Determinants Of Compliance with Quality & Regulatory Requirements in Solar Energy in South-West, Nigeria

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Abstract- ***This study examined determinants of compliance with quality standards in solar energy adoption in Nigeria. Despite Nigeria's vast solar potential, poor product quality, weak regulatory enforcement, and inadequate technical expertise hinder sustainable utilization. The study adopted a cross-sectional design. A purposive sampling technique was employed to select 106 consumers utilizing solar energy facilities in Lagos, Ondo and Oyo States in Nigeria. A multiple-choice questionnaire was used for data collection. The data was analyzed using IBM SPSS version 26. The results were presented in frequency-percentage tables. The results showed that 69.8% of respondents reported that solar installations hardly last beyond five years, while 68.9% affirmed that not all imported facilities meet quality requirements. Affordability and reliability were major drivers, with 84.9% and 88.7% respectively affirming solar as cheaper and more dependable than grid electricity. Determinants of compliance included quality of materials (93.4%), poor grid supply (89.5%), installer competence (70.8%), enforcement of standards (89.6%), and maintenance culture (95.3%). These findings align with empirical evidence highlighting the prevalence of substandard products and weak enforcement in Nigeria's renewable energy sector. The study concludes that stronger regulatory frameworks, professional training, and improved maintenance culture are essential for sustainable solar energy adoption in Nigeria.***

Index Terms- ***Solar energy adoption, Quality standards, Compliance determinants, Renewable energy policy, Nigeria***

I. INTRODUCTION

Nigeria as a country is blessed with diverse human and natural resources that are capable of making her self-sufficient in energy requirements. However, the current reality is precisely the opposite, because there is an acute shortage of energy leading to incessant power outages. This, over the years, has culminated in an economic crisis, low-capacity utilization in the manufacturing sector, unemployment, corruption, excessive capital flight, and dwindling Gross Domestic Product (GDP). About 60 - 70 percent of the citizens do not have access to power for up to 4 hours per day (Oyedepo, 2012), while only 60.5% of the country's entire population has access to electricity (Energy Progress Report, World Bank, Washington DC, 2022).

This implies that the issue of environmental sustainability is not being effectively addressed in Nigeria's energy sector. No nation can survive without an adequate power supply for domestic, commercial, and industrial usage. The high rate of rural-urban migration in Nigeria and its consequences, increased energy demands by about 180,000 Megawatt. With the present power generation of less than 4,000 megawatts, unless something is urgently done, Nigeria will remain in the economic doldrums for a long time with adverse effects on developmental goals, livelihood, and well-being. Nigeria needs to take deliberate steps toward

an energy mix and build inter-capacities to enable and support the economy to mitigate this current problem. It has been reported that per capita power consumption of energy in Nigeria's is now only 151 kilowatt hours per year, representing one of the lowest in the region and globally (Omontuemhem & Wijeratne, 2016). It is expedient that economically, energy sources need to be diversified. This is because a single source of energy cannot provide all the energy required satisfactorily for sustainable development with the present trend in growth rate of the population, coupled with the increase in urbanization and anticipated industrialization (Uzoma et al, 2016). Most households in Lagos, Ibadan and some urban towns in the South-West of the country have two generators, with the removal of subsidy on fuel by the Federal Government has led to inflation and untold hardship on the citizens. So prevalent that the use of fossil fuel generation become and is estimated that off-grid power provides more than four times the level of power actually delivered by Nigeria's national grid (George, 2020). Exploitable alternative sources of energy in Nigeria that are clean, guarantee environmental sustainability, and are affordable technology, but not limited, are solar energy, solar heating systems, wind, tidal, biogas, and biomass (Abam, et al, 2014).

A 2023 study by the Nigerian Energy Support Programme (NESP) showed that solar energy systems is one form of renewable energy source, whose facilities have witnessed adverse importation and installation in Nigeria (Alli, 2025). The enormous potential of this energy source is being under-utilized, because Nigeria enjoys all-year-round sunshine. The average in annual total radiation in Nigeria is between 12.6 megajoules per millimeter square (MJ/m^2) per day across the coastal regions and about 25.2 megajoules per millimeter square (MJ/m^2) per day in the northern part of Nigeria (Giwa, et al, 2017). According to Sambo (2009), this implies that Nigeria recovers 5.08 x 10^{12}-kilowatt hour (kWh) energy per day from the sun. Assuming that 5% in efficiency is used to cover about 1% of the country's surface area, then 2.54 x 10^6 megawatts hour MWh of electrical energy can be obtained from the sun. This will be equivalent to 4.65 million daily barrels (Sambo, 2009). The present contribution of electricity consumption in Nigeria is far less than expected; with this in mind, massive efforts have been geared to exploit these opportunities by local and foreign operators in the renewable energy sector. Hence, to ensure that good quality products and services are rendered in system designs, installations, maintenance, and effective services in Nigeria, statutory and regulatory requirements must be established, and compliance must be ensured.

Solar energy system is another alternative energy source, which involves the use of solar panels, charge controllers, high-quality solar batteries, and solar inverters which require less maintenance attention in terms of regular fueling. However, lack of effective implementation of regulatory requirements and regulation of the practitioners in this sector, in terms of technical competence have reduced the enormous advantages of this emerging technology, due to poor installations. Study carried out by NESP showed that some panels lose up to 20% of their output within three years (Alli, 2025). According to NESP 2023 report, up to 40% of solar components in the market fail to meet the requirements of international standards (Chibuzor, 2025).

Importations of poor-quality components, and technical know-how constitute major problem for many practitioners involved in solar energy systems. The Renewable Energy Association (REAN) observed that almost 50% of installed systems suffer from design flaws, including incorrect panel orientation, inappropriate inverters, wrong battery capacity. This will lead to reduction in performance, short life span and frequent outages. These are due to low-quality materials being imported which were not certified by the Standards Organization of Nigeria (SON) and unprofessional practices by the vendors. Lack of post-installation maintenance is inimical to performance of solar energy facilities. A study carried out by Nigerian Economic Summit Group indicates that 60% of solar system users are not given any after sales support. In another study, 70.2% of respondents indicated that no maintenance activities were carried out on their solar systems (Adetona, et al, 2020). This is an indication that compliance level by practitioners to specified requirements is likely to be absent.

In this work, there are need to assess the attitude and financial capabilities of the stakeholders in the region affect the importation of good quality and compliance level to established quality requirements; and identifying determinants of compliance of practitioners and customers to quality requirement of Solar Energy facilities.

Globally, in order to generate electricity wind energy, need to increase to 32% by 2030 and beyond 2030, and there is need for solar PV which has now becoming more competitive. This is because Solar PV is increasingly driving most of the energy system, and wind energy plays a vital role with about 18% of the share in 2050. It has been projected that share in Solar PV supply is expected to increase from 37% in 2030 to about 69% in 2050, becoming the minor cost energy source (Manish, et al., 2019). The Climate Reality Project (CRP), on its February 3, 2016 annual report shows a critical study of the blueprints of countries like Sweden, Germany, Costa Rica, Morocco, and Kenya, that would be an impetus that could be leveraged in Nigeria. These countries are already harnessing the potentials of renewable energy and are progressing towards a low-carbon emission in the future.

Whether solar energy systems are gaining forefront or not, the answer is blowing in the wind, the solutions are growing every day. Still on the CRP report, in 2015, Sweden came up with a climate goal agenda of eliminating fossil fuel consumption within its borders. Within the context of achieving this agenda, the country geared its efforts in stepping up investment in wind energy, solar energy, improve its energy storage, improve on its smart grids, and ensure clean transport system. According to ITA report, 2022, more than 98% of Costa Rica's electricity came from RE in 2018. It was reported that in 2015, wind powered energy produced about 97% of the country's household electricity needs. At the end of 2014, Germany generated about 38.2GW of electricity through solar energy, which constitutes about 78% of the total electricity demand of the country.

Morocco has one of the world's largest concentrated solar plants, with wind and hydro plants playing dominant role in the country's energy generation (Ibtissam, 2016). The country's mega-project in energy generation will provide about half of the country's electricity by 2020. Studies revealed that as at 2015, geothermal in Kenya accounted for about 51 per cent of country's energy mix – up from only 13% in 2010. Kenya is also improving on wind energy generation, and as present, the country has one of Africa's largest wind farms (310 MW) which has also set to provide another 20% of the country's installed electricity generating capacity. According to the CRP 2016 annual, the combination of the two will help Kenya in generating about 71% of its electricity from renewable energy sources. No doubt outcome of a diligent study on the modality of operations of the framework provided by the governments of these nations can be a guide to the development of frameworks specific to Nigeria's context.

II. METHODS

Research Design

The study employs a cross-sectional design to examine the consumer's attitude toward compliance assessment of solar energy to specified quality requirements and the determinants of compliance of practitioners and customers to quality requirement of Solar Energy facilities.

III. STUDY AREA

The research was conducted in Lagos, Ondo and Oyo States, due to their population densities, location of markets and relative numbers of installations of solar energy projects in southwestern Nigeria. These states were chosen due to their representation of the diverse solar energy markets in the region.

IV. TARGET POPULATION

The target population in the study included practitioners involved in the design, installation, and vendors of solar energy systems, as well as consumers utilizing solar energy facilities in Lagos, Ondo and Oyo States.

The Cochran formula (Cochran, 1977) was used to determine the sample size for both consumers and solar professionals.

V. SAMPLING

A purposive sampling technique was employed to select 106 participants for the survey. Relevant industry associations, organizations, and regulatory bodies including the Standard Organisation of Nigeria (SON) collaborated to identify potential stakeholders and participants who possess the necessary expertise and experience in the solar energy sector.

VI. RESEARCH INSTRUMENTS

The research instrument for data collection was a questionnaire consisting of multiple-choice and closed-ended questions. The questionnaire was divided into sections, covering socio-demographic characteristics, attitudes toward compliance assessment, and determinants of compliance of practitioners and customers to quality requirement of Solar Energy facilities.

VII. DATA COLLECTION

Data were collected through survey questionnaires with the aid of trained research assistants on the field to collect the data. The questionnaires were self-administered or conducted through assisted-administered interviews, depending on the preference and convenience of the participants.

VIII. DATA ANALYSIS

The survey questionnaire data was analyzed using Statistical Package for Social Sciences (SPSS) and Excel. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize the survey responses.

IX. ETHICAL CONSIDERATIONS

Ethical considerations were taken into consideration throughout the conduct of this research work. Informed consents were done on all participants with a view to ensuring that their confidentialities and voluntary participation are secured. The research also adhered to all ethical principles and guidelines of data privacy and protection.

X. RESULTS

Table 4.1: Attitude toward compliance assessment of Solar Energy to specified quality requirements

Statement	Response	Frequency (n=106)	Percentage %
The understanding as regards quality requirements/ standards on solar energy facilities	Low	35	33.0
	Much	42	39.6
	None	8	7.5
	Outstanding	21	19.8
Period (years) using/installing solar energy facilities	Less than 5	34	68.0
	less than 10	10	20.0
	More than 10	6	12.0
The use of solar energy is cheaper than power from Distribution Companies	I don't know	6	5.7
	No	10	9.4
	Yes	90	84.9
The use of solar energy is more reliable than power from Distribution Companies	I don't know	14	13.2
	No	6	5.7
	Yes	86	81.1
As a user/installer, I buy what I can afford	No	16	15.1
	Undecided	21	19.8
	Yes	69	65.1
Are you aware that not all solar energy facilities	No	21	19.8
	Undecided	12	11.3

imported to Nigeria are of good quality	Yes	73	68.9
Do you import your Solar Energy from the manufacturers	No	63	59.4
	Yes	43	40.6
Do you buy your Solar Energy facilities from local sellers in Nigeria	Anyhow	5	4.7
	No	30	28.3
	Yes	71	67.0
Do you check for the certification/registered mark of quality before buying solar energy items?	No	20	18.9
	Undecided	22	20.8
	Yes	64	60.4

A significant proportion of respondents (69.8%) agreed that solar energy installation hardly lasts up to 5 years, indicating relatively recent involvement in the sector. A smaller proportion (19.8%) subscribed to between 4 and 10 years of experience, while 10.4% subscribed to more than 10 years of experience.

Majority of respondents (84.9%) accepted that the use of solar energy is cheaper than power from Distribution Companies, indicating a positive perception of solar energy affordability. Similarly, 88.7% of respondents believe that solar energy is more dependable than power from Distribution Companies, indicating a high level of confidence in solar energy technology. On affordability, 65.1% of respondents embraced solar energy, while 34.9% considered other factors as the basis of selection for their decision. A substantial portion of respondents (68.9%) agreed that not all solar facilities imported to Nigeria are of good quality, highlighting concerns about product quality and reliability. Importantly, 60.4% of respondents consented to check for certification/registered marks of quality before purchasing solar energy facilities, indicating a proactive approach to ensuring quality and compliance. A very high proportion of respondents (81.6%) engaged in buying solar energy facilities from local sellers in Nigeria, showing a preference for local suppliers. However, a smaller proportion (40.6%) reported importing directly from manufacturers, indicating diverse sourcing strategies within the respondent group.

Table 4.2**:** Determinants of compliance of practitioners and customers to quality requirement of Solar Energy facilities

Statement	Response	Frequency (n=106)	Percentage (%)
Poor electricity supply from Distribution companies	No	10	20.0
	Yes	40	80.0
Quality of materials used	No	7	6.6
	Yes	99	93.4

Qualifications of practitioners	No	31	29.2
	Yes	75	70.8
Availability of standard	No	12	11.3
	Yes	94	88.7
Levels of awareness of quality products	No	6	5.6
	Yes	100	94.3
Enforcement of standards	No	11	10.4
	Yes	95	89.6
Government policy on renewable energy	No	15	14.2
	Yes	91	85.8
Certification Process	No	22	20.8
	Yes	84	79.2
Duration of Certification process	No	20	18.9
	Yes	86	81.1
Financial capability of importers/ Installers	No	20	18.9
	Yes	86	81.1
Availability of genuine spare parts	No	10	9.4
	Yes	96	90.6
Maintenance culture	No	5	4.7
	Yes	101	95.3
Attitude to public properties	No	11	10.4
	Yes	95	89.6

Table 4.2 outlines determinants influencing compliance with quality requirements among practitioners and customers in the solar energy sector.

A vast majority of respondents (89.5%) cited poor electricity supply from distribution companies as a determinant influencing compliance. This reflects how unreliable power from the grid could be, and the need to invest in solar energy as the preferred option. Quality of materials was identified as a critical parameter by almost all the respondents (93.4). This indicates that quality of facilities determines performance and longevity of installations.

Competence and qualifications of installers were also identified as major factors influencing the performance of solar energy facilities by a significant majority of respondents (70.8%). This underscores the importance of skilled and qualified professionals in the solar energy industry. The availability of relevant standards (88.7%) and high levels of awareness of certified products (94.3%) were cited as very critical, indicating the importance of clear guidelines and informed decision-making in ensuring compliance with quality requirements. Most Respondents (89.6%) recognized the significance of enforcement of standards and government policy on

renewable energy (85.8%) in driving compliance. Factors such as the certification process (80.8%), its duration (81.1%), the financial capability of importers/installers (81.1%), availability of genuine

spare parts (90.6%), and maintenance culture (95.3%) were also identified as important determinants. These factors collectively contribute to ensuring the quality and reliability of solar energy systems over their lifecycle. Lastly, respondents highlighted the attitude toward public properties (89.6%) as a determinant, suggesting the importance of responsible behavior and stewardship in the solar energy industry.

XI. DISCUSSION OF FINDINGS

I. Product Quality and Durability

The study revealed that more than two-third of respondents agreed that solar installations hardly last up to five years. This finding reflects the Nigerian Energy Support Programme (NESP) study, which reported that some panels lose up to 20% of their output within three years (Alli, 2025). Similarly, Chibuzor (2025) noted that up to 40% of solar components available in Nigeria fail to meet international standards. These results highlight the challenge of substandard products and poor installation practices, which are consistent with the Renewable Energy Association of Nigeria's (REAN) observation that almost half of installed systems suffer from design flaws, including wrong orientation and inappropriate inverters.

II. Consumer Perception and Affordability

The findings indicate strong consumer confidence in solar technology, almost 9 in ten of respondents affirmed that solar is cheaper than electricity from distribution companies, while the majority considered it more dependable. This perception aligns with Uzoma et al. (2016) and George (2020), who emphasized the unsustainability of reliance on fossil fuel-based generators and the rising costs of fuel. Globally, Manish et al. (2019) projected that solar PV will account for up to 69% of the energy share by 2050, a projection reinforced by the high level of dependability attributed to solar energy in this study.

III. Awareness and Quality Assurance

A significant proportion of respondents reported checking for certification or quality marks before purchasing solar facilities, indicating an encouraging awareness of quality standards. This supports Giwa et al. (2017) and Sambo (2009), who emphasized that Nigeria has vast solar potential but requires strong quality assurance mechanisms to maximize it. Nonetheless, despite consumer vigilance, weak enforcement of regulations allows the influx of uncertified products, suggesting a gap between awareness and regulatory oversight.

IV. Grid Supply and Drivers of Solar Adoption

The study identified poor electricity supply from distribution companies approximately 9 in ten as a major determinant influencing compliance with solar quality standards. This finding is consistent with George (2020), who argued that off-grid generation already provides more than four times the supply of the national grid. The unreliability of grid power, therefore, compels households and businesses to embrace solar energy as a more stable and secure option.

V. Technical Competence and Installation Practices

Very large proportion of the respondents highlighted the importance of installer competence in ensuring system performance and longevity. This echoes Adetona et al. (2020), who reported that poor technical expertise and installation flaws significantly undermine solar systems. The prevalence of design errors and wrong battery capacities in Nigeria reflects the need for professional training and stricter licensing of practitioners to raise the sector's technical standards.

VI. Policy, Standards, and Enforcement

The importance respondents placed on enforcement of standards and government policy supports international experiences. For instance, the Climate Reality Project (2016) showed that Sweden, Germany, and Costa Rica successfully advanced renewable energy through deliberate policy frameworks, strong regulatory enforcement, and investments in smart technologies. In contrast, Nigeria's weak enforcement culture and inadequate statutory regulation (Alli, 2025) limit the sector's growth and allow unprofessional practices to thrive.

VII. Maintenance and Sustainability

A striking proportion of the respondents cited maintenance culture as a key determinant of compliance, while 90.6% emphasized availability of genuine spare parts. This is consistent with Adetona et al. (2020), who found that three-quarter of users reported no maintenance on their solar systems, and more than half received no after-sales support. Without sustainable maintenance frameworks, even high-quality installations may fail prematurely, reinforcing the importance of after-sales services and consumer education on system care.

CONCLUSION AND IMPLICATIONS

The findings of this study show that while solar energy is widely perceived as a cheaper and more dependable alternative to grid electricity, the sector in Nigeria is constrained by poor-quality products, weak regulatory enforcement, and inadequate technical expertise. The short lifespan of many installations and the widespread presence of uncertified components confirm earlier empirical studies that highlight the dominance of substandard materials and poor installation practices in the market.

On the positive side, respondents demonstrated a high level of awareness of certification and quality requirements, and most recognized the importance of government policy, enforcement of standards, and maintenance culture in ensuring system reliability. These align with global lessons where renewable energy success has been driven by strong regulations, quality assurance, and supportive policy frameworks.

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