the author, in which a genset is offered to be given as a prize by union bank to its customers; genset is valuable and inside the lives of Nigerian people although they don't like the noise or refueling and maintenance and so on. Unfortunately, this prize is not a solar system yet, or a financial support for a solar system could have been an interesting prize by the same bank.

Figure.5 An advertisement flag on a pole in Lagos / Nigeria offering genset as a prize by union bank. (Photo taken personally in July 2017 by the author)

Within the Nigerian power system, captive generation offers some distinct advantages. First, industrial consumers can generate the power needed for their operations. Secondly, the request for a permit for captive generation involves the least hurdles in terms of financing and regulatory risks. And thirdly, captive generation represents the optimal use of electrical power, since there are theoretically no technical (transmission) or commercial losses to be dealt with. But there obviously are some major disadvantages. The use of decentralized diesel generators alone is economically and environmentally questionable (GIZ, 2015; p36).

Another disadvantage is that a permit for captive generation does not allow for supplying external off-takers. According to report, there is an excess of self-generation capacity in the manufacturing sector. Hence, trading between energy surplus and energy negative firms would be beneficial for both, but is coupled with the acquisition of an off-grid or embedded generator license and the management of associated regulatory issues. In this context, the acquisition of an embedded generator license seems more advantageous, since electricity can be evacuated through the existing distribution grid, which makes the acquisition of a distribution license needless. (GIZ, 2015; p36). Furthermore, embedded generation does not only offer advantages for industrial consumers, but also for states and local governments, which can achieve power supply aspirations within their borders without constitutional constraints. However, the propagation of embedded generation is impeded by missing liquidity of distribution companies, which hinders them to off-take power from potential embedded generators. (Detail, 2016)

2.2 On-Grid Solar Power Plants in Nigeria

In the field of utility-scale solar power projects, there is an array of solar farms that have just obtained licenses or are in the license pipeline. The total power of the projects to be studied are about 1200MWp installed capacity. They include a 100 MW facility in Bauchi State, one of 120 MW in Katsina State, and various others in Ekiti, Kaduna, and Nasarawa States.

The Ministry of Power has a 10 MW pilot wind plant in Katsina, which is scheduled for commissioning in the near future (GIZ, 2015; p36). The nationwide potential for large-scale renewable energy projects is huge, especially for solar PV. Each technology has its specific challenges and many projects are under development for implementation. Existing large-scale grid connected renewable energy projects mainly take the form of large hydropower plants. To date, no real commercial large-scale project has been successfully implemented, other than hydropower (GIZ, 2015; p.89).

The first official project to be implemented under a 20-year PPA is a 75MW solar plant in Katsina state, to be developed by EU/Nigerian utility scale investor and developer Pan Africa Solar, in collaboration with JCM Capital, an Ontario based developer. The signing of PPA with the FGN is a significant breakthrough for the project which has been under development since 2011 (Ola, 2016). However; the PPA is not a guaranteed paper to see the project to be implemented, commissioned and in operation under the circumstances of Nigeria. The point of on-grid solar projects related to this study is to see their viability from different perspectives. PPA model is the first method that has been adopted to Nigerian solar power sector in terms of finance. This model will be analyzed in coming chapters.

2.3 Off-Grid Solar Electric and Sustainable Energy Access in Nigeria

A standardized approach at national level to planning and promoting rural electrification is being supported. Five federal states are being supported to produce electrification plans and develop a data management system. The electrification of off-grid villages, social facilities and small businesses will demonstrate how renewable energy can contribute to providing electricity access to rural areas. (GIZ, 2016)

Compared to mini-grids, stand-alone systems (SASs) have gotten far less attention from local financial institutions. Nigerian-based commercial banks as well as international organizations have often found it more appealing to provide funding for relatively larger scale developments, such as mini-grids, or sometimes – to the dismay of decentralized power advocates – projects in the already quite saturated and inefficient on-grid space. In fact, the ever-growing level of support for the emerging mini-grid regulation, and the high level of anticipation regarding the release of the regulation continue to affirm the preference for mini-grids above SASs in various financial quarters (HBS Nigeria, 2017).

Quoting one senior finance executive, the head of energy sector investments at a leading commercial bank in the country, who commented on the investment outlook for rooftop solar and other stand-alone solutions in Nigeria, "the decision to or not to invest is really a matter of scale." To be able to access greater streams of finance, off-grid and decentralized renewable energy projects must be financially attractive, scale-wise (Ajao, 2011). Often times, the situation is that, developers approach banks with projects such as SASs, at a scale too small to make financial sense to a bank operating in hundreds of millions of naira – a challenge sometimes compounded by the bank's incompetence at de-risking RE projects. With this in mind, it becomes needful for developers to scale up the volume of projects for which they pursue funding (HBS Nigeria, 2017).

Granted, in a RE market like Nigeria's, it can often be difficult for off-grid entrepreneurs to have an ever-present huge stream of prospective customers for SASs. This weak demand for RE solutions for homes and businesses is also exacerbated by competition from fellow developers, thus creating a fragmented pool of projects here and there for which different developers seek funding; usually from different commercial banks who often turn down such requests for finance, because only little returns are envisaged. Truly, this situation of scale and project

fragmentation exposes a gap in a young and growing market. But it also reveals an opportunity for collaboration. If there is a need for greater access to finance the projects, developers and providers of micro- and small-sized (home, office or SME) solutions inevitably need to collaborate. Such collaboration would need to be done at a level higher than the market is currently witnessing, since several commercial banks have alluded to the problem of "scale". The HBS paper points out that this calls for a culture of aggregation in which dozens of smaller projects, especially those scattered within the same neighborhood or local community are aggregated and consolidated into one bigger project in an investment pitch to a given local financier – rather than multiple, fragmented projects pitched separately to different banks (HBS Nigeria, 2017). This perspective can be a hint for a financial model for solar-diesel hybrid distributed generation within a neighborhood or a town to have micro grids with diesel support.

It is also on option stated by HBS Nigeria that at a time when the industry is seeing the formalization and institutionalization of the recently established Renewable Energy Association of Nigeria (REAN), to create an industry platform, on which more than one bit-sized projects – for which funding is required – may be registered by individual developers, and thereafter aggregated into a project of larger scale. This approach/model will not be void of initial challenges. Clearly, it would call for innovative and prudent allocation and disbursement of funds received; a binding legal mechanism for ascertaining that project terms are followed by all concerned developers as dictated by, or agreed with fund providers; as well as a well-thought-out framework for ensuring that debts and loans are paid back by all parties as at when due. With such aggregation platforms in place, competence on the part of project developers, convincing business cases, and providing that other conditions are met, access to loans and capital for standalone RE solutions promises to be less of a hassle in Nigeria (HBS Nigeria, 2017).

2.4 The Concept of Solar-Diesel Hybrid Power Generation

With decreasing Solar PV prices, Solar-diesel-hybrid mini-grids attract significant attention from institutions in charge of rural electrification and donor agencies - to mitigate fuel price increases, deliver operating cost reductions, and offer higher service quality than traditional single-source generation systems. The combining of technologies provides interesting opportunities to overcome certain technical limitations (IEA, 2013; p.4). The progressive electrification of areas not yet interconnected to the main electricity grid and too remote for grid extension has mainly been achieved through installation of decentralized generation units with diesel gensets and, to a lesser extent, via systems using a local renewable resource, such as solar PV stand-alone systems. Each of these two technologies has its own limitations: the diesel genset option suffers from increasing fuel prices, added cost for both fuel transportation to remote areas and for operation and maintenance in remote areas, as well as genset inefficiency when run at low load factors; meanwhile solar energy is an intermittent energy resource, which requires storage when not used during generation time (daylight hours) and implies a high upfront investment cost but low operating costs. Combining both technologies makes it possible to offset some of these limitations. For this reason, Solar-diesel genset hybrid-systems offer interesting opportunities and can be used productively within local mini-grids. However; important to mention about solar-diesel-hybrid systems is that the cost advantage becomes limited if there is relatively low diesel prices and low solar radiation; it is always good to seek the most viable cases for hybridization plant with the highest local diesel cost to site (distant areas) and relatively high solar radiation (FS-UNEP, 2016; p.18).

A hybrid generation system is a system combing two (or more) energy sources, operated jointly, including (but not necessarily) a storage unit and connected to a local AC distribution network (mini-grid). As Solar PV power output is DC and mini-grids operate in AC, at the heart of the hybrid system are the multifunctional inverter devices able to convert DC and AC

currents, control the generation and storage systems and set up the voltage and frequency of the mini-grid (Figure.5) (IEA, 2013; p7f).

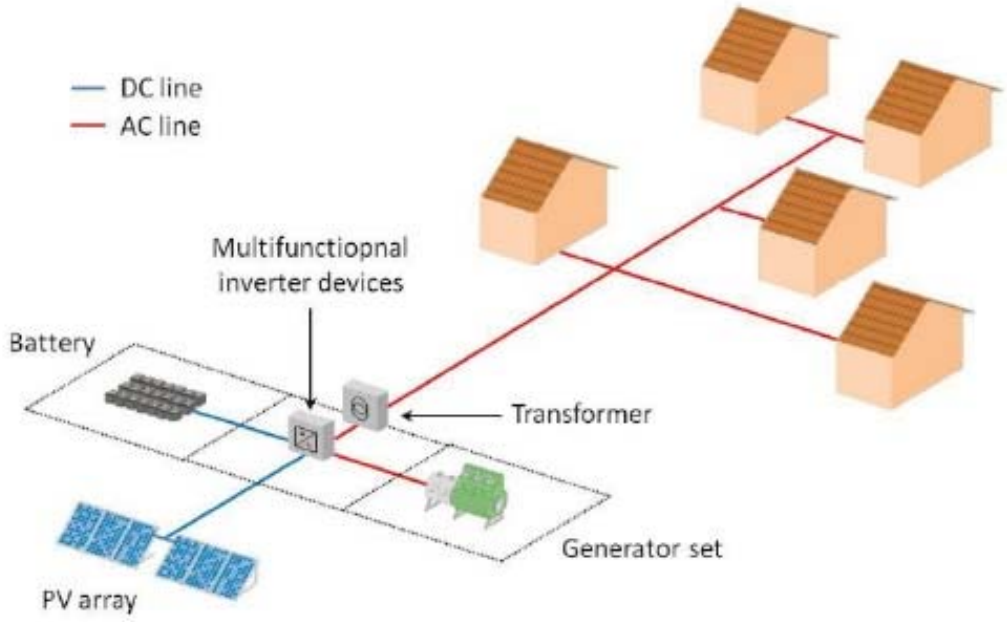

Figure.6 Schematic View of a Solar-Diesel-Hybrid System (Source: Report IEA-PVPS T9-13:2013)

The future deployment of hybrid technology in developing countries will be driven by different factors according to the type of application addressed. The micro-hybrid system range for use as a reliable and cost-effective power source for telecom base stations continues to develop and expand. The development of small distributed hybrid generation systems for rural electrification to address the needs of remote communities will rely on the impetus given by institutions in charge of providing public services to rural customers. Capacity building and access to concessional financing will be the key enablers for the development of this segment. Medium-size distributed hybrid systems need political momentum to foster the involvement of the private sector. Larger isolated mini-grids require substantial investments and then appropriate profitability. The question of the extension of the grid to these places is critical. The private sector should play a decisive role as investor and supplier of turnkey

systems. Lessons from past projects show that, beyond problems related to the technology, many failures are due to inappropriate or unclear organizational schemes to operate and maintain the systems and to the lack of appropriate energy management concepts**.** The main observed causes of weakness in the systems are: poor understanding of users and unplanned increases in the load, inadequate revenue, unavailable after-sales service, and unsuitable ownership models (IEA; 2013; p4ff). A technical phenomenon about renewable energy sources is that these sources tend to fluctuate during operation, produce intermittent electrical energy that is not compatible with current electrical grid systems. Consequently, people who want to use intermittent, fluctuating or alternately ceasing and beginning again from time to time, renewable energy power produced by solar power systems must have power consumption schemes that can automatically control their electrical loads (Gevorkian, 2007; p308). At this point, it is important to mention that solar-diesel-hybrid technology is capable of this automatic control by technology, by means of synchronizing electronic units the arming and disarming with power outputs done continuously. In developed countries and in places which already started smart grids, setting lower electrical utility tariffs for peak solar power output periods and higher tariffs for conventional electrical power, consumers are encouraged to schedule their power consumption (Gevorkian, 2007; p308). Solar-diesel-hybrid system is already capable of choosing or setting the primary energy source to be whether solar, diesel genset or utility grid; according to user setting or time interval. This study is intended to show for advantages or disadvantages of the systems but it is good to mention as this synchronized structure can be also set according to financial table; i.e. if one couldn't pay for solar-diesel-hybrid system he/she still could be able to get the grid power and the system must be as smart as possible to a lot of options and settings for various cases.

2.5 Financial Cost Analysis & Justification of Solar-Diesel-Hybrid Systems

As worldwide researches on financial cost analysis show, the hybridizing Solar and diesel generator makes an economically efficient power generating system for residential consumption. The hybrid system reduces the high capital cost associated with PV panels and reduces the high fuel cost, operation and maintenance costs associated with diesel generator. The use of diesel generator reduces the number of modules needed for the PV array, while at the same time the operation hours of the diesel generator is drastically reduced because of high contribution of the PV array to power generation. From the optimization done by Ogajelu et. al., it is reported that system with 20 modules supplies the power needs at minimum cost, with the PV array generating 89.2% of the total power demand and the diesel generator producing 10.8% of the electricity demand.

The economic analysis shows that the solar-diesel-hybrid system has the least life cycle cost and cost of energy out of the three power systems considered. When the net present value of the hybrid system is compared with that of PV stand-alone system, with the diesel stand-alone system as the base case, it is also shown that the hybrid system has a higher NPV than PV stand-alone system. The hybrid system has an internal rate of return of 26.3% while the PV stand-alone system has an internal rate of return of 24.6%. Apart from the economic gains made, the hybrid system is also environmentally friendly because of the reduced emission of greenhouse gasses and other pollutants associated with diesel. The environmental impact will be mentioned separately later in this study. It is also important to state that the hybrid system will help in extending the lifetime of the non-renewable energy sources (Ogajelu et.al, 2013; p29).

3. The Policy Process and Diversification of Economy in Energy Sector of Nigeria

3.1 Energy Policy in Nigeria

3.1.1 Energy Policy Regulations

The energy policy of Nigeria mainly encompasses the development and regulation of the petroleum and electricity industry. Both sectors were characterized by large government agencies that were responsible for a large part of the activities but have undergone significant changes in recent years. These sector and market modifications are mainly driven by a constant move towards privatization and liberalization. The policies governing the electricity market and corresponding regulations have undergone significant changes in the last two decades. The main focus has been the drive from a monolithic, vertically integrated organization under the roof of the state-owned utility National Electric Power Authority (NEPA) toward a multi-actor landscape in a liberalized and privatized market. In the late 1990's the population and the economy both grew rapidly while NEPA failed to keep pace with this demand increase by adding more generation capacity and expanding the electricity system. This development led into an energy supply crisis in 2001. In reaction to the situation, in 2001 the Federal Executive Council (FEC) issued the National electric power policy (NEPP), aimed at fundamental changes of ownership, control and regulation of the power sector. This and subsequent policies as well as legislative changes focused on privatization and liberalization of the electricity sector (GIZ, 2015).

3.1.2 Incentives in Renewable Energy

A good number of policies have been in place in Nigeria for renewables, however they have been largely ineffective. Also, there were various gaps and overlaps in many of the policies (Detail, 2016). From a financial perspective, the most important incentives that the Ministry of Power to apply according to NREEP, National Renewable Energy and Energy Efficiency Policy, are as follows;

1. Free Custom Duties for two (2) years on the importation of equipment and materials used in renewables and energy efficiency projects;
2. Allows for project developers to obtain soft loans and special low interest loans from the Renewable Electricity Fund for renewable energy supply and energy efficiency projects;
3. Advocates for the Government to ensure that an appropriate economic instrument is put in place to allow generators of renewables to obtain preferred pricing and rates as they sell;
4. Tax incentives to manufacturers of renewable energy and energy efficient equipment and their accessories. Incentives include: (i) five-year tax holiday for manufacturers from date of commencement of manufacturing; (ii) five-year tax holiday on dividend incomes from investments on domestic renewable energy source;
5. Government is to assist in allocation or grant of land to manufacturers of energy efficient products and renewables projects.

(Detail; 2016)

3.1.3 Tariff for Renewable Energy Sourced Electricity in Nigeria (REFIT Regulations)

Feed in Tariffs (FITs) are generally applicable to solar power generation (as with other renewables). FITs refer to a minimum guaranteed price per unit of produced electricity to be paid to the renewable power producer or as a premium in addition to general market electricity prices. FITs are designed to enable the producers sell their power to the grid at considerably higher prices than the tariffs obtainable for other power generation sources such as thermal generation. Inducements implied in FITs include (a) guaranteed market; (b) priority grid connection and off-take; (c) facilitated land acquisition process; (d) concessionary tariff rates and (e) simplified licensing/permit process (Detail, 2016).

The tariff structure for solar power generation (as with other renewables) in Nigeria was originally provided for as FITs under the multi-

year tariff order 2 (effective between June 2012 and March 2015). However, MYTO 2.1, (MTYO 2 amended) and the recently reviewed MYTO 2015 did not make provisions for FITs. Notably, NERC has recently issued a regulation on feed in tariff for renewable energy sourced electricity in Nigeria (REFIT regulations) passed in December 2015, which provides for the tariff framework for renewables. The salient highlights of the REFIT regulations are considered below (Detail, 2016):

i. The REFIT regulations set a target generation output cap from renewable sources at 2000MW by 2020. The distribution companies (Discos) and Nigerian bulk electricity trading plc (NBET) are obligated to purchase the power on a "must buy" basis, thereby providing priority grid access to renewables generators.

ii. Eligible renewable energy sources under the REFIT regulations are wind, small hydro, bio-mass and solar.

iii. Eligible renewable projects under the REFIT regulations are restricted to projects with a capacity between 1-30MW. Off-grid Renewable projects are also excluded from the ambit of the REFIT regulations. Notwithstanding the exclusion, the REFIT regulations mandate that NERC and the REA develop technical and operational modalities for off-grid projects.

iv. Power Purchase Agreements (PPAs) under the REFIT are structured to be for 20 years and payments are for energy delivered only.

v. Costs of shallow connections (i.e. installation of facilities required to deliver power at the connection point, excluding any grid upgrade beyond the common point of coupling) are to be borne by the project developers; however, off-takers can fund interconnections and recover the costs from developers. Costs of deep connections (i.e. reinforcement, extension or reconfiguration of the existing transmission network beyond the point of connection at higher voltage levels connecting the generating unit) are to be borne by the transmission service provider or Disco.

vi. The FITs may be reviewed every three years. However, the prevailing tariff at the time a PPA is signed with a renewables developer shall be

fixed for the term of such PPA and the tariff review would only be applicable to new projects.

vii. FITs applicable for solar projects for 2016 as indicated in Schedule 5 of REFIT regulation consists of capital cost $/MWh176.85; operations and maintenance $/MWh0.15, making a total of $/MWh177.00 per MWh (Detail, 2016).

The maximum capacity of solar renewables is 5MW under the REFIT regulations. This means solar generation projects outside this threshold would not come under the REFIT regulations. Furthermore, unsolicited bids for solar projects negotiated with NBET, as well as off-grid power projects, are excluded from the REFIT. Tariffs for projects not covered by the REFIT are generally to be agreed between the parties, subject to the approval of NERC (Detail, 2016). Rural electrification is coordinated at the federal level, whereby implementation is at the state level (GIZ, 2015; p.77). The policy process of Nigeria, after the review of the literature and reports, has obviously always been a top-down policy process; the government decides what to do and take the action over the public.

The prospects for solar power generation are quite high in Nigeria and are as follows:

(a) The REFIT regulations indicate that the government has set an on-grid target for solar renewable generation of 380MW by 2018. This means that there is a deliberate drive by the government to ramp up electricity generation from solar sources.

(b) Solar is a major energy resource in Nigeria from a geographical perspective. Analysts have projected that Nigeria could generate 600,000MW by deploying solar PV panels from just 1% of Nigeria's land mass.

(c) Given the high level of solar radiation in the northern part of Nigeria (about 5.0-7.0Kw.m^2/day), utilizing solar power generation in the northern part of the country has potential to steadily increase the power generation capacity in Nigeria.

(d) In light of (c) above, there are opportunities for solar power developers to partner with Discos to provide embedded power generation, particularly for the Discos in northern Nigeria.

(e) There is a ready market for solar power developers to operate in, in view of the huge demand for power supply; high population density; and the fact that solar power projects take less time to reach commercial operations compared to the conventional gas-fired generation. In terms of our natural and topographical features, the total land mass in Nigeria is estimated at 923.97 thousand square kilometers.

(f) The tariff structure for solar generation within and outside the REFIT regulations is currently higher than many African countries.

For example, the price of 11.5 cents per kWh recently agreed by NBET for large solar on-grid and off grid projects outside the REFIT regulations compares favorably against the current price of 0.14 cents per kWh in South Africa (based on the renewable energy IPP program), and 6 cents per kWh in Zambia (under the scaling solar power project). This should incentivize local and international investment in solar power projects in Nigeria.

(g) Both the federal and state governments are looking to partner with project developers under Public Private Partnership (PPP) structures for the provision of solar power generation. For example, a German company, Nova Solar power, recently agreed a partnership with Katsina State for the development of a 125MW solar plant under a PPP structure.

(h) The federal government plans to facilitate the promotion of rural electrification through both on-grid and off-grid power generation by the utilization of energy sources including solar energy.

There are many solar PV projects currently being contemplated in the on-grid and off-grid space. In the off-grid space, many homes and businesses are opting for solar stand-alone systems. Examples of non-individual off-grid solar projects either operational or in development are the Lagos State Government 5MW Lagos solar project (in collaboration with the UK Department for International Development) for electrification of public secondary schools and primary healthcare centers in Lagos State.

Also, the Bank of Industry recently commissioned a 24KW off-grid solar project located in Kaduna State. NBET has recently initialed solar PPAs with 14 developers which are reported to have the potential of adding about 1,125MW to the grid. The fact that there is now an NBET-agreed tariff for large solar on-grid generators outside the REFIT Regulations (11.5 cents per kWh), would encourage an influx of solar power generators willing to invest in the Nigerian electricity sector (Detail, 2016).

3.2 The Diversification of Economy through Energy Sector

The diversification of economy and growth of non-oil economy is among the targets of the macroeconomic outlook for 2017 by PSRP, Power Sector Recovery Program, a report published by Federal Government of Nigeria. The reason to this has been identified as the growth model of Nigeria is dependent to a consumption based growth model fueled by oil revenues; but the dramatically drop-down of oil prices has never been predicted (PSRP, 2017; p.14). The electricity concern has been disregarded with a poorly diversified energy mix where the majority (85%) of installed capacity is fueled by gas. Investment in the publicly-owned power sector seriously diminished by the early 90s, with maintenance budgets greatly reduced and no new capacity added, which contributed to keep the lag of Nigeria far behind other developing nations in terms of electricity consumption with supply-demand imbalances (PSRP, 2017; p.15). Granting preferential tariffs is pivotal to achieving diversification in the electricity mix of the country. However, in line with the "Regulations on the Procurement of New Generation Capacities", the support mechanism of the Feed-in Tariff (FIT) system is likely to change to a competitive bidding system for large-scale renewable energy. (GIZ, 2015; p.92)

In today's world, it is anticipated by the PWC conducted "Africa Power & Utilities Sector Survey" that within the next decade step-change milestones will be reached such as grid parity of solar distributed

generation, lower cost of hybrid systems and mass scale storage solutions, vibrant and secure micro-grids. The acceleration of local energy systems and more technological solutions will serve the grid much more efficiently (PWC, 2015; p.17). Besides, the solutions to energy problems always need a good finance model prior to the solution providing process. On the other hand; projects and public & private cooperation's need differentiated good support schemes to realize the energy supply with the least burden.

4. The Restoration of Financial Viability in Energy Sector of Nigeria

4.1 The Restoration of Stability to Reach Financial Viability

The FGN formulizes numerous stability concerns to restore financial viability in energy sector of Nigeria and these are enlisted with extensive focus clarification on PSRP, Power Sector Recovery Program. The issues to follow are;

- The completion of disbursement of the balance of Nigerian Electricity Market Stabilization Facility (NEMSF) to the respective gas suppliers, generation companies and distribution companies.
- The efforts to implement of N701bn payment assurance program with CBN created for NBET (Nigerian bulk electricity trading) to pay future bills.
- To pay accrued market shortfall accumulated in the year 2015-2016 attributable to the non-cost reflective tariff, FX shock and low energy levels.
- To ensure that distribution companies that perform below the agreed loss levels at the time handover as approved by NERC in 2014, be held accountable for the inefficiency.
- To ensure board approvals for the power sector government agencies are completed to ensure adequate corporate governance.
- To ensure a transparent and effective regulatory framework.

- To provide a regulatory environment that is sufficiently flexible to into account new technological developments and the international trends in the power sector.

All these terms stated by PSRP report is mentioned here to identify the level of seriousness of the energy sector handicap in Nigeria evident by literature and government reports. Financial stress and policy framework regulatory complexity are the most serious problems from a macro point of view (PSRP, 2017).

4.2 How to Attain Viability?

The report also attaches five terms to attain viability. These are;

1- To develop and implement a cost-effective tariff for the Nigerian Electricity Market.
2- To implement a short – medium term government support that reduces rate shock to consumers, which will improve ATC & C losses.
3- To ensure that distribution companies implement the agreed loss reductions targets as stated in the performance agreements.
4- To recruit a technically competent individual on the board of each of the distribution companies to represent BPE.
5- To ensure that Nigerian Bulk Electricity Trading is adequately capitalized to meet its obligations as a credit worthy off-taker. (PSRP, 2017; p.31)

Although Nigeria is among top 10 fastest growing economies in the world between 2000 and 2010, this growth does not necessarily reflect the development challenges that the country has been facing in terms of infrastructure (The Economist; 2011). One of the most important factors is the insufficient investment levels for energy and related sectors in the country as the attraction of new investors is the biggest barrier (MacLean and Olderman, 2015).

5. Analyzing Solar Finance Models for Distributed Generation and Hybrid Power Plants

5.1 Innovative Finance of Distributed Generation

Financing is among the most important factors of a project in Nigeria and it must be designed innovatively by considering the most influential models. As it is reported by MacLean and Olderman, '*Traditional sources for project funding, from government allocations to private investment by equity firms and corporate investors, have not been sufficient to meet the need for energy infrastructure development''*. According to Milken Institute Financial Innovations Lab Report, compounding the financing problem is among the historical difficulties of attracting new investors to Sub-Saharan Africa energy infrastructure projects (MacLean and Olderman, 2015). The configuration of a financing model should be open to customization because of the expected and unexpected factors and realities of the Nigerian case. Our analysis is undoubtfully considering the historical background, financial situation and cultural and national situations which we have reviewed so far in previous chapters.

One of the first issues to mention is the complementing domestic government allocations, multi and bilateral organizations and development finance institutions (DFIs) like the Multilateral Investment Guarantee Agency (MIGA), the Overseas Private Investment Corporation (OPIC), the International Finance Corporation (IFC), the World Bank, the African Development Bank provide financing for energy infrastructure projects. These organizations play significant roles in attracting private-sector investment, as well. Since DFIs have a long track record in funding projects that both encourage sustainable development and allow for economic returns on investment, they are persuasive and compelling partners for traditional financiers. They can offer tools that play a crucial role in risk mitigation in an area where political and economic instability may be viewed as undue hazards (Maclean and Olderman, 2015).

Mechanism	Direct public financing or guarantee?	Debt or equity?	Risk level	Mitigates which risks?
Political risk insurance	Guarantee	Mix	Medium	Currency inconvertibility, expropriation, regulatory, political violence
Credit enhancements	Guarantee	Debt	Medium	Commercial/default risks
Full credit wrap	Guarantee	Debt	High	Credit (covers entire debt load of project)
Sovereign guarantees	Guarantee	Mix	High	Contractual, failure to pay (provided by host government)
Partial risk guarantees	Guarantee	Debt	High	Political, sovereign, contractual (provided by DFIs regarding host governments)
Direct debt financing	Direct financing	Debt	Medium	Perceived credit and political risks by commercial banks
Forex liquidity facility	Direct financing	Debt	Low	Liquidity
Portfolio guarantees/first loss	Direct financing	Equity	High	Credit, political

Table.3 Financing Tools Analysis Table (Source: MacLean and Olderman, 2015)

DFIs utilize a variety of mechanisms, including loan guarantees, insurance, and subordinated equity, to mitigate risk and offer assurances to investors. OPIC and MIGA, for example, provide support to multiple energy projects in sub-Saharan Africa through loan guarantees and Political Risk Insurance (PRI). Other development institutions, including the Africa Development Bank (AfDB) and the International Finance Corporation, have also had success in providing financing options such as direct loans, credit enhancements, and first-loss funds. The IFC, a member of the World Bank Group, provides substantive debt and equity financing for infrastructure projects in Africa, and helps governments design public-private partnerships for infrastructure projects. Export Credit Agencies (ECAs) have also helped to bridge financing gaps, providing products like many DFIs, such as guarantees and insurance, through either a public agency, such as the U.S.'s Export-Import Bank, or a private company, such as Coface (MacLean and Olderman, 2015).

The Energizing Access to Sustainable Energy (EASE) in Nigeria program of European Union aims to improve framework conditions for renewable energy and energy efficiency for the use of renewable energies

by households and small and medium enterprises in particular. The program will be run in partnership with the World Bank (contributing €4.6 million) and the GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) (contributing €9 million). It includes the design of energy strategies to increase energy access and the development of business plans to demonstrate commercial viability of certain resources (EU, 2013; p1ff).

Another traditional source of funding has been project finance from commercial banks, although the liquidity requirements of Basel III and other market reforms have made non-recourse lending, typical for infrastructure finance, very difficult. Standard Bank, based in South Africa, provides financing for energy deals around the continent and is currently involved in projects to increase the supply of power generation in Ethiopia, Ghana, Namibia, Nigeria, Mozambique, Zambia, and Zimbabwe (MacLean and Olderman, 2015).

Other domestic and foreign commercial banks make substantial contributions to infrastructure projects as well, including Bank of America, which recently announced a US$10 billion "Catalytic Finance Initiative" aimed at addressing the lack of available renewable energy investments. The London-based Standard Chartered Bank recently agreed to double its funding to US$5 billion for USAID's Power Africa initiative, whose aim is to increase access to electricity. And Rand Merchant Bank (RMB), a holding company of FirstRand Bank Ltd. in South Africa, has facilitated US$11.31 billion in African infrastructure projects over the past two decades (MacLean and Olderman, 2015). According to the report it is also mentioned that Examples exist as well of successful non-bank, private-sector infrastructure investment. Some corporations and private equity funds have already begun to invest on the continent, with remarkable success. In August 2014, General Electric committed to a new investment of $2 billion in energy development over the next four years for projects to advance grid reliability in Algeria and Nigeria, and to fund

$1 billion in railway and power equipment in Angola (MacLean and Olderman, 2015).

5.2 The Projection of Renewable Energy Support Mechanisms and Tax Incentives

Independent Power Producers (IPPs) relying on renewable energy can expect to face the same difficulties as their larger conventional "sisters": The lack of coherence in the regulatory regime as will be outlined below in the discussion of PPAs. The key hurdles in the transition to a fully operational market are the guarantees NBET and by extension the DISCOs shall provide. In the absence of a firm metering system there are fears that DISCOs may not be able to recoup their costs, and thus they will find themselves unable to pay the IPPs the tariffs they have committed to. To date, only one privately-financed large gas thermal IPP has been finalized, with market players no doubt waiting to see how the interim market evolves. While power purchasing agreements for gas-fired power stations are a highly complex undertaking (especially given the difficulties of indexing of gas prices), this will not apply to renewable PPAs, where the feedstock is steady and has no price (GIZ, 2015; p.97).

With regards to financing opportunities, international Development Finance Institution's (DFI) financing is available to a certain extent for utility scale projects that meet the respective criteria as is indicated by some of the projects in the license approval pipeline. However, until now none of the utility-scale pipeline projects have secured DFI financing. Local semi-commercial finance institutions like The Bank of Industry and The Infrastructure Bank have expressed interest, however wish to act mainly as 'financial arrangers', meaning they will not provide debt. On the private financing side, various commercial banks have indicated a willingness to become involved in renewable energy financing. These may provide debt, but at 15% interest rate upwards, which makes the return on investment the project would need to generate too high (GIZ, 2015; p.97).

The Federal Government of Nigeria has put in place several investment incentives for the stimulation of private sector investment from within and outside the country. While some of these incentives cover all sectors, others are limited to some specific sectors. We have mentioned the incentives in renewable energy in chapter 3.1.2. The nature and application of these incentives have been considerably simplified. “Pioneer Projects” is also one of these incentive schemes (Bio, 2014). It grants tax holidays to qualified or (eligible) industries anywhere in the Federation and seven-year tax holiday in respect of industries located in economically disadvantaged local government area of the Federation (GIZ, 2015; p.98).

Now, there is a list of 71 approved industries declared as pioneer industries that can benefit from tax holiday. The Government encourages investors in the following industries related to renewable energy with tax holiday of 5 – 7 years, which may be granted to: companies that manufacture transformers, meters, control panels, switchgears, cable and other electrical related equipment, which are considered pioneer products/industries and manufacturers of solar-energy-powered equipment and appliances, biomass, large scale mechanized farming (wheat, maize, rice and sorghum) energy efficiency schemes, for manufacturers of oven, cookers, cold rooms, refrigerators, fridges, freezers, air conditioner, utility services (independent power generation utilizing gas, coal and renewable energy sources) (GIZ, 2015; p.98). In this respect; our survey on “Access to Electricity in Nigeria” shows the fact that more than 50% of the participants are agreed to work for government to pay their bills or to pay for their solar-diesel-hybrid distributed generation system. Therefore; it can be emphasized that the manufacturing industry for solar diesel hybrid system components can be combined with 5-7 years tax holiday together with non-paid voluntary workers that access to electricity and that create jobs for themselves. This issue will be analyzed with the public survey opinion facts on chapter-6 onwards.

The FGN has ongoing efforts on the (not yet operational) Rural Electrification Fund (REF), which so far is the only government-led structured funding mechanism. The incentives are designated to be infrastructure based (incentives to reduce the installation costs) and not electricity-production based (incentives to reduce the consumption costs). The REF will function as a "challenge fund", i.e. interested parties are expected to submit applications in consecutive rounds of competition, whereby projects will be selected according to a transparent set of criteria:

• Economic and financial viability, with the initial capital subsidy;
• Promotion of social and economic objectives;
• The choice of technology to be used
(e.g., preferential scoring of RE projects);
• Cost-effectiveness;
• Nature and extent of community support; and
• Investor commitment.

The REF will only "supply some proportion of the total funding so that other parties (distribution companies, local communities, business groups, etc.) would have to provide the rest". The sourcing for the funds consist in accordance to the EPSR Act 2005 of fines obtained by NERC, donations, gifts or loans made by international agencies, state governments, the federal government, local communities, businesses or any other entity. Finally, rural electrification developers, including the DISCOs, shall be engaged in a public private partnership by the REA (GIZ, 2015). Co-funding of individual projects with other sources of funds multiplies the benefits delivered by the REF. Co-funded projects are expected to be the most successful in competing for REF funding. The REF has initially been equipped with a seed funding of 2 billion Naira (around US$6M) by the Federal Government; however, pending the approval of the RESP, it has not been operationalized so far (GIZ, 2015; p.128).

The acceleration of the adoption of solar energy and distributed energy usage by means of equity/venture capitals depend on the federal government warranty. Moreover; it is a must to utilize from north to south

and east to west in wide Nigerian land. Several finance models to be constructed that apply various methods under the structural condition of Nigerian solar electricity modelling study. To improve and facilitate an innovative financial analysis, a mixture of world well know models are going to be analyzed and a unique Nigerian model can be created as an idea to entrepreneurship. The latter chapters are to analyze innovative finance models for solar-diesel hybrid distributed generation system from the perspective of citizens among Nigeria; with the contributions of our public opinion survey held in Nigeria which is called ‘‘Access to Electricity in Nigeria’’. The survey questions will point out; which innovative models seem to be more applicable from public perspective among models such as PPA, Solar Lease, Third Party Financing, Loan and Joint Venture, Pay-As-You-Go models or a combination of several of these models.

5.3 The Concept of Third Party Financing for Innovative Solar Financing Models

The Analysis of innovative solar financing models and possible support schemes for distributed generation/ hybrid power plants in Nigeria is an approach to funding the access to energy which targets positive social, environmental and financial impacts over the society. Solar-diesel-hybrid systems can be bought by public or private entities with their own budget or with a kind of fund raiser that can be also called as a solar financing lender. A solar financing lender might be a bank, a solar company, a credit union, a public-private partnership, a green bank, a foundation or a utility. These financial models let the people avoid high upfront costs and pay the cost in various schemes over a period. Development of finance solutions such as incorporated solar leases, public & private shared loans, pay-as-you-go model, joint-venture model and structured PPA for communities should be depicted with third party ownership finance solutions to suggest influential support schemes for distributed generation and hybrid power plants (Hausman, 2015; p.3).

5.4 Solar Power Purchase Agreement Model (PPA)

5.4.1 The Concept of PPA

One of the most suitable and influential mechanisms to secure the stakeholders of a renewable energy system is a power purchase agreement (PPA). In this model, an owner contracts with a project developer that design, install, own and operate a solar system on the owners site and obliged to provide all the electricity produced by the system to the owner at a fixed per-kilowatt-hour rate, almost always competitive in comparison to the utility price. PPA contractual terms may vary in payment models such as build-own-transfer (BOT) or a concession project for an independent power plant (IPP). The agreement is between the purchaser which is often the electric utility company or state and a privately-owned power producer. The power producer agrees to make available to the purchaser the contracted capacity of energy and deliver the energy in accordance with PPA (World Bank, 2017).

Another important concern is the private investment and the participation of certain big players in the sector. A PWC survey report depicts that “There is still a considerable way to go and investors do not feel there was sufficient certainty on government backing for power purchase agreements.” According to the survey “only six percent of the participants felt that the local commercial banking industry in Sub-Saharan Africa (SSA) had sufficient liquidity to finance new power projects without some form of credit enhancement being available.” (PWC, 2015; p.5)

5.4.2 Recent PPA Situation in Nigeria

Potential suppliers of electricity from renewable energies can apply to the NBET’s Unsolicited Power Program. If a project is approved, at maximum feed-in tariffs set by MYTO II are paid to the producer. The application under the NBET’s unsolicited power program follows six steps until a PPA is effective. Before negotiations between the applicant and NBET begin (step 1) a list of information needs to be provided, including

property and evacuation information on the project site, a complete environmental impact assessment as well as project, partner and license/permit information. In the steps 2 – 4 details on the PPA are negotiated, an application for a power generation license is initiated and information on the financial model as well as an energy yield report need to be presented. In step 5 the developer is required to initiate three tender processes for 1) engineering, procurement and construction, 2) long term services and 3) operation and maintenance. If both parties agree on the terms in the PPA, the tariffs and the tender processes are executed, the PPA can be enforced. The costs for studies and an estimated 18 months minimum to complete the process are an obstacle for companies pursuing renewable energy projects. Until 2016, no PPA has been concluded by NBET for either a small hydropower, a wind power, a solar PV or a concentrated solar power plant. This lack in experience on both sides, applicant as well as NBET, sets another hurdle to investors. In the absence of a PPA template, prospective investors do not yet know in what sort of a financing model they can be active under. Furthermore, the payment for electricity from renewable energies does not guarantee a positive environment for investments. The maximum feed-in tariffs are advantageous, even by international comparison. However, due to the high tariffs especially for solar power plants, NBET has never accepted the full PV tariff and also said it will not do so in future (GIZ, 2015; p.98).

In Nigeria, as it was mentioned before, the first and only official project that was awarded with a Solar PPA signature by Federal Government of Nigeria (FGN) is a 75MW solar plant in Katsina State in 2016. According to the given numbers announced in pv-tech.org website of the pv-tech magazine the project is worth US$146M and the plant will sell power at a fixed rate of US$11.5cents per kWh. The project is a breakthrough for FGN as Nigeria has stayed silent in solar energy up till this signature (Ola, 2016). All this PPA structure has been utilized by Power Africa, an initiative by US government which goes back to year 2013. The initiative supports the development of the energy sector through credits,

grants, technical assistance by US companies and the promotion of investment backed by US government (USAID, 2017). Although this first and only PPA has been structured and concluded; this does not necessarily mean that the solar power plant will be implemented on-time or on-budget. There are still a lot of unclear points such as grid integration, synchronization and grid reliability and handling the frequency and voltage fluctuations to support this power plant once commissioned.

5.5 Solar Lease Model as a Method (SL)

On a worldwide known basis a solar lease arrangement covers a contract between homeowner and the leasing company to pay scheduled and pre-determined monthly payments. The leasing company installs and owns the solar system on the homeowner's property. In Micro-grid case, this homeowner can be a group of homeowners in a community to be fed by the solar diesel micro-grid system. The system allows users to be energized by solar PV-Diesel hybrid system continuously throughout the day and their payments only differentiate proportionate to the diesel and O&M costs, as well as escalation payments over years. Major cost of the Solar PV system is fixed in long term leases. Under a solar lease arrangement, there is also possibility to pay regular utility rate for an electricity consumed beyond what the solar system generates, in this case the system is composed as hybrid Solar PV, Diesel and Utility grid (See Hausman, 2015; p.4f).

In solar lease model, it is important to specify on agreement that under which terms and conditions that the maintenance cost would be covered. Solar systems have maintenance and replacement issues and unlike other finance models the responsibility needs to be specified carefully. The solar lease may cover the maintenance but still may not cover the cost of replacing the aging equipment. The core benefit of solar lease is that the owner avoids upfront cost that can be quite high in solar diesel hybrid micro-grid systems. Another benefit is the transfer of operations and maintenance cost to the developer who supposedly have

more qualification and apply certain warranty terms. (See Hausman, 2015; p5).

5.6 Loan Financing, Shared Loans and Joint Venture (JV)

Solar Loans are the methods that allow customers to pay the system cost over time in instalments, however, in this model the owner of the system is the customer or homeowner. This direct ownership loan model can be created as loans to homeowners, or loans to communities and or local governments as a means of financial support scheme for solar diesel hybrid distributed generation systems. The products that are used in the system can also be a matter of loan and/or for instance components manufacturers such as solar panels can be offered as a product for these loans. The financial, cultural and traditional structure in Nigeria of course very important to create and generate, therefore, the model must be organized according to the feedback and /or desires and capabilities of the community besides to fundraising. As stated by Hausman, solar loans have the same basic structure as other kinds of loans and are being offered by an increasing number of lending institutions worldwide- from banks and credit unions to utilities, solar manufacturers, state green banks and financing programs, housing investment funds and utilities (Hausman, 2015; p.4).

According to Loan Pricing of Nigerian Microfinance Banks: Survey & Methods of Assessment report by Bernhardt et al., the introduction of the "Regulatory and Supervisory Guidelines for Microfinance Banks (MFBs) in Nigeria" of 2005 marked a change in the Nigerian microfinance landscape. Not only did it aim at bringing all financial institutions for low-income earners under a common regulatory framework, it also aimed at fostering a stronger profit and market orientation of the sector. At the same time, the regulatory body, Central Bank of Nigeria (CBN), mandates microfinance banks (MFBs) for poverty alleviation. These different overarching goals of operating financially sustainable and profitably on the one hand, while fostering social inclusion and alleviating poverty on the other is usually referred to as the double-bottom line of MFBs. In Nigeria,

there seems to be a general perception that the interest rates on microloans are very high. This is important as responsible pricing is a core determinant of the sectors' sustainability, growth and outreach. Yet there is virtually no knowledge on how expensive loans really are throughout the country and which factors are responsible for the charges (Bernhardt et al., 2105; p.4).

Another model to be analyzed is the joint venture model where companies and suppliers can jointly involve in the power plant from beginning to the end of its lifecycle. With this model under the Nigerian federal government warranty; a model that both sides own a distributed plant constructed and operation of the plant would be much easier with distributed local participation among the companies nationwide. Financial structure is also analyzed separately.

5.7 Pay-As-You-Go (PAYG)

5.7.1 PAYG System to Reach Rural Nigeria

Many startup energy enterprises are now leveraging digital finance —especially mobile payments — to deliver modern energy to the poor, sold on a pay-as-you-go (PAYG) basis. PAYG pricing holds the potential to disrupt the energy sector in many of the same ways it helped to fuel the growth of mobile communication in the developing world. The energy poor earn and spend money on inefficient energy alternatives such as kerosene in a similar manner — through small, User-defined increments as and when cash is available. Designed to be flexible, PAYG service could then fit well with the existing economic realities of the energy poor consumer (Winiecki and Kumar, 2014; p.3).

While the business model and customer offerings can vary widely among companies, PAYG solar approaches do share a few common elements. First, energy poor consumers are required to make a small down payment or deposit, typically 10–30 percent of the fully financed cost, to receive the solar product or to have it installed at their premises. Second, customers are required to prepay for the ability to use the solar product via mobile money or through a mobile-based energy credit model.

Technology within the product denies energy service if the customer's prepaid balance has been used or expires, enabling access again when the customer adds prepaid credit to their account. In some models, the customer pays off faster and ultimately owns the energy asset through a rent to-own or lease, while others deliver prepaid energy as an ongoing service, pushing the equipment financing upstream to the energy enterprise. In many ways, this end-customer transaction structure dictates other aspects of the PAYG solar business model, such as sales and distribution channels, after-sales service, and agent network requirements (Winiecki and Kumar, 2014; p.3). In the past five years, several converging trends have made it possible to combine PAYG pricing and innovative end-user financing to small-scale solar energy:

- The cost of solar panels, batteries, and light-emitting diodes (LEDs) has dropped significantly in the past five years, and research indicates these trends will continue. Solar panels today are about half the price they were in 2008 and are expected to reach a delivered price of less than $1 per watt in the next two years. IFC estimates that the average portable solar lighting product sold in 2020 will have twice the battery life, five times the brightness, and cost 33 percent less than similar products on the market in 2012.

- The small-scale solar product market has experienced dramatic growth in terms of units sold and new market entrants in the past five years. Since 2008, over 100 new companies have entered the portable solar lighting product market. In Africa alone, over 4 million solar lighting products were sold from 2009 to 2012, with annual sales growth at almost 100 percent per year. Significant advancements have been made in the past decade to improve the reliability and life of solar products and related appliances, increasing consumer trust in the product category in key markets. High-quality solar products targeting the energy poor today often boast a useful life of over three years with minimal maintenance (Winiecki and Kumar, 2014; p.3).

5.7.2 Use of Digital Payments by PAYG

PAYG solar solutions on the market today generally have three basic parts to how digital payments are used (a) end-customer payments are digitized, either via formal mobile money channels or, in the absence of mobile money, through proof-of-payment codes sent via SMS; (b) proprietary hardware is used to tie the usage of energy services to payments; and (c) software that processes digital payments and manages automated communication with products, end customers, and agents (Winiecki and Kumar, 2014; p.9).

(a) Digitizing payments at the end-customer

PAYG solar customers prepay for the ability to use the product through formal mobile money transfer channels, or digitized energy credits through a form of agent banking in markets where these options are not yet available. Mobile Money PAYG companies operating in East African countries overwhelmingly use existing mobile payment platforms to accept payments from end-customers (Angaza Design, Fenix International, M-KOPA, Mobisol,). These and many other PAYG companies have developed a software platform that integrates with mobile money platforms to receive payments, update customer accounts, and deliver proof of payment data that is transferred to the solar device to unlock for the prepaid usage, often via direct data or SMS messages. Some companies send proof of payment data directly to the solar devices over the cellular network to unlock services, and receive product performance and customer usage data from each unit. In Uganda, Fenix International sends an SMS, which includes a unique code that is then transferred to the solar device through a hand-held keypad, to the end-user upon receipt of a mobile payment (Winiecki and Kumar, 2014; p.9).

For some products, upon receipt of a mobile payment, the company's software initiates a voice call to the end-customer's registered mobile number, which the customer then holds next to the PAYG product to communicate proof-of-payment and usage authorization data via audio tones. It is also possible to deploy a version of the energy credit model

that uses a smartphone to process the proof-of-payment data transfer directly to portable solar lights. Under this model, customers can pay via mobile money or pay cash to an appointed agent who has a smartphone with an app from one of the PAYG providers. The agent can record cash payments via this app, which then communicates via the internet to the PAYG provider's software to update the customer's account. The smartphone can then communicate proof-of-payment to the portable solar light via a data cable or wirelessly via Bluetooth protocol. These forms of digitizing payments allow companies to sell PAYG solar products in markets that may not already have an active mobile money facility. However, the energy credit model often 12 requires PAYG companies to organize and manage a network of authorized agents in areas where customers live or work to collect cash and digitize payments via SMS or through a GSM connected device. For some companies, this model may also require issuing smartphones to authorized agents collecting cash payments and/or unlocking portable solar lights (Winiecki and Kumar, 2014; p.10f).

(b) On-network vs. off-network payment hardware on the backend

Once the proof-of-payment is transferred to the PAYG solar device, either through a direct message to the product's GSM chip, a unique numeric code entered by the customer using a keypad, or data transfer from an agent's smartphone, technology within the product regulates the usage. This is typically done by a circuit board within the solar device with software designed by the PAYG solar company to govern how and when electricity is sent from the battery to the end appliances, such as the lights and mobile phone charging port. If this product-embedded PAYG hardware does not receive a proof-of-payment message, electricity is not sent to the end appliances. PAYG hardware can be initially divided into two groups based on whether the solar device is directly connected to the cellular network. The specific PAYG technology approach is heavily influenced by the prevalence of mobile money services

among target customer segments and the likelihood of reliable cellular coverage in off-grid areas of the target market. If most off-grid consumers in a particular market do not have reliable cellular coverage, a PAYG company is likely to pursue an off-network approach. A company's research and development budget and the target cost of the energy asset also play a major role in this decision. Reliable GSM/M2M chips are currently more expensive on a per-unit basis than off-network hardware, though these prices continue to drop. For lower-cost products such as solar lanterns, it is not yet cost effective to add a GSM/M2M chip to allow for two-way communication via the cellular network (Winiecki and Kumar, 2014; p.12).

(c) PAYG as a Foundation

A model with the combination of flexible pricing and product-embedded hardware enable energy enterprises to directly extend a range of product financing and energy service options directly to end-customers. PAYG solar businesses can structure the transaction with end-customers as a product financing relationship, where the customer is paying off and ultimately owns the solar device, or energy-as-a-service, selling prepaid electricity on a use-basis. In many ways, this end customer transaction structure dictates other aspects of the PAYG solar business model in combination with; (a) Asset ownership vs. energy-as-service; and (b) Time-based versus usage-based pricing. Broadly speaking, PAYG solar companies deploy two types of end-customer transactions: rent to-own, where the end-customer ultimately owns the solar device through a series of usage payments; and energy delivered as a service, where the solar device remains as an asset owned by the PAYG company through the life-cycle of the customer relationship. More than half of PAYG solar companies offer a rent-to-own or lease transaction with end customers whereby ownership of the asset is ultimately transferred to the end-customer. Under this model, end-customers are required to make an initial payment in the form of a deposit or down payment, and pay off the remaining outstanding balance over time through prepaid usage. Legal ownership of the asset

typically lies with the PAYG company until the end-customer has completed the leasing term and "earns" the right to own the system—sometimes through a closing payment. In many markets, a solar product purchased over 12–36 months through a rent-to-own transaction can be the first time some customer segments achieve a formal payment history. This model offers consumers the opportunity to turn what was a perpetual expenditure—ongoing purchase of kerosene fuel and fees paid for mobile phone charging—into ownership of a clean energy asset that can deliver free energy once the product is paid off. The ownership aspect of rent-to-own models can be particularly attractive to end-consumers with a desire to add asset value to their home or business. For some consumers, the promise of ownership at the end of the payment term might be a strong incentive to better maintain the solar device, potentially leading to lower after-sales service costs for PAYG providers (Winiecki and Kumar, 2014; p.17).

6. Survey on the Access to Electricity in Nigeria

6.1 Combined Survey & Research Method

6.1.1 Survey & Research Methodology

Participants from public on the streets of Nigeria were surveyed with a questionnaire to fill, information is collected first by giving people verbal instructions and explanations about the background information, aim, objective and explanations about the survey. Afterwards people read the questions, record their answers and comment on the access to electricity issues they have in their country. The sampling of the survey kept irregular from various social and financial backgrounds from the public. The sampling frame is identified to have a mixture of various groups and the design of the questions address to have wider point of view. The participants are from backgrounds such as villagers, bankers, business people, engineers, shop owners and residents of from different backgrounds. The data is collected with a one-time survey to be filled out and finish to proceed with the evaluation of the statistical data. Most of

the questions kept with single Yes/No answer to make sure the choices are unique and some of the questions are extended with anticipation of all possible answers to be made properly. The words chosen for the survey are simple and easily understood to avoid complex jargons and sentence misunderstanding in the text (Bradburn et.al, 2004; p283ff). The survey questionnaire design and content is exclusively based on and prepared for this study and prepared according to several sources such as Harvard University program on survey research tips, University of Virginia Office of Process Simplification survey design guide and another guide called "Asking Questions" by Bradburn et al.; with questions as precise as possible to keep the respondents answer the questions that apply to them properly. Survey begin with a clear title and a purpose, continue with instructions and directions followed by effective open-ended, closed-ended and multiple-choice questions and end with a closing statement with thanks in a complimentary format (Harrison; 2007) (Collie and Rine, 2009) (Bradburn et.al, 2004).

The survey on "Access to Electricity in Nigeria" with 23 questions were individually conducted with 100 participants randomly selected on the streets of Nigeria with the help of the partners of Depar Energie GmbH. To obtain a good sampling and objective data, the respondents were picked randomly from various backgrounds and financial conditions. The survey was conducted between 5th of June to 25th of July in 4 geographical locations; Lagos the biggest metropolitan city, Abuja as the capital city of Nigeria; Anambra, Enugu, Port Harcourt, Delta and Imo States from southern regions and Kaduna, Kano from Northern states. These regions compose a mix of social, political and financial nature in Nigeria as well as a mix of different solar irradiation levels and geographical conditions. Expectations are met with this way as target population to have an optimum sampling of the population in Nigeria. The survey results, response rate and percentages to each question and multiple choices can be shortly reviewed in appendix 1, the number of questions left blank, unanswered or invalid are also mentioned in this

paper with details. Besides, an answered sample survey paper consist of 2 pages can be found in Appendix 2 and Appendix 3 as well.

The aim of the survey is to understand, compare the financial situation of public side to governmental, institutional and private investor sides to contribute and fill the gap in our analysis of financial models of solar-diesel-hybrid systems and possible support schemes. The research question was analyzed with 23 unique questions to collect both standardized and comparable data from 100 people and their characteristics. The questions in survey were picked carefully to have both qualitative and quantitative data set. The survey is well-suited for our research question to clearly point out what people think and react on our analysis seeking to measure parameters of Nigerian citizens. The limitation for the survey is that some people do not reply their exact answer or they sometimes tend to change the answer because of their feelings. This is the nature of survey and we must rely on the existing data. The survey also aims to analyze the usage of electricity, its challenges and what people expect from a financial model and a support scheme. The study seeks to outline the status of the Nigerian energy sector and to analyze which opportunities this spells for the subsectors of renewable energy, distributed generation and off-grid rural electrification.

This research study combined with a survey provides an overview and supplementary baseline information to initiate and facilitate the flow of private and public investments into the fields of renewable energy. The study is based on data gathered from existing database researches and a series of interview/surveys conducted in Nigeria from April until July 2017. Any such study is beset by the challenge of identifying reliable data from various resources because of the lack of reliable data. Moreover, sources are not always given in studies or papers that offer statistics, meaning citation of such sources is potentially problematic, especially if they are the only source. For the purposes of this study we have consulted national and international data sets for each case.

The analysis is based on empirical data from Government databases, company databases, public opinion survey, government personnel interview, as well as online and archival resources and libraries. A qualitative and quantitative study is combined to gather statistical data and theoretical perspectives to be blended together. This data helps us to observe if global solar finance methods can be modified according to the background and how all this information can be utilized to innovate special solar finance methods and support schemes to be created and suitable for the highest number of people living in Nigeria. This study does not address technical solutions among different solar or RE technologies but only use them to innovate financial models.

6.1.2 Survey Questions

The survey is composed of below mentioned format and questions;

Access to Electricity in Nigeria
Survey by Omer Muhtaroglu
Depar Group – Depar Energie GmbH Munich Germany Date: ……/……/2017
(You may pass the questions if you don't have any idea about it)
Name and Surname:
1-Which country are you living in?
2- What is your sex/gender?
▫ Male ▫ Female

3- What Type of a house do you live in?

- ▫ Flat
- ▫ Family House- single family
- ▫ Family House- Multi
- ▫ Villa
- ▫ Other …….

4- Do you have grid electricity in your house?

▫ Yes ▫ No

5- Do you own or use a genset in your house? If yes, how many hours you operate?

▫ Yes …… hours per day ▫ No

6-How much money do you spend for your fuel per day? Or what is the average electricity bill you pay per month?

7-What is the combined monthly income for your household?

8-What percent of your combined income (salary) is spent on your electricity expenses?

9-What is your profession?

10-Does your spouse (husband or wife) also work?

▫ Yes ▫ No

11-Have you ever use any solar electric product?

▫ Yes ▫ No

12-Have you ever awakened from sleeping by the genset noise?

▫ Yes ▫ No

13-If government pay for your solar electric system, would you like to work for government to repay your cost of installation at an affordable monthly rate? ▫ Yes ▫ No

14-If a corporate company finance your installation cost for solar diesel hybrid electric system, would you be willing to work for them for a period of time to cover this cost?

15-If government put a kWh meter based on Pay-As-You-Go model, do you think you can decide to have your house to be connected to this solar diesel solution?

16-Would you be willing to sell/distribute any solar electric system to harder to reach, high impact rural areas?

17-Do you think you can invest your capital or get a loan from bank if there would be a support scheme for your electricity need without an interest rate and with a very low monthly payment?

18-Assume a financier is investing your territory; as an investee what is the maximum amount of money you can pay per month for your rural household electricity from solar diesel hybrid system? ……NGN

19-By 2025 Access to energy in Nigeria will have largely solved by Federal Govt. of Nigeria (FGN)?

▫ Yes ▫ No

20-Do you think the rural electrification problem in Nigeria can be solved by means of corporate fast growing high impact companies or entrepreneurs that are widespread all around the country with small & medium scale companies (locally)?

▫ Corporate Companies ▫ Small & Medium Scale Local Companies

21-Would you like to support a solar finance model with long term monthly bill for a large system and help your government/country or prefer to stay with your genset?

▫ Solar Finance Mode ▫ Stay with Genset

22-What are the main barriers to improving the electrification rates in Nigeria?

▫ Funding
▫ Extension of Distribution Grid
▫ Limited Electricity Generation
▫ Lack of Affordable off-grid solar diesel hybrid

23-In your opinion, do you think access to working class skills in solar diesel micro-grid technology would be a problem by 2025 or you believe that Nigeria has ability to create enough skilled workers in near future?

- ▫ Yes, skill is big problem.
- ▫ Yes, but can be solved
- ▫ No, Not big problem
- ▫ No, skilled workers will be ready by 2025.

THANK YOU FOR YOUR ANSWERS! THESE WILL HELP NIGERIA TO IMPROVE AND GET BETTER!

6.1.3 About Survey Response and Results

This survey on Access to Electricity in Nigeria looks out public opinion on the electricity issues that Nigeria has been experiencing; as well as some important challenges facing the sector in recent years. The main objective of the survey is to determine the public perspective on solar diesel hybrid distributed generation and grasp their financial and social condition to support our analysis on innovative solar finance models. Below mentioned table with 23 questions and several sub-questions show us the sampling of the citizens of the society with 100 counted participants from various backgrounds. The model assumptions and survey responses are interpreted in chapter 6.2 in more detail; however, the survey results also allow the reader to interpret these answers from their perspectives for the studies they conduct independent from our focus point of financial outlook of solar-diesel-hybrid distributed generation systems. In the next few pages you can find the survey result document with questions, answers, response rates and response percentages for each question and choice from the participants. This result paper is also available in appendix.1.

Survey Question	Response Rate	Reply	%
1- Which country are you living in?	100%	Nigeria	
2- What is your Sex/Gender?	100%	38 Female	38% F
		62 Male	62% M
3- What type of a place do you live in?	100%		
3.1 Flat		55	55%
3.2 Family- Single		18	18%
3.3 Family -Multi		7	7%
3.4 Self Con/Room		12	12%
3.5 Shop		4	4%
3.6 Villa		4	4%
4- Do you have grid electricity?	100%	89 YES	89%
		11 NO	11%
5- Do you own or use a genset?	100%	87 YES	87%
		13 NO	13%
5.1 Use More than 4 hours a day		55	55%
5.2 Use More than 8 hours a day		28	28%
5.3 Use Less than 4 hours a day		17	17%
6- Money spent for fuel per month	90%		
6.1 Equal or Less than EUR10/month (Naira 4000)		62	62%
6.2 Equal or Less than EUR50/month (Naira 20000)		30	30%
6.3 Equal or More than EUR50/month (Naira 20000)		8	8%
7- Combined monthly income level	80%	14 BLANK	
7.1 Less than EUR100/Month (Naira40.000)		22	22%
7.2 Between EUR100 and EUR300/Month (Naira120.000)		26	26%
7.3 Between EUR300 and EUR600/Month (Naira240.000)		16	16%
7.4 Between EUR600 and EUR1000/Month (Naira400.000)		14	14%
7.5 More than EUR1000/Month (Naira400.000)		8	8%
8- Percentage of income spent for electricity expenses.	80%	20 BLANK	
8.1 Equal or Less than 2%		32	32%
8.2 Between 2% and 4%		10	10%
8.3 More than 4%		38	38%
9- Profession	94%	6 BLANK	
9.1 Student		10	10%
9.2 Businessman/Businesswoman/ Tradesman/ Shop-owner / Reseller		14	14%

9.3 Farmer / Villager		20	20%
9.4 Banker		4	4%
9.5 Engineer		6	6%
9.6 Worker & Sergeant		10	10%
9.7 Housewife		2	2%
9.8 Doctor / Health Sector		4	4%
9.9 Hairdresser		2	2%
9.10 Driver		5	5%
9.11 Cleaner		7	7%
9.12 Unemployed		10	10%
10- Does your spouse also work?	100%	50 Yes	50%
		22 No	22%
		28 No Spouse	28%
11- Have you ever used solar electric product?	100%	53 Yes	53%
		47 No	47%
12- Have you ever awakened from sleeping by the genset noise?	100%	100 Yes	100%
13- If govt. pay for your solar, would you work for govt. to repay?	100%	52 Yes	52 %
		48 No	48%
14- If financed by a corporate, would you work for them to cover the cost?	100%	45 Yes	45%
		55 No	55%
15- If Govt. put a pay-as-you-go, do you think you can decide to connect to a solar-diesel hybrid?	100%	95 Yes	95%
		5 No	5%
16- Would you sell solar electric system to harder to reach high impact rural areas?	100%	64 Yes	64%
		36 No	36%
17- If there is a support scheme without interest rate, would you invest or get a loan with a monthly payment?	74%	1 Probably	1%
		33 Yes	33%
		40 No	40%
		26 Blank	
18- Assume a financier is investing; what is the maximum amount you can pay per month for your solar diesel hybrid electric system?	92%	8 BLANK	
18.1 Less than EUR2 (Naira 800)		9	9%
18.2 Less than EUR5 (Naira 2000)		24	24%
18.3 Less than EUR10 (Naira 4000)		12	12%
18.4 Less than EUR20 (Naira 8000)		43	43%
18.5 Less than EUR50 (Naira 20.000)		4	4%
19- By 2025 Access to Energy in Nigeria will be solved by Federal Government of Nigeria?	100%	22 Yes	22%
		78 No	78%

20- Rural electrification problem can be solved by means of;	98%	2 BLANK	
20.1 Corporate fast growing high impact companies or,		61	61%
20.2 Local small& medium scale entrepreneur companies around the country		37	37%
21- Would you like to support a solar finance model with a long term monthly bill or prefer to stay with your genset?	100%		
21.1 Solar Finance Model		100	100%
21.2 Stay with genset		0	
22- What are the main barriers of improving the electrification in Nigeria?	99%	1 BLANK	
22.1 Funding		47	Tick
22.2 Extension of Distribution Grid		22	Tick
22.3 Limited Electricity Generation		23	Tick
22.4 Lack of Affordable off-grid solar diesel hybrid		39	Tick
23- Access to working class skills in solar diesel hybrid technology would be a problem by 2025 or Nigeria has ability to create enough skilled workers in near future?	100%		
23.1 Yes, Skill is big problem		7	7%
23.2 Yes, but can be solved		28	28%
23.3 No, Not big problem		53	53%
23.4 No, Skilled workers will be ready by the year 2025.		12	12%

Table.4 Access to Electricity Survey Results (Source: Muhtaroglu, 2017) (Also see in Appendix)

6.1.4 The Objective & Findings in the Study

The objective of the study is to indicate the most suitable finance model for distributed generation / hybrid power plants to increase the access to energy and improve clean energy usage in Nigeria. By doing this survey; the author tries to create a professional sectoral perspective to enlighten the local entrepreneurship with the sampling of the survey as the goal of the research. The author believes in his rationale that this

study should be conducted to make both public and private sides more participatory in the solution of the problem of access to energy in Nigeria. This research is not a summary of the recent condition but an opportunity to grasp the latest situation and to be a candle to Nigerian people to see what further can be done for their nation with the help of the contribution of this research. In this respect, the findings and the truth in this survey sampling is a chance for improvement.

Successful business models usually include a financing component. This is particularly important for the mass market in rural areas of emerging regions where most people do not have access to commercial financing, or are overwhelmed in dealing with loan applications. Furthermore, to be attractive for potential customers, business models must appear to be clear and simple, even if sophisticated processes run below the surface (Meier, 2014). In chapter 6.2 we are going to analyze and interpret survey results to see the social and financial situation which might open new opportunities and fill a gap in our knowledgebase.

6.1.5 Limitations

The limitations on this analysis might be the lack of detailed financial data as recent projects are tending to disclose information after some period or may not disclose any information at all. The data that is used in the paper rely on the latest available information. Access to the information is the biggest limitation but local, governmental and international resources are exploited as much as possible. The limitations of the survey itself is the tendency of people that could give different answers than what is in real. Harvard University program on survey research tips suggest that this is a natural attitude and there is no solution to this situation and the response of the participants should be considered accordingly (Harrison, 2007).

6.2 Survey Analysis & Interpretation

6.2.1 Social Framework of the Survey

Among the participants only 10% is unemployed and the rest is a mixture of various sectors and from various income levels such as bankers, villagers, students, workers, doctors, drivers, hairdressers, cleaning social workers and civil sergeants, housewives, engineers and so on. There is not any majority from one side but the number of farmers and village people compose 20% and business people 14% as the biggest groups. Another question pointed out that from all these respondents 50% said that their spouse also works for the income of the house; 22% said their spouse does not work and the rest 28% does not have spouse. This social structure shows that more than two-third of the married ones work together to bring double income, to survive or to live better. This question is asked to clarify the percentage of houses or people living with single income. From another perspective, the working-class lifestyle can lead to a different user habit for electricity as during the day no one is in the house, at least for working days.

It is important to have as much background as possible to get a good mixture of sampling the whole country. However, that does not necessarily show a common social behavior but only the financial stability or income level of the participants may affect their answers in financial analysis. This is a natural part of the survey that we want to look at the access to electricity problem and how these participants can contribute in future decisions considering the results of this survey. No matter what their social background or income levels are, all the participants are willing to have the problem of access to electricity in Nigeria to be solved as we analyze in coming sections.

6.2.2 Access to Electricity by the Respondents

Before looking at the financial results it is good to outline the level of access to electricity among survey participants. According to survey 89% of the participants report that they have grid electricity connection. As we pointed out before, the electrification rate in Nigeria

is around 55% in cities and 35% in rural areas. The reason of high percentage in our survey might be a matter of coincidence since the participants were picked random from public or there might be a tendency to tell different from what is in real, to not to tell the truth. Another reason could be the lack of electricity coverage on the grid although there seems to be grid connection. Access to electricity and grid coverage are two different issues in Nigeria (GIZ, 2105) but at the end if one doesn't have electricity in his/her house, he/she lacks electric current no matter what is the reason. With reference to the overall responses in the survey the participants are willing to access the electricity on a continuous basis and all willing to get rid of generators and go with uninterruptable sources of energy and systems.

6.2.3 Financial Situation in Search of a Good Model

As per our survey results, in which 62% of the participants are men and 38% are women. As a lower-middle class indicator in Nigerian society the clear majority of 55% are living in flats, and 18% living in single family houses which shows that 73% of this survey can be of this level. Only 4% of the survey participants live in Villas, obviously from higher income level. The places they live do not only give an idea about their income level but also give a picture of the level of their share from the infrastructure and available services; which are also depend on the places they live. 18% living in single family houses can be interpreted as without full-time sufficient on-grid electricity and among the ones that use genset between 4h to 10h per day.

The combined monthly income level varies from less than EUR100/month to more than EUR1000/month. 80% of the participants replied this question and among them 22% earns less than EUR100/month, 26% earns between EUR100/month and EUR300/month, 16% reported to have an income level between EUR300 and EUR600 per month and 14% between EUR600 and EUR1000 per month. Only 8% has an income level more than EUR1000 per month. First two income levels consist of 48% of the total among the ones who replied the question. Knowing the fact that

1 liter of diesel is EUR0.59 and an average household uses 5 liters per day to lights and household, apart from extra heaters or air conditioning (Globalpetrolprices; 2017). A standard house with an income level of EUR100 or EUR300 cannot handle a full time genset which cost EUR2.8/day and nearly EUR95 per month. This cost is only for fuel and the total cost also involve the purchase of the genset, risk of using highly flammable machine, poisonous emissions, cost of servicing and maintenance with spare parts and the non-stop noise. This shows that only 8% with a high-income level more than EUR1000 per month can have the luxury of using generator sets full time.

When the participants are asked to tell about the percentage of income spent for electricity expenses we have an 80% of response to this question in which 32% says less than 2%, 10% says between 2% and 4% and majority of 38% reports that their expenses are more than 4% of their income. These percentages could be enough in a solar finance model to be structured as monthly payments for a solar-diesel-hybrid distributed generation system. If the government and all other bodies for financing solar-diesel-hybrid system could meet on a common ground for such system, the people of Nigeria indicate willingness to choose for solar model and support.

6.2.4 Genset Usage among the Respondents

Our survey question whether participants own or use a genset has brought a high rate of genset usage which is 87% in total and 13 percent do not use genset. The ones who do not use genset might use solar power or kerosene or remain silent without electricity throughout the day. The hourly usage rate was also asked in this question and 55% of the owners/users depict that they use more than 4 hours per day. 28% of the owners/users report that they use more than 8 hours per day; thus, in total 83% of the owners/users are involved in genset more than 4 hours daily. This rate also shows that even the participants report that they have grid access, the access to electricity is low as they use gensets quite a long period in the day. Only 17% of the users utilize genset less than 4

hours a day. These numbers seem reasonable but it might be helpful to remind that most of these people do not use electricity with full availability and comfort of non-stop grid coverage or the comfort of genset is limited to their permitted maximum output power on the device they own/use. Even if they have gensets, they sometimes cannot use A/C units together with other powerful devices such as heaters or deep freezers, they must choose among several devices because of the limitations of the output power of gensets.

Additionally, according to our interview with a government official (name kept undisclosed) in Anambra State, Nigeria it is reported that governments also cover the electricity in some territories with the help of big gensets. Therefore, the public people might think that they have grid electricity but the actual coverage could still be from a genset which public don't know about. Unfortunately, it is almost impossible to find out how much coverage is handled by these big backup gensets. Similarly, there has been an energy efficient street lighting program called "Light up Anambra" in the same state, partnered by our sponsor company Depar Energie GmbH, to determine most efficient illumination rates and the impact of high efficiency LED armatures in comparison to old type Sodium Vapor and High-Pressure Sodium (HPS) lights or Metal Halide lights. The state government started to use gensets for every several roads and streets to be powered by genset and use highest efficiency led lighting equipment to light up some places. This genset usage model and the statistical data is also out of scope when it comes to electrification rate but this is part of the reality in Nigeria.

Survey question.12 asking about the noise of genset is one of the most important social issues in Nigeria that this question was replied by all participants and 100% of the participants replied Yes when we asked them if they were ever being awakened from sleeping by a genset noise. During survey one of the biggest complaints was this noise issue that the participants emphasized how much this noise affect their lives. This

genset noise is one of the first things that one recognizes as soon as leaving the airport and start roaming on the streets and roads of Nigeria. This point of view seems to be from a social perspective but still contributes to the willingness towards a cleaner, silent and convenient source of energy for a huge amount of people. Afterwards; the survey followed by a set of questions on solar systems and the responses on their financial modelling.

6.2.5 Responses for Solar Diesel Hybrid Distributed Generation System and Financial Models

Two important questions were asked to participants whether they might be willing to work for government or a corporate company to cover the cost if there is a model for their solar diesel hybrid system to let them access a reliable source of electricity. These questions address the foundation of a financing model in which the citizens participate in less with their budget but more with their efforts. All participants replied these questions and 52% agreed on working for the government if there is such model to repay their cost. This corresponds to more than half of the participants can get involved in a Solar Lease Model with small financial participation and 48% do not want to spend any efforts; they might rely on their pockets for another model or keep relying on diesel gensets. Interestingly only 45% of the participants agreed to work for a corporate company, thus, the people has less tendency to trust in private sector companies and more people see government a better post.

On the other hand, the survey asked if government put a pay-as-you-go model whether they can decide to connect to a solar –diesel-hybrid or not; 95% of the participants agreed on such a model financed by the government and paid by people as installments or with prepaid cards, digital payments etc. The financial burden of such a system is on the government or co-operated funds, partner banks or international funds created by the governance of the FGN. This model is the most welcomed model among others. Besides, 64% of the participants; no matter what their professions are, agreed that they can be part of selling solar electric

systems to harder to reach high impact rural areas. Socially people are willing to help to solve the access to energy problem and this can be utilized by the government with a proper method. People agree to get involved a mid-size PAYG system for solar-diesel-hybrid distributed generation but only 33% of the participants agreed to invest or get a loan with monthly payment without interest. Thus, if government structures the business model and organizational model even with interest rate people agree; but if you ask them to get a loan without interest, they don't agree to get. When they participants are asked about maximum monthly payment for a solar-diesel-hybrid electric system they can pay only 4% of the participants agree to pay less than EUR50/month, majority of 43% agree to pay less than EUR20/month and some 24% report to pay EUR5/month; and a 9% of the group can only pay EUR2/month which is an insufficient amount of monthly payment. EUR2/month even cannot buy a Pico type small solar light. As mentioned previously, 48% of these people has reported a combined income level of less than EUR300/month; therefore, expecting a payment model more than EUR20/month would be highly risky for these people. An average trainee engineer salary in Nigeria is starting from EUR250/month if you are lucky to find a job (Glassdoor, 2017).

6.2.6 The Perception of Access to Electricity by Nigerian People

The perception of Access to electricity in Nigeria is seen in two dimensions; one is the grid coverage part of the problem and the second and more important is the rural electrification. The participants are asked to give their idea that by 2025 access to energy in Nigeria will be solved by federal government of Nigeria or not. Unfortunately, 78% of the participants is not optimistic about a solution and they think the problem will still largely exist 8 years from now. 22% believes that Nigeria will get over with this issue. When we ask the model to solve the rural electrification problem we got 95% replies to this question and 61% choose the solution to be by means of corporate fast grooving high impact

companies; only 37% supports the idea of local small & medium scale entrepreneur companies around the company can contribute more in the solution.

Apart from the solution the respondents are also asked about the main barriers of improving the electrification. In this question, the multiple choices were given as a) Funding, b) Extension of distribution grid, c) Limited electricity generation, and d) Lack of affordable off-grid solar diesel hybrid. Multiple ticks were allowed at this question and funding got 47 ticks followed by lack of affordable solar-diesel-hybrid with 39 ticks. This is the picture of what people has in mind; the government does not have money/funds or does not use them for electrification. The lack of affordable solar-diesel-hybrid solutions is proposed by our survey no matter if the participants have any idea before this survey. However, after the survey instructions and question/answer session all of the participants had an idea on this topic. This could be the reason why their tick on this choice is this much.

As our analysis is on the solar-diesel-hybrid technology, one of the most important handicaps in front of this technology is the skilled workers. Solar-diesel-hybrid systems bring technical complexity in areas where skills are generally lacking. The development of a more secure environment is still necessary for private investors to be willing to participate. In addition, the lack of locally available after sales service and skilled personnel is hampering the development of this technology in the rural electrification sector. Public-private partnerships need to be promoted and facilitated. For the sustainability of the projects, local buy-in by the communities and end-users is essential. Adequate capacity building and training courses for local operation and maintenance will be necessary to ensure long-term viability. Agencies should encourage the involvement of local authorities from project planning to project implementation and monitoring, and additionally for local operation and maintenance (IEA, 2016; p.4). Knowing the fact that skill is an important point, we asked the survey participants whether access to working class skills in solar-diesel-hybrid technology would be a problem by 2025 or

Nigeria has ability to create enough skilled workers in near future. The multiple choices in the question were; a) Yes, skill is a big problem, b) Yes, but can be solved, c) No, not big problem, d) No, skilled workers will be ready by year 2025. 53% of the participants mentioned that skill is not big problem, and 28% said yes, it is a problem but can be solved. 12% believe that skilled workers will be ready by year 2025 and only 7% report that skill is big problem and will remain to be in the future. This result is optimistic but the Federal Government of Nigeria should organize well to provide solutions for people's hope.

With reference to survey question.21 we have another full block answer set to one choice. The participants are asked if they would like to support a solar finance model with a long term monthly bill or prefer to stay with a genset. 100% of the participants replied this question and 100% replied solar finance model as their choice rather than staying with genset. From a personal point of view, obviously genset is a burden and people ready to sacrifice. Besides, the people are asked about a solar finance model without having a detailed feedback on how this model would be or how much they will pay for this system. The choice of generator and the idea of staying with genset is annoying and it is one of the biggest problems of the society. Authorities need to take this set of answers into account a model for public society from a bottom up perspective that can serve to the farthest rural setting needs to be created.

6.3 Survey Focus Points & the Truth in the Study

The focus point of this study is to draw attention to socially acceptable and eco-friendly as well as technically and economically viable solutions and to support their replication throughout the country. This could be complemented by comprehensive training measures for partners and professionals within the Nigerian power sector (GIZ; 2015). Whatever the chosen ownership model, both the involvement and support of the local community are essential for the long-term sustainability of the

project. Participation by the users from an early stage in the project definition, in project execution and in operation helps to realize a design that matches the actual demands and makes the final users take more responsibility for wise use and maintenance of the installations (PVPS, 2011).

According to this paper findings, the most well-known models recently experienced in Nigeria are PAYG and PPA models. PPA is quite new and not exactly experienced yet on-site in renewable energy sector but because of the nature of PPA most big projects are entitled to be executed, or planned to be executed with this model. Hundreds of megawatts in project pipeline with PPAs signed. However, as also pointed out in survey answers, even public people aware of the fact that lack of funding, lack of enough transmission lines, lack of proper infrastructure, besides time consuming bureaucracy and historically lack of organizational behavior keeps these big investments slower and slower. On the other hand; with the help of the telecom systems that are started to be using solar-diesel systems a chance of digital finance or microfinance models by reaching more rural people.

Our survey also address how people can be adopted to the solution. According to the percentages of the answers they are willing to pay energy as a service, they can work for government but not for corporate companies. They don't have tendency to get loans even without interest rate but they can involve with microfinance model, rent-to-own model or usage based kWh meter PAYG model to contribute to the solution of Access to electricity problem in Nigeria. All participants, 100% would like to support solar finance model with long term monthly bill for a large solar-diesel-hybrid distributed generation system. This question particularly shows their readiness to pay for their infrastructure that should normally be provided by the government. They are even ready to sell/distribute solar electric system to harder to reach, high impact rural areas. The participants that are introduced to our survey in Nigeria agreed to solve the access to electricity problem with solar-diesel-hybrid distributed generation. After years spent in Nigeria, the truth in this study from

authors' point of view is that there is a possibility to settle a policy to create co-operative bodies composed in rural villages or communities, which are non-profit and self-organized but still subordinated by local state governments, that can contribute to create thousands of solar-diesel-hybrid distributed generation projects in a very short period of time.

7. Impact Measurement and Environmental Perspective

While discussing the electricity and energy issues there is one point that must be clearly stated in all stages which is the impact measurement before, during and after the projects followed. The energy sector is not only a matter of financial issue but also an optimizer positive social and environmental impact. All available financial and philanthropic tools should be available to the growth of these enterprises. One of the reasons that traditional structures will not suffice is that they often treat impact measurement as either nice to have or a post project calculation, and do not see as an integrated part of the strategy or as a key component of how strategy is allocated and is experienced. It is crucial to embed the practices and information gathered from surveys and information from public opinion into the actual flow of capital to understand if the impact is optimized or not (Patton Power et.al, 2016; p3ff).

Another important factor to improve impact measures is the capacity building. The capacity of organizations for training delivery is being strengthened by NESP. The national power training institute of Nigeria (NAPTIN) and other training institutes are being assisted to deliver a range of relevant training courses on renewable energy and energy efficiency for engineers, architects and technicians. Interventions will also train selected professionals of partner institutions and enhance capacities of the power sector as whole (GIZ, 2016). A chain reaction might be possible to revolutionize a good structure with the help of the new capacities built up for the cause.

When it comes to the usage of renewables, the first and most important issue is in fact environmental impact which not only influence our lives but also have enormous effect on the nature and the lives of our children, our future. As we mentioned before, apart from the economic gains made, the solar-diesel-hybrid distributed generation system is also environmentally friendly because of the reduced emission of greenhouse gasses and other pollutants associated with fossil fuels. In this respect, impact measurement could also be treated with more attention as the pollution in Nigeria is also directly polluting the whole world, or contributing to this environmental impact.

8. Possible Support Schemes for Solar-Diesel-Hybrid Distributed Generation in Nigeria

The reasoning for renewables is strong as we have been analyzing different aspects of solar-diesel-hybrid distributed generation from public, governmental and private sector point of views and the solutions and support methods with good mechanisms must be paid attention. On the one hand, power plants overcome geographical grid challenges and on the other hand, renewable energies offer fast-delivery solutions and are cost-effective especially when replacing diesel generation capacity. At the same time, challenges are highlighted in what could be a key pioneering area.

The results of the analysis of financial models for solar diesel hybrid distributed generation focus on access to energy problem in Nigeria and main recommendations are:

1. To set-up a structured and reliable support mechanism such as a bidding system for utility scale (larger than 10 megawatt) renewable energy and a feed-in tariff for small renewable energy projects,
2. To focus efforts on development of solar photovoltaic (PV) farms and small hydropower plants (primary focus on quick wins),
3. To link the vast biomass potential to rural electrification schemes,
4. to pin-point the wind potential through detailed mapping and the identification of development corridors,

5. To align policies between governmental institutions, thus mitigating potential conflicts and to continue the support of the nation's current electricity delivery system,

6. To strengthen key stakeholders' capacity in order to ensure the achievement of the policy targets and to monitor and evaluate its results based on sound data and reliable statistical records,

7. To develop financial and investment instruments including public-private partnerships (PPPs) and promote the contribution of private banks and International Financial Institutions (IFIs) to develop financial and investment instruments adapted to each energy efficiency market segment (for example for industry/buildings: to offer incentives through savings from a better conversion rate and for the private household segment: microfinance schemes; non-bank financial institutions; bank consumer loans for appliances; leasing provisions; donor lending programs),

8. To focus primarily on the establishment of an energy efficiency financing facility designed for small- and medium-sized enterprises (SMEs).

The study determines that there is great potential for rural electrification and that some of it could be accounted from solar-diesel-hybrid distributed generation system. However, FGN will need to address the issue of sourcing of investments. Potentially, this third subsector is the one where government and international donor agencies will need to join forces. The study's main recommendations are:

A. To finalize, approve and operationalize the Rural Electrification Strategy and Plan (RESP) incl. the mix of regulatory policy and public financing mechanisms

B. To operationalize the Rural Electrification Fund (REF) and IFIs a clear basis for decision making

C. To strengthen institutions to ensure the delivery of the RESP targets including its monitoring and evaluation based on sound data and relevant statistical records

D. For solar PV, to encourage the provision of solar packs (incl. panels and battery storage systems backed up by O&M instructions) for households and microsystem water irrigation pumps

E. For micro-hydro schemes to first evaluate the cost/benefits of run-of-the-river micro systems and of converting micro-dams into hydropower systems

F. For wind, to encourage stand-alone microsystem water irrigation pumps (backed up by instructions schemes on O&M)

G. The wide chasm between research bodies (universities, polytechnics and research institutes) and manufacturing industries must be bridged (Oji et al., 2012).

The development of small distributed hybrid generation systems for rural electrification to address the needs of remote communities will rely on the impetus given by institutions in charge of providing public services to rural customers. Capacity building and access to concessional financing will be the key enablers for the development of this segment. This segment could benefit from standardized technical solutions developed by the manufacturers. The medium-size distributed hybrid systems still need a political impetus to foster the involvement of the private sector. With the implementation of mechanisms to mitigate risks and agreements that help fair sharing of the risks between private investors and other stakeholders, this segment can significantly develop if PV panel and inverter costs continue to decrease. Standardization will be less feasible in this segment because of the impact of local specificities on the design of the system that limit replication (in particular the local load profile). However, component modularity might offer in the future standardization opportunities, with the associated cost and reliability benefits (IEA PVPS Task 9, 2013; p.37).

Therefore, there are calls for financing mechanisms, especially through new investment platforms, and for regulatory and operational alterations to improve overall market efficiency. But the key to open new funding opportunities is to attract more investors that do not yet consider Nigerian energy infrastructure development to be a safe

and long-term investment. Given the huge potential for solar-diesel-hybrid power generation, Nigeria must make efforts to diversify its energy mix with less emphasis on thermal generation and invest heavily in research and development on the exploitation of solar energy technologies. In terms of a legal, regulatory and tariff framework, a lot has been done in terms of policy and regulation. However, these need to be implemented and the framework for solar-diesel-hybrid projects needs to be tested. It is hoped that the framework and the liquidity issues across the electricity value chain are resolved, we will see a lot more solar projects come on stream and possibly open the way for competitive projects across the land of Nigeria (MacLean and Olderman, 2015).

9. The Outcome and Future Prospect of This Research

In Nigeria, consistent power sector policies and regulations are crucial to increase investment and to improve access to energy. Thus, policy process and financial mechanisms work together to bring new investments. Policy process and regulatory strategies are two major risk factors when it comes to risk assessment. A lot of people in our survey, as 47% of the participants, believe that major barriers to invest in new generation and transmission projects can be minimized with government aided financial support schemes or funds that applied to solar diesel hybrid micro-grid, local power generation and interconnection of distributed generation towards a smarter grid with a bigger viability. These elements of distributed generation constitute less burden on FGN in both monetary terms and in policy & regulatory terms with the availability of various financial players and simple policy process in contrast to fossil fuel or hydropower generation.

In rural-scale solar-diesel-hybrid distributed generation the correct choice of the ownership of the system depends on socio-economic conditions of the country and it will have a strong impact on the success of the projects. Considering our research and survey, the government, institutions and public people are willing to solve the problem. From public will based on the survey, a cooperative organization in rural communities can foster improvements on access to energy in Nigeria with solar-diesel-hybrid systems. Governments and public agencies are increasingly aware of the benefits of hybrid technologies. It is expected that, along with this growing interest, there will be more funding available from electrification funds for this technology. Nevertheless, with the increasing sizes of the hybrid power plants that are planned, the involvement of the private sector to complement public funding will be increasingly required. If the local political will can play the role of the trigger by setting up programs and implementation plans for the development of solar-diesel-hybrid systems, the participation of the

private sector with public people should be the enabler for the actual realization of these projects (IEA, 2013; p.36).

As a result, our research and survey indicates that solar-diesel-hybrid distributed generation present an attractive option for the solution of access to electricity in Nigeria. A systematic promotion of the financial methods with bottom-up policies that can create solutions with monthly payment models with co-operatives structured in rural communities which are backed financially by government and all funding supports is the best of the outcome of this research. Other type or methods of researches might also be analyzed to see, compare with this study that all could be helpful for the stakeholders from top to down. This research is supported with a survey in real life from the streets and rural areas of Nigeria indicates that solar-diesel-hybrid with a monthly payment based on digital payment with a participatory business model from corporate investment portfolio backed by both federal and state government contribution is a good framework of a foundation for such co-operative policy. With this way, the federal government could take big steps in solving the rural electrification problem and supply electricity to people which transmission lines does not support; the investors and companies can be part of this with funding, procurement and implementation; philanthropic institutions can play an active role in process and progress; the people of Nigeria could be served for what they need and deserve with their willingness and being part of this co-operative body in which they believe 100% in solar finance model.

10. Literature

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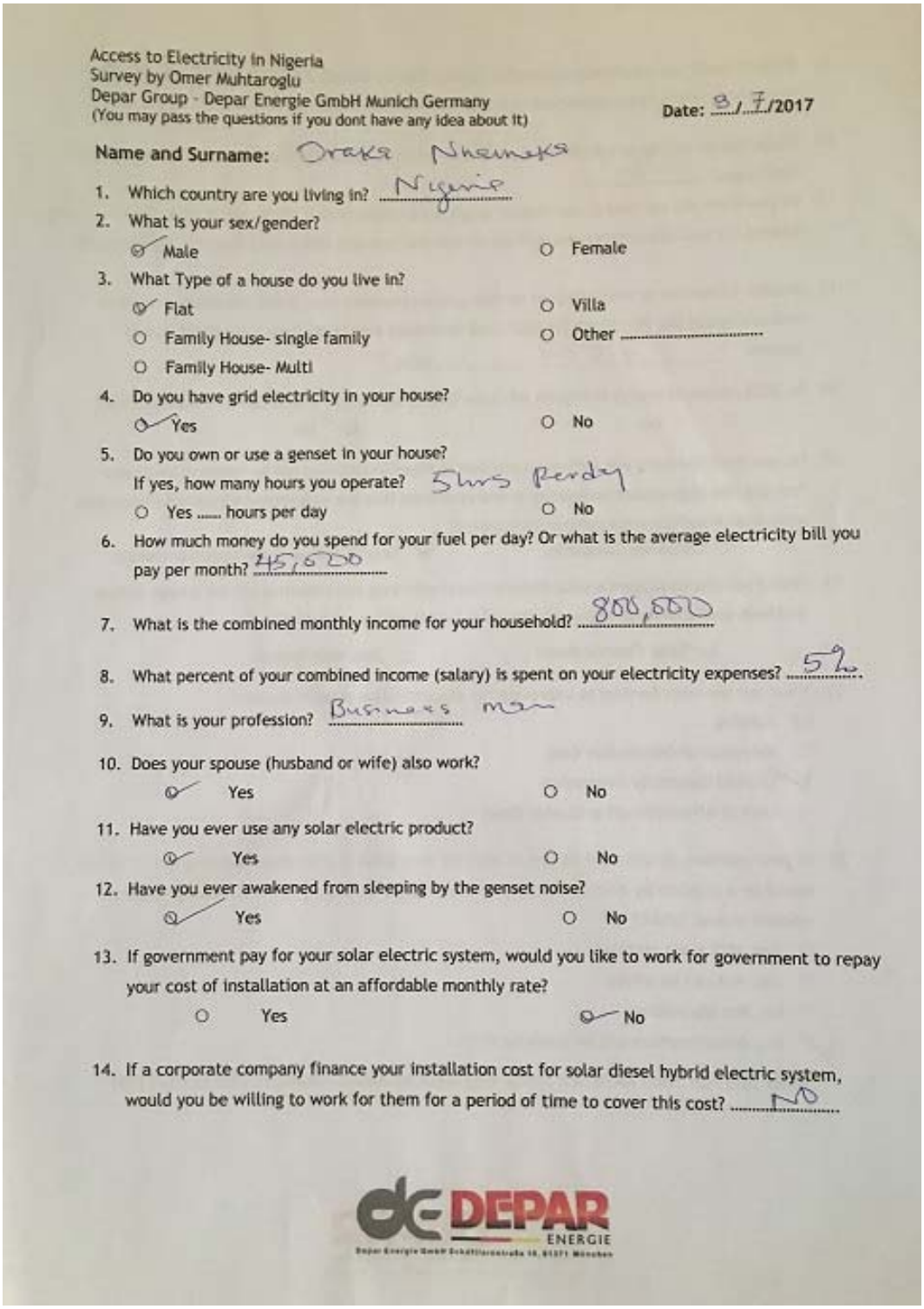
Appendix 1- Survey Answers, Response Rates and Percentages (3pgs)

Survey Question	Response Rate	Reply	%
1- Which country are you living in?	100%	Nigeria	
2- What is your Sex/Gender?	100%	38 Female	38% F
		62 Male	62% M
3- What type of a place do you live in?	100%		
3.1 Flat		55	55%
3.2 Family- Single		18	18%
3.3 Family -Multi		7	7%
3.4 Self Con/Room		12	12%
3.5 Shop		4	4%
3.6 Villa		4	4%
4- Do you have grid electricity?	100%	89 YES	89%
		11 NO	11%
5- Do you own or use a genset?	100%	87 YES	87%
		13 NO	13%
5.1 Use More than 4 hours a day		55	55%
5.2 Use More than 8 hours a day		28	28%
5.3 Use Less than 4 hours a day		17	17%
6- Money spent for fuel per month	90%		
6.1 Equal or Less than EUR10/month (Naira 4000)		62	62%
6.2 Equal or Less than EUR50/month (Naira 20000)		30	30%
6.3 Equal or More than EUR50/month (Naira 20000)		8	8%
7- Combined monthly income level	80%	14 BLANK	
7.1 Less than EUR100/Month (Naira40.000)		22	22%
7.2 Between EUR100 and EUR300/Month (Naira120.000)		26	26%
7.3 Between EUR300 and EUR600/Month (Naira240.000)		16	16%
7.4 Between EUR600 and EUR1000/Month (Naira400.000)		14	14%
7.5 More than EUR1000/Month (Naira400.000)		8	8%
8- Percentage of income spent for electricity expenses.	80%	20 BLANK	
8.1 Equal or Less than 2%		32	32%
8.2 Between 2% and 4%		10	10%
8.3 More than 4%		38	38%
9- Profession	94%	6 BLANK	
9.1 Student		10	10%
9.2 Businessman/Businesswoman/ Tradesman/ Shop-owner / Reseller		14	14%

9.3 Farmer / Villager		20	20%
9.4 Banker		4	4%
9.5 Engineer		6	6%
9.6 Worker & Sergeant		10	10%
9.7 Housewife		2	2%
9.8 Doctor / Health Sector		4	4%
9.9 Hairdresser		2	2%
9.10 Driver		5	5%
9.11 Cleaner		7	7%
9.12 Unemployed		10	10%
10- Does your spouse also work?	100%	50 Yes	50%
		22 No	22%
		28 No Spouse	28%
11- Have you ever used solar electric product?	100%	53 Yes	53%
		47 No	47%
12- Have you ever awakened from sleeping by the genset noise?	100%	100 Yes	100%
13- If govt. pay for your solar, would you work for govt. to repay?	100%	52 Yes	52 %
		48 No	48%
14- If financed by a corporate, would you work for them to cover the cost?	100%	45 Yes	45%
		55 No	55%
15- If Govt. put a pay-as-you-go, do you think you can decide to connect to a solar-diesel hybrid?	100%	95 Yes	95%
		5 No	5%
16- Would you sell solar electric system to harder to reach high impact rural areas?	100%	64 Yes	64%
		36 No	36%
17- If there is a support scheme without interest rate, would you invest or get a loan with a monthly payment?	74%	1 Probably	1%
		33 Yes	33%
		40 No	40%
		26 Blank	
18- Assume a financier is investing; what is the maximum amount you can pay per month for your solar diesel hybrid electric system?	92%	8 BLANK	
18.1 Less than EUR2 (Naira 800)		9	9%
18.2 Less than EUR5 (Naira 2000)		24	24%
18.3 Less than EUR10 (Naira 4000)		12	12%
18.4 Less than EUR20 (Naira 8000)		43	43%
18.5 Less than EUR50 (Naira 20.000)		4	4%
19- By 2025 Access to Energy in Nigeria will be solved by Federal Government of Nigeria?	100%	22 Yes	22%
		78 No	78%

20- Rural electrification problem can be solved by means of;	98%	2 BLANK	
20.1 Corporate fast growing high impact companies or,		61	61%
20.2 Local small& medium scale entrepreneur companies around the country		37	37%
21- Would you like to support a solar finance model with a long term monthly bill or prefer to stay with your genset?	100%		
21.1 Solar Finance Model		100	100%
21.2 Stay with genset		0	
22- What are the main barriers of improving the electrification in Nigeria?	99%	1 BLANK	
22.1 Funding		47	Tick
22.2 Extension of Distribution Grid		22	Tick
22.3 Limited Electricity Generation		23	Tick
22.4 Lack of Affordable off-grid solar diesel hybrid		39	Tick
23- Access to working class skills in solar diesel hybrid technology would be a problem by 2025 or Nigeria has ability to create enough skilled workers in near future?	100%		
23.1 Yes, Skill is big problem		7	7%
23.2 Yes, but can be solved		28	28%
23.3 No, Not big problem		53	53%
23.4 No, Skilled workers will be ready by the year 2025.		12	12%

Appendix 2- Sample Survey Question/Answer Paper 1st page



Access to Electricity in Nigeria
Survey by Omer Muhtaroglu
Depar Group - Depar Energie GmbH Munich Germany
(You may pass the questions if you dont have any idea about it)

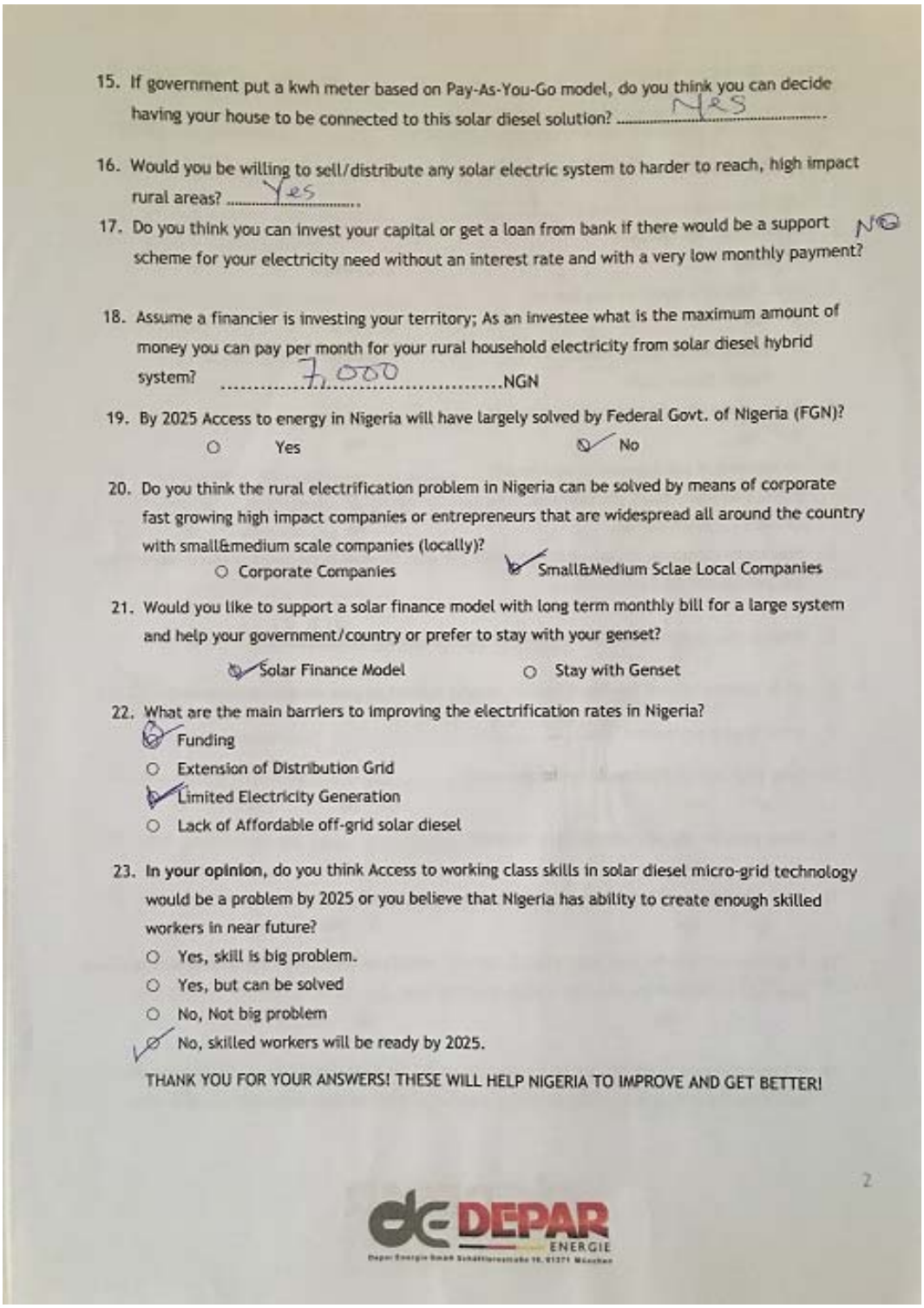
Date: 9/7/2017

Name and Surname: Oraka Nnamaka

1. Which country are you living in? Nigeria
2. What is your sex/gender?
   - ☑ Male
   - ○ Female
3. What Type of a house do you live in?
   - ☑ Flat
   - ○ Villa
   - ○ Family House- single family
   - ○ Other .....
   - ○ Family House- Multi
4. Do you have grid electricity in your house?
   - ☑ Yes
   - ○ No
5. Do you own or use a genset in your house?
   If yes, how many hours you operate? 5hrs Perday
   - ○ Yes ..... hours per day
   - ○ No
6. How much money do you spend for your fuel per day? Or what is the average electricity bill you pay per month? 45,500
7. What is the combined monthly income for your household? 800,000
8. What percent of your combined income (salary) is spent on your electricity expenses? 5%
9. What is your profession? Business man
10. Does your spouse (husband or wife) also work?
    - ☑ Yes
    - ○ No
11. Have you ever use any solar electric product?
    - ☑ Yes
    - ○ No
12. Have you ever awakened from sleeping by the genset noise?
    - ☑ Yes
    - ○ No
13. If government pay for your solar electric system, would you like to work for government to repay your cost of installation at an affordable monthly rate?
    - ○ Yes
    - ☑ No
14. If a corporate company finance your installation cost for solar diesel hybrid electric system, would you be willing to work for them for a period of time to cover this cost? NO

DEPAR ENERGIE

Appendix 3- Sample Survey Question/Answer Paper 2nd page



15. If government put a kwh meter based on Pay-As-You-Go model, do you think you can decide having your house to be connected to this solar diesel solution? ..... Yes

16. Would you be willing to sell/distribute any solar electric system to harder to reach, high impact rural areas? ..... Yes

17. Do you think you can invest your capital or get a loan from bank if there would be a support scheme for your electricity need without an interest rate and with a very low monthly payment? No

18. Assume a financier is investing your territory; As an investee what is the maximum amount of money you can pay per month for your rural household electricity from solar diesel hybrid system? ..... 7,000 .....NGN

19. By 2025 Access to energy in Nigeria will have largely solved by Federal Govt. of Nigeria (FGN)?
    - ○ Yes
    - ✓ No

20. Do you think the rural electrification problem in Nigeria can be solved by means of corporate fast growing high impact companies or entrepreneurs that are widespread all around the country with small&medium scale companies (locally)?
    - ○ Corporate Companies
    - ✓ Small&Medium Sclae Local Companies

21. Would you like to support a solar finance model with long term monthly bill for a large system and help your government/country or prefer to stay with your genset?
    - ✓ Solar Finance Model
    - ○ Stay with Genset

22. What are the main barriers to improving the electrification rates in Nigeria?
    - ✓ Funding
    - ○ Extension of Distribution Grid
    - ✓ Limited Electricity Generation
    - ○ Lack of Affordable off-grid solar diesel

23. **In your opinion**, do you think Access to working class skills in solar diesel micro-grid technology would be a problem by 2025 or you believe that Nigeria has ability to create enough skilled workers in near future?
    - ○ Yes, skill is big problem.
    - ○ Yes, but can be solved
    - ○ No, Not big problem
    - ✓ No, skilled workers will be ready by 2025.

THANK YOU FOR YOUR ANSWERS! THESE WILL HELP NIGERIA TO IMPROVE AND GET BETTER!

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DEPAR ENERGIE