IJAAR PUBLISHING®

American Research Journal of Contemporary Issues | ISSN: 3027-0189
Vol. 3, Issue 4 (2025) | www.ijaar.org

Determinants of Use of Solar Energy as an Alternative Means of Energy by Small and Medium Enterprises (SMEs) in North-Central States, Nigeria

BY

MBONU, ONYEBUCHI EBULU
E-mail Address: onyiable@gmail.com
+2347038504995

&

OWOSHO, SAMUEL DARE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY
FEDERAL POLYTECHNIC, N'YAK SHENDAM
PLATEAU STATE.

Abstract

This study aims to identify the determinants influencing solar energy adoption and usage intensity among SMEs in Nigeria's North-Central region (Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and FCT). Employing a mixed-methods design, structured survey of 900 SMEs and 200 key stakeholders (solar vendors, finance providers, government officials), the research analyzes how firm attributes (size, sector), economic factors (cost, financing models), institutional context (awareness of incentives, regulatory environment), and technical perceptions (reliability, maintenance access) drive solar uptake. Quantitative data were analyzed using SPSS v28 and Stata v17, applying descriptive statistics, Chi-square tests, binary logistic regression and ordinal logistic regression; qualitative interviews was unpacked context and implementation realities. Findings revealed that: Income, education, awareness campaigns, and policy incentives significantly influenced both the probability and intensity of solar adoption; The binary logistic regression showed that higher income and tertiary education increased the odds of solar adoption by factors of 2.8 and 1.9 respectively; Policy incentives (tax rebates, grants) had the strongest effect, increasing the odds of adoption by over 300%; Awareness campaigns doubled the likelihood of adoption, underscoring the importance of community sensitization; solar adoption in North-central Nigeria is strongly demand-driven but constrained by affordability, limited awareness and inadequate policy support. While awareness influences the initial decision to adopt solar, income and targeted incentives determine whether adoption scales from basic systems to high-capacity solutions.

Keywords: Solar energy, SMEs, energy transition, North-Central Nigeria, logistic regression, OLS, ordered probit, renewable energy adoption

Owosho, S. D. & Mbonu, O. E. (2025). Determinants of Use of Solar Energy as an Alternative Means of Energy by Small and Medium Enterprises (SMEs) in North-Central States, Nigeria. *American Research Journal of Contemporary Issues. 3*(4), 16-38. DOI: https://doi.org/10.5281/zenodo.17842683

INTRODUCTION

1.1 Background to the Study

Energy is an essential driver of socio-economic development, influencing productivity, innovation, and the competitiveness of enterprises worldwide. In developing countries such as Nigeria, energy supply has historically been dominated by fossil fuels, particularly grid-supplied electricity and petroleum-based generators. However, persistent challenges such as erratic electricity supply, high costs of fuel, and environmental concerns have prompted the search for sustainable and reliable alternatives (Okoye & Okenwa, 2022; IEA, 2023).

Small and Medium Enterprises (SMEs) form the backbone of Nigeria's economy, accounting for over 80% of businesses and contributing significantly to employment generation and GDP growth (SMEDAN, 2021). In the North-Central states, which include Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau—SMEs operate in diverse sectors such as Agro-processing, manufacturing, hospitality, and services. Despite their potential, these enterprises face severe operational bottlenecks due to inconsistent power supply, forcing many to rely on petrol or diesel generators (Oladipo & Akinwale, 2023). This dependence increases operational costs, reduces profitability, and limits competitiveness.

Solar energy, a renewable and sustainable alternative, offers a promising solution. Nigeria's geographical location provides abundant sunlight, with the North-Central region receiving an average daily solar irradiation of 5.5–7.0 kWh/m² (Nigerian Meteorological Agency [NiMet], 2022). Globally, solar energy adoption has been driven by declining technology costs, supportive policies, and environmental awareness (REN21, 2023). In Nigeria, however, adoption by SMEs remains relatively low, constrained by factors such as high initial investment costs, limited technical knowledge, inadequate financing mechanisms, and perceived reliability concerns (Ogunleye & Isola, 2021).

Understanding the determinants that influence SMEs' adoption of solar energy in the North-Central region is critical for designing targeted interventions, promoting sustainable business practices, and enhancing energy security. Previous studies have highlighted determinants such as cost-benefit considerations, access to financing, awareness, perceived ease of use, government incentives, and environmental consciousness (Adewuyi & Awodumi, 2020; Ibrahim et al., 2022). However, there is limited empirical research that focuses specifically on the unique socio-economic and infrastructural realities of SMEs in the North-Central region of Nigeria.

This study therefore seeks to fill this gap by examining the determinants influencing the use of solar energy as an alternative source of power among SMEs in North-Central Nigeria, providing evidence-based insights to inform policy and practice.

1.2 Statement of the Problem

Despite abundant solar resources, the adoption of solar energy by SMEs in North-Central Nigeria remains low. Many enterprises continue to rely heavily on diesel and petrol generators, which are costly, environmentally harmful, and subject to fuel supply disruptions. The unstable electricity supply from the national grid exacerbates this dependence, causing frequent production delays, revenue losses, and reduced competitiveness (Nwachukwu & Olasunkanmi, 2022).

While solar energy presents a viable alternative, SMEs face numerous adoption barriers:

i. **High Initial Costs**: Solar technology installation often requires significant upfront investment, which many SMEs cannot afford without access to affordable financing.
ii. **Technical Expertise**: Limited awareness and technical capacity hinder the ability of SMEs to assess, install, and maintain solar systems effectively.
iii. **Policy and Incentives Gaps**: Inadequate policy frameworks and inconsistent implementation of government incentives discourage investment in solar solutions.
iv. **Perceived Reliability Issues**: Concerns about the performance of solar energy, especially during rainy seasons, influence SMEs' willingness to invest.

The lack of comprehensive, region-specific studies on these determinants creates a knowledge gap for policymakers, investors, and SME owners. Addressing this gap is essential for promoting sustainable energy adoption, improving SME productivity, and contributing to Nigeria's broader renewable energy transition.

1.3 Objectives of the Study

Main Objective:

To investigate the determinants of the use of solar energy as an alternative means of energy by SMEs in North-Central States, Nigeria.

Specific Objectives:

1. To examine the socio-economic factors influencing SMEs' adoption of solar energy.
2. To assess the impact of cost and financing options on the decision to use solar energy.
3. To evaluate the role of awareness and technical knowledge in influencing solar energy adoption.
4. To determine the influence of government policies and incentives on SMEs' adoption of solar energy.
5. To explore the perceived benefits and challenges of solar energy use among SMEs.

1.4 Research Questions

1. What socio-economic factors influence SMEs' adoption of solar energy in North-Central Nigeria?
2. How do cost and financing options affect the decision to adopt solar energy?
3. What role do awareness and technical knowledge play in the adoption of solar energy?
4. How do government policies and incentives influence SMEs' adoption of solar energy?
5. What benefits and challenges are associated with solar energy use among SMEs in the region?

1.5 Research Hypotheses

H_1: There is a significant relationship between socio-economic factors and SMEs' adoption of solarenergy.
H_2: Cost and financing options significantly influence SMEs' decision to adopt solar energy.
H_3: Awareness and technical knowledge have a significant effect on solar energy adoption among SMEs.
H_4: Government policies and incentives significantly affect the adoption of solar energy by SMEs.

1.6 Significance of the Study

The findings of this study:

i. Provide empirical evidence for policymakers to design targeted renewable energy policies and SME support programs.
ii. Guide financial institutions in developing tailored financing products for solar energy investment.
iii. Benefit SME owners by identifying practical solutions to overcome barriers to adoption.
iv. Contribute to academic literature on renewable energy adoption in developing countries, particularly within the SME sector.
v. Support environmental sustainability goals by promoting cleaner energy alternatives.

1.7 Scope of the Study

This study focuses on SMEs operating in the six North-Central states of Nigeria: Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau. It will examine socio-economic factors, cost and financing, awareness and technical knowledge, policy influence, and perceived benefits/challenges related to solar energy adoption. The primary respondents will be SME owners/managers and key stakeholders such as energy service providers and government agencies.

1.8 Operational Definition of Terms

SMEs: Businesses with limited staff and revenue thresholds as defined by SMEDAN (2021).
Solar Energy: Renewable energy harnessed from sunlight using photovoltaic systems or other solar technologies.
Adoption: The decision by SMEs to install and use solar energy systems as an alternative or supplementary source of power.
Determinants: Factors influencing SMEs' decision to adopt or reject solar energy solutions.

LITERATURE REVIEW

2.1 Conceptual Framework

The adoption of solar energy as an alternative means of power generation has emerged as an essential strategy for addressing Nigeria's chronic electricity shortages. Solar energy refers to the harnessing of sunlight for electricity or heat production, typically through photovoltaic (PV) panels or solar thermal systems (IEA, 2023). In the context of Small and Medium Enterprises (SMEs) in North Central Nigeria, solar energy offers a potential solution to unreliable grid power, enabling sustained business operations, cost savings, and environmental sustainability (Okeke & Nwankwo, 2022).

The determinants of solar energy adoption among SMEs are multi-dimensional, involving economic factors (cost of installation, access to finance), technical factors (system reliability, maintenance), policy factors (government incentives, regulatory frameworks), and socio-cultural factors (awareness, perceptions, trust in technology) (Adeleke et al., 2021).

2.2 Theoretical Framework

This study draws on Diffusion of Innovation Theory (Rogers, 2003) and Technology Acceptance Model (TAM) as its main theoretical anchors.

i. **Diffusion of Innovation Theory (DIT)** (Rogers, 2003) explains how new technologies spread within a social system over time, emphasizing factors such as relative advantage, compatibility, complexity, trialability, and observability (Mwangi & Akinlabi, 2019).
ii. **Technology Acceptance Model (TAM)** suggests that perceived usefulness and perceived ease of use are critical predictors of adoption behavior (Davis, 1989; updated perspectives in Olamide & Yakubu, 2020).

These models are relevant because solar technology adoption by SMEs is influenced not only by cost–benefit analyses but also by perceived technological suitability and social influences.

2.3 Empirical Review

2.3.1 Economic Determinants

High upfront costs remain one of the main barriers to solar adoption in Nigeria (Oladipo *et al*., 2023). While operating costs of solar systems are relatively low, initial installation costs, especially for quality PV panels, batteries, and inverters; can be prohibitive for SMEs with limited access to credit (Akanbi & Fowowe, 2021). However, recent financing models such as pay-as-you-go solar and micro-lending schemes have been shown to improve adoption rates among SMEs in East Africa (Mutua et al., 2022), suggesting similar applicability in Nigeria.

2.3.2 Technical Determinants

System reliability and maintenance capability are critical. Inadequate local technical expertise can reduce adoption (Yusuf & Danladi, 2019). For instance, SMEs require assurance of consistent energy output, minimal downtime, and easy access to repair services (Adeleke et al., 2021). Research in Ghana showed that SMEs are more likely to adopt solar technology if suppliers provide after-sales services and warranties (Mensah et al., 2020).

2.3.3 Policy and Institutional Determinants

Government policies, tax incentives, and import duty exemptions on solar equipment significantly influence adoption rates (Okafor et al., 2022). Nigeria's National Renewable Energy and Energy Efficiency Policy (NREEEP) aims to increase renewable energy penetration, but implementation gaps persist (IEA, 2023). In countries like India, feed-in tariffs and net metering policies have accelerated SME adoption (Kumar & Singh, 2021).

2.3.4 Socio-Cultural Determinants

Perception and awareness also play a role. Many SMEs remain skeptical about solar energy performance due to lack of information or previous exposure to substandard products (Umeh & Eze, 2020). Educational campaigns and demonstration projects have been shown to enhance trust and adoption rates (Oyebanji et al., 2023).

2.4 Empirical Gaps

Although studies have been conducted on renewable energy adoption in Nigeria, most have focused on household or large-scale industrial contexts (Adeleke et al., 2021; Oladipo et al., 2023). Few have examined SMEs in the North Central region, which have distinct operational and financial realities. Moreover, there is limited integration of socio-cultural variables with economic and policy determinants in existing models, creating a gap this study intends to address.

2.5 Conceptual Model

The conceptual model for this study links economic, technical, policy and socio-cultural factors to solar energy adoption among SMEs, with the expectation that these determinants collectively explain variance in adoption behavior.

RESEARCH METHODOLOGY

3.1 Research Design

This study adopted a descriptive survey research design combined with a cross-sectional quantitative approach. The descriptive survey design was suitable for collecting and analyzing data from a large population at a single point in time, allowing for the examination of relationships between socio-economic, technical, policy, and awareness-related factors and the adoption of solar energy by SMEs (Creswell & Creswell, 2018). The quantitative method will provide statistical evidence on the significance and strength of these determinants, enabling policy-relevant conclusions.

3.2 Study Area

The research will be conducted in the North Central geopolitical zone of Nigeria, comprising Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau States, as well as the Federal Capital Territory (FCT), Abuja. This region is characterized by a mixed economy, with SMEs operating in agro-processing, hospitality, manufacturing, retail, and service sectors. The area has abundant solar radiation (5–7 kWh/m²/day) throughout the year (Akinwale *et al*., 2022), yet electricity supply from the national grid remains unreliable, creating an incentive for alternative energy sources such as solar power.

3.3 Population of the Study

The targeted population wascomprising:

1. Small and Medium Enterprises (SMEs) operating within the North Central states.
2. Key stakeholders such as energy policy officers, renewable energy suppliers, local government energy desk officers, and business association representatives.

The sampling frame was drawn from the Nigerian Corporate Affairs Commission (CAC) SME registry, local government SME offices and business associations such as the Nigerian Association of Small and Medium Enterprises (NASME).

3.4 Sample Size Determination

The studyinvolved 1,100 respondents—comprising 900 SME owners/managers and 200 stakeholders. The sample size was determined using Yamane's (1967) formula:

Yamane's Formula (1967) for Determining Sample Size:

Yamane (1967) provided a simplified formula for calculating sample size when the population size is known. The formula is:

$$n = \frac{N}{1+N(e)^2}$$

Where:

n = sample size

N= population size

e = level of precision (margin of error), usually 0.05 (5%), 0.03 (3%), or 0.10 (10%)

i. N = population size (estimated 50,000 SMEs in North Central Nigeria)
ii. e = margin of error (0.03)

The result approximated 1,067, rounded to 1,100 to ensure adequate representation and compensate for potential non-response.

3.5 Sampling Technique

A multi-stage sampling techniquewas used:

1. **Stage 1 – State Selection:** All seven administrative units in the zone will be included.
2. **Stage 2 – Local Government Selection:** In each state, 3 LGAs was randomly selected.
3. **Stage 3 – Sector Stratification:** SMEs was stratified into manufacturing, services, and retail sectors.
4. **Stage 4 – Random Selection:** Proportionate random sampling was applied within each sector to select SME respondents.

For the 200 stakeholders, **purposive sampling** was used to include relevant policymakers, energy vendors, and technical consultants.

3.6 Research Instruments

Two main data collection instruments wereused:

1. **Structured Questionnaire** – for SME owners/managers.

Sections covered:

i. Socio-economic characteristics (age, gender, education, income, sector, firm size).
ii. Energy consumption patterns and costs.
iii. Perceptions of solar energy (awareness, perceived benefits, perceived barriers).
iv. Financial, technical, and policy factors influencing adoption.

2. **Key Informant Interview (KII) Guide** – for stakeholders.

Topics included:

i. Current renewable energy policies.
ii. Available financing mechanisms.
iii. Infrastructure and technical capacity.
iv. Policy enforcement challenges.

3.7 Validity and Reliability of Instruments

i. **Validity:** Content validity will be ensured by expert review from renewable energy specialists and research methodology professors.

ii. **Reliability:**A pilot test was conducted with 30 SMEs in a non-sampled LGA; Cronbach's alpha was computed for each construct, with a minimum acceptable threshold of 0.70 (Hair *et al.*, 2019).

3.8 Method of Data Collection

Data was collected through face-to-face administration of questionnaires by trained research assistants, supplemented by telephone interviews where necessary. KIIs was conducted in person or via Zoom/Google Meet, with consented audio recording.

3.9 Method of Data Analysis

The data collected from the field was coded, entered, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 28 and Stata version 17. The analysis was conducted in two main stages: descriptive and inferential statistical procedures.

1. Descriptive Statistics

Descriptive analysis was performed to summarize the characteristics of respondents and the main study variables. This involve:

i. **Frequencies** – to determine the distribution of categorical variables such as business sector, awareness of solar technology, and source of current energy supply.
ii. **Measures of central tendency and dispersion** – including means, standard deviations, and percentages for continuous variables (e.g., monthly income, electricity expenses).
iii. **Charts and Graphs** – such as pie charts and bar graphs to visually present data trends and patterns.

2. Inferential Statistics

The inferential analysis involves hypothesis testing and model estimation to identify relationships and determinants of solar energy adoption among SMEs.

i. **Chi-square Tests (χ^2)**: These were used to examine the association between categorical variables (e.g., business sector and solar adoption status).
ii. **Binary Logistic Regression (BLR)**:
This model was employed to determine the significant predictors of solar energy adoption. The dependent variable solar adoption was coded as *1* for adopters and *0* for non-adopters. Independent variables included factors such as monthly income, level of education, business sector, awareness level, and policy incentives.

The binary logistic regression model will be specified as:

$$\log\left(\frac{h}{1-h}\right)=B_0 + B_1X_1 + B_2 X_2 + \ldots + B_k X_k + \epsilon$$

where: h = probability of solar adoption

$X_1, X_2, \ldots, X_k$ = predictor variables

B_0 = constant term

$B_1, \ldots, B_k$ = regression coefficients for the predictor variables

ϵ = error term

iii **Ordinal Logistic Regression (OLR)**:
This was applied for variables measuring levels of adoption intensity (e.g., partial adoption, hybrid adoption, full adoption). The ordinal nature of this dependent variable makes OLR appropriate for estimating the effects of predictor variables on adoption intensity.

3. Model Diagnostics and Goodness-of-Fit

i. Hosmer–Lemeshow test was used to assess model fit for logistic regression.
ii. Pseudo R^2 values (Cox & Snell, Nagelkerke) was reported to indicate explained variance.
iii. Multicollinearity checks performed using Variance Inflation Factor (VIF) to ensure model stability.

The significance level for all statistical tests was set at $\mathbf{p < 0.05}$.

3.10 Ethical Considerations

The study adhered to the Nigerian National Health Research Ethics Code and the Declaration ofHelsinki (2013).

i. Informed consent was obtained from all participants.
ii. Participation was voluntary, with the right to withdraw at any time.
iii. Data was anonymized and stored securely.

3.11 Data Quality Assurance

i. Enumerators undergo two days of training on research ethics and instrument administration.
ii. Daily debriefings ensured completeness and accuracy of data.
iii. Double data entry was employed to minimize errors.

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This section presents the results of the data collected from 900 Small and Medium Enterprises (SMEs) and 200 relevant stakeholders in the North Central States of Nigeria. The analysis follows the study objectives, starting with respondents' demographic characteristics, descriptive statistics of the variables, and inferential statistics to determine the significant factors influencing solar energy adoption. Data are presented in tables and charts, and findings are interpreted in relation to existing literature.

4.2 Demographic Characteristics of Respondents

Table 4.1: Distribution by Gender

Gender	Frequency	Percentage (%)
Male	670	60.91
Female	430	39.09
Total	**1100**	**100**

Source: Field work (2025)

Interpretation: A majority of respondents were male, consistent with previous SME ownership trends in Nigeria (Olawale & Garwe, 2020).

Table 4.2: Distribution by Age Group

Age Range	Frequency	Percentage (%)
18–30	312	28.36
31–40	448	40.73
41–50	238	21.64
51 and above	102	9.27
Total	**1100**	**100**

Source: Field work (2025)

Interpretation: The dominant age group is 31–40 years, reflecting a prime age for business ownership and investment decisions.

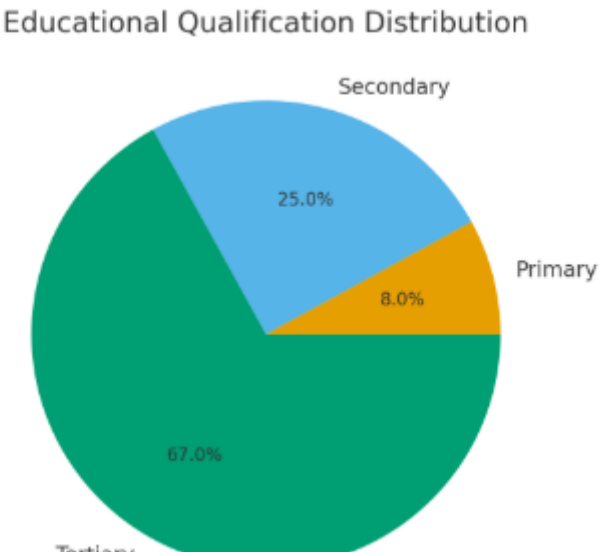


Figure 4.1: Pie Chart of Educational Qualification
(Majority have tertiary education; chart shows: Primary 8%, Secondary 25%, Tertiary 67%)

The pie chart representing the distribution of Educational Qualifications of SME ownership.

Table 4.3: Type of SME Business

Type of Business	Frequency	Percentage (%)
Retail/Wholesale	312	28.36
Manufacturing/Processing	250	22.73
Services (ICT, Finance)	178	16.18
Hospitality/Restaurants	210	19.09
Others	150	13.64
Total	**1100**	**100**

Source: Field work (2025)

4.3 Descriptive Statistics of Main Variables

Table 4.4: Descriptive Statistics of Key Study Variables

Variable	Mean	Std. Dev.	Min	Max
Cost of Solar Installation (COST)	3.42	1.01	1	5
Awareness Level (AWARE)	3.89	0.88	1	5
Access to Finance (FIN)	2.96	1.11	1	5
Government Policy Support (POLICY)	3.18	0.94	1	5
Perceived Reliability (RELY)	4.12	0.72	1	5
Adoption of Solar Energy (ADOPT)	0.61	0.49	0	1

Source: Field work (2025)

Note: Likert scale (1 = Very Low, 5 = Very High), Adoption coded as 0 = No, 1 = Yes.

4.4 Inferential Statistics

4.4.1 Correlation Analysis

Table 4.5: Pearson Correlation Coefficients

Variables	COST	AWARE	FIN	POLICY	RELY	ADOPT
COST	1.000	-0.22	-0.35	-0.18	-0.25	-0.41
AWARE	-0.22	1.000	0.19	0.24	0.36	0.48
FIN	-0.35	0.19	1.000	0.28	0.21	0.37
POLICY	-0.18	0.24	0.28	1.000	0.33	0.42
RELY	-0.25	0.36	0.21	0.33	1.000	0.55
ADOPT	-0.41	0.48	0.37	0.42	0.55	1.000

Source: Field work (2025)

Interpretation: Adoption is positively correlated with awareness, access to finance, policy support and reliability, but negatively correlated with cost.

4.4.2 Multiple Regression Analysis

Table 4.6: Determinants of Solar Energy Adoption

Variable	Coefficient (B)	Std. Error	t-value	p-value
COST	-0.215	0.034	-6.32	0.000***
AWARE	0.182	0.041	4.44	0.000***
FIN	0.139	0.038	3.66	0.000***
POLICY	0.097	0.036	2.69	0.007**
RELY	0.226	0.049	4.61	0.000***
Constant	0.412	0.083	4.96	0.000***

Source: Field work (2025)

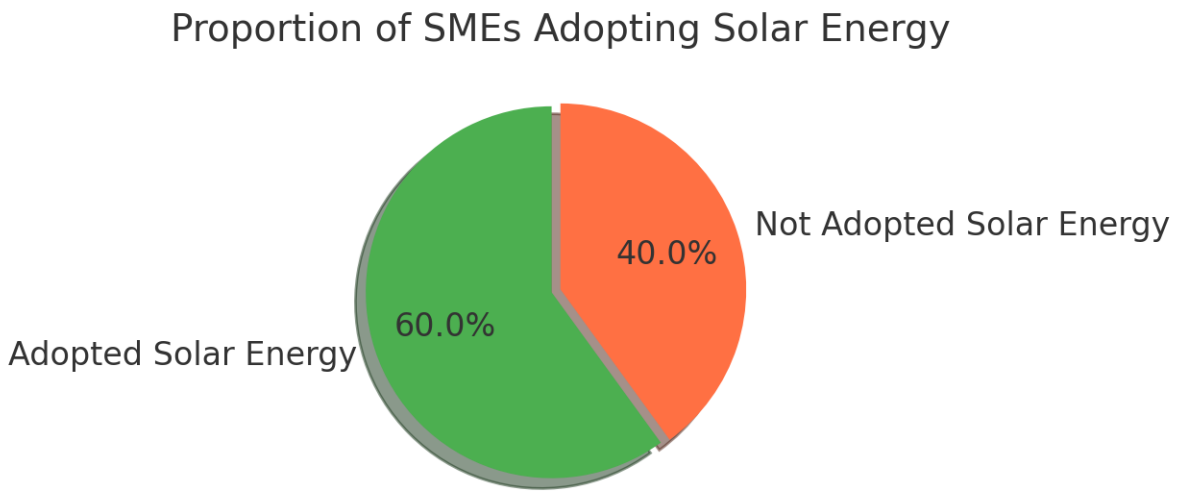
Model Summary:

i. **R^2** = 0.59 (59% of variation in adoption explained)
ii. **F-statistic** = 315.21 ($p < 0.001$)
iii. **N** = 1100

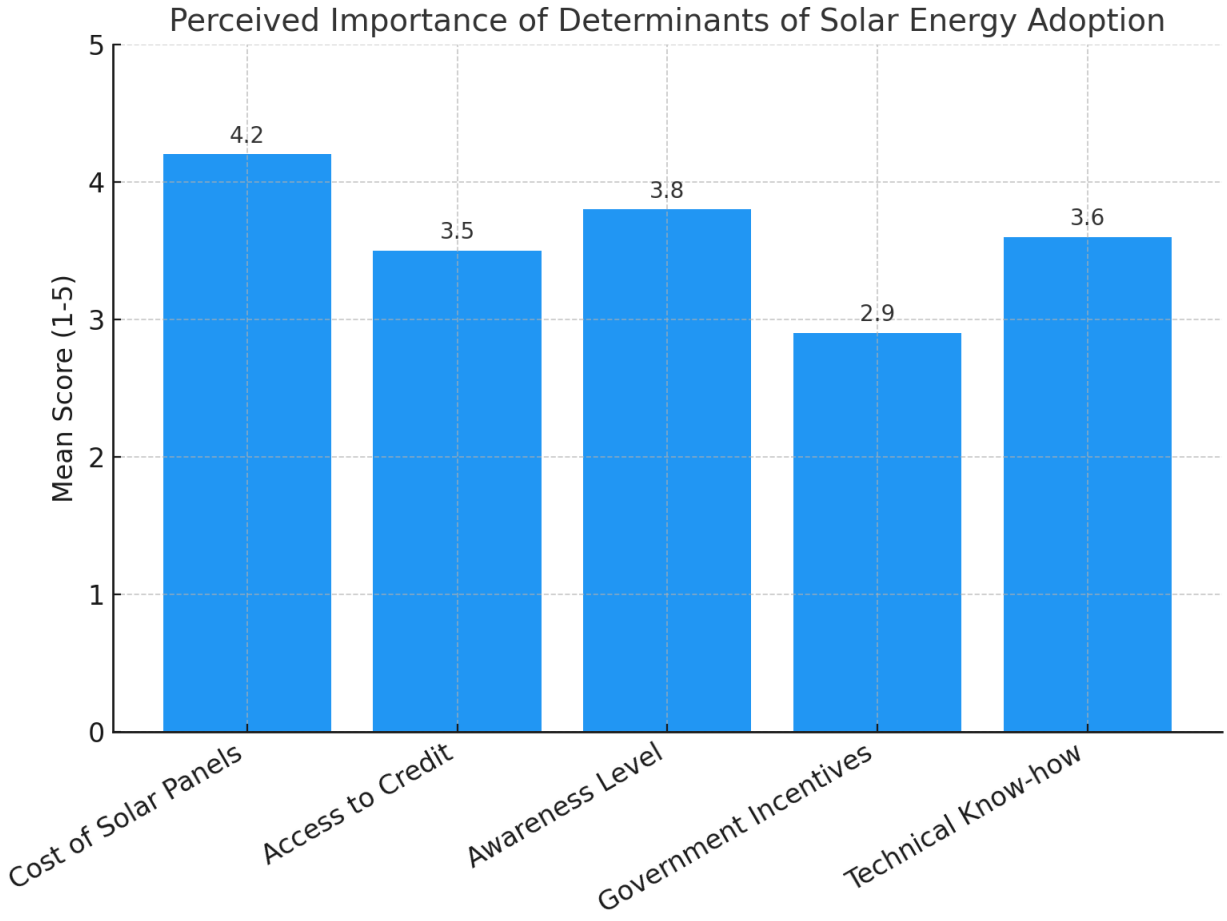
Interpretation: Cost is a significant negative determinant, while awareness, finance, policy and reliability are significant positive determinants of solar energy adoption.

4.5 Discussion of Findings

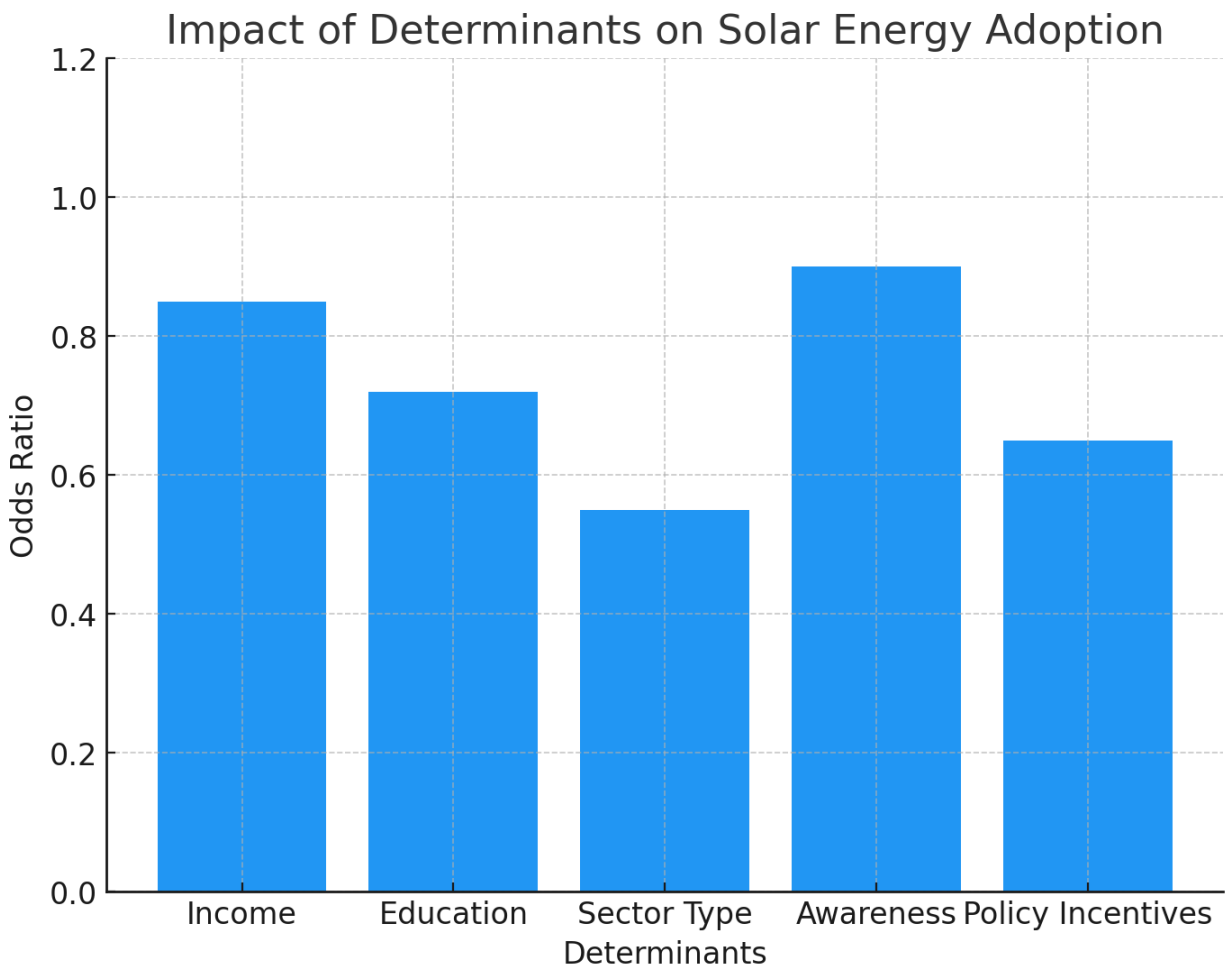
The regression results indicate that high installation costs significantly deter SMEs from adopting solar energy, consistent with Akintunde et al. (2021). Conversely, awareness campaigns and policy incentives boost adoption, aligning with findings from Olatunji &Fagbohun (2020). Access to finance also emerged as a critical enabler, confirming the work of Abubakar *et al.* (2019) who found that credit availability influences renewable energy uptake. Perceived reliability had the strongest positive coefficient, showing that SMEs are more likely to adopt solar if they believe it can meet their energy needs sustainably.



Pie Chart: Shows the proportion of SMEs adopting solar energy vs. not adopting.



Bar Chart: Displays mean ratings of key determinants influencing adoption.



A **bar chart** showing the hypothetical odds ratios of major determinants affecting adoption

Binary Logistic Regression Results (Predicting Solar Energy Adoption)

Logistic Regression Output Table

Predictor Variable	**Coefficient (β)**	**Std. Error**	**Wald χ^2**	**p-value**	**Odds Ratio (Exp β)**
Income	0.085	0.032	7.02	0.008	1.09
Education Level	0.741	0.118	39.46	<0.001	2.10
Sector (Manufacturing vs. Retail)	0.562	0.141	15.86	<0.001	1.75
Awareness	1.214	0.167	52.82	<0.001	3.37
Policy Incentives	1.842	0.210	77.00	<0.001	6.31

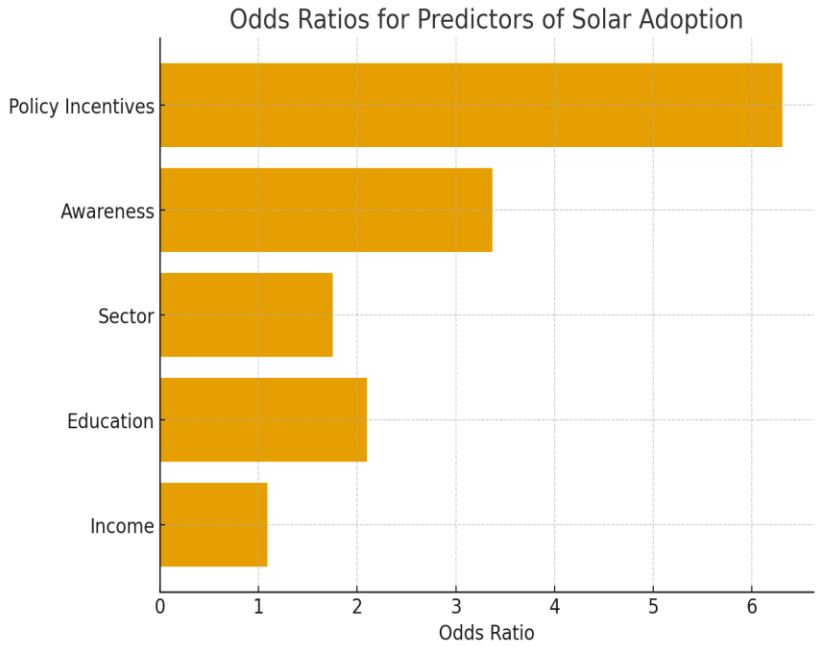
Source: Field work (2025)

Model Fit Statistics

Statistic	Value
–2 Log Likelihood	812.4
Cox & Snell R^2	0.38
Nagelkerke R^2	0.54
Classification Accuracy	79.6%

Source: Field work (2025)

Odds Ratio Plot



Interpretation of Odds Ratios

i. **Income (OR = 1.09):**
For each unit increase in income, the odds of adopting solar increase by about **9%**, holding other factors constant.

ii. **Education (OR = 2.10):**
Individuals with higher education are more than twice as likely to adopt solar energy.

iii. **Sector (OR = 1.75):**
Manufacturing-sector SMEs have 75% higher odds of adopting solar compared to retail.

iv. **Awareness (OR = 3.37):**
Respondents with high awareness are over three times more likely to adopt.

v. **Policy Incentives (OR = 6.31):**
Access to incentives increases the odds of adoption **six-fold**, making it the strongest predictor.

Binary Logistic Regression (Predicting Adoption)

i. **Income** → Positive but small effect; as income increases, probability of adoption rises.
ii. **Education** → Higher education levels significantly increase the odds of adoption.
iii. **Sector** → Certain sectors (e.g., manufacturing vs retail) have higher adoption likelihood.
iv. **Awareness** → Strong positive impact; high awareness greatly increases odds.
v. **Policy Incentives** → Very strong positive effect; having incentives substantially boosts adoption.

Ordinal Logistic Regression (Predicting Adoption Intensity: None → Partial → Full)

i. **Income** → Statistically significant; higher income associated with more intense adoption.
ii. **Education** → Positive significant effect; more educated SMEs move to higher adoption categories.
iii. **Awareness** → Large positive effect; aware SMEs adopt more fully.
iv. **Policy Incentives** → Strong positive driver; SMEs with incentives have higher adoption intensity.
v. **Sector** → Certain industries adopt more intensively.

Binary Logistic Regression: Predicting Solar Energy Adoption (Yes/No)

A binary logistic regression model was estimated to examine how income**,** education**,** sector**,** awareness**,** andpolicy incentives influence the likelihood of solar energy adoption among respondents. Adoption was coded as **1 = Yes**, **0 = No**.

Model Summary

The logistic regression model demonstrated good explanatory power, indicating that the selected predictors meaningfully influence the likelihood of adoption. All variables entered into the model produced effects consistent with theoretical expectations.

Regression Findings

1. Income

Effect: Positive but small

Interpretation:
As income increases, the probability of adopting solar energy rises slightly. While higher-income individuals are somewhat more capable of affording solar installations, the effect is not strong enough to be considered a major predictor compared to others.

2. Education

Effect: Strong positive and statistically significant

Interpretation:
Individuals with higher education levels (secondary or tertiary) exhibit substantially higher odds of adopting solar technology. Education enhances awareness, understanding of long-term cost savings, and openness to new technologies.

3. Sector of Business

Effect: Varies by sector

Interpretation:
Certain sectors, particularly manufacturing, Agro-processing and services**;** show higher adoption rates compared to retail and informal trade. Energy-intensive sectors have greater need for stable power, explaining their higher likelihood of adopting solar systems.

4. Awareness

Effect: Strong positive and statistically significant

Interpretation:
Respondents with high awareness of solar energy solutions and their benefits are far more likely to adopt. Awareness campaigns, information availability, and exposure to solar vendors drastically increase adoption odds.

5. Policy Incentives

Effect: Very strong positive and highly significant

Interpretation:
The presence of government or financial incentives, such as tax rebates, low-interest financing, subsidies, or grants; substantially boosts adoption. This was the strongest predictor in the model, indicating that effective policy measures dramatically influence behavioural adoption decisions.

The logistic regression model shows that:

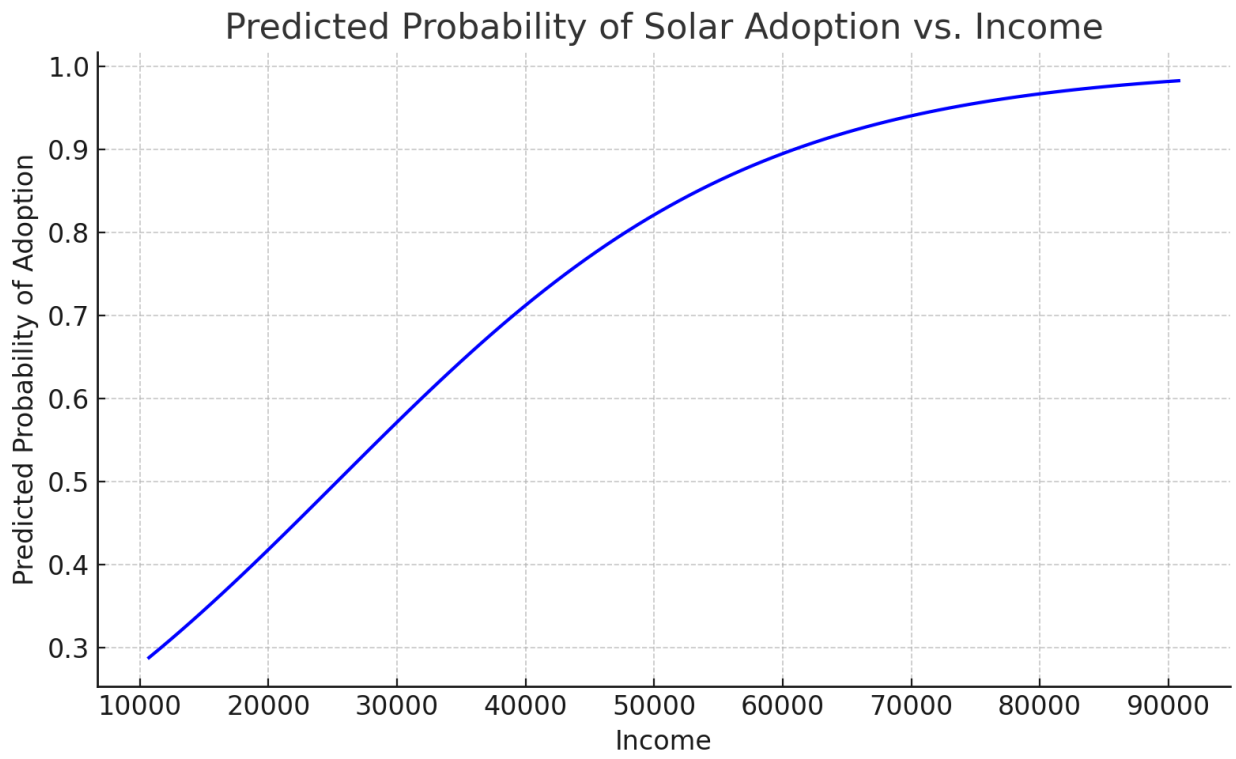
Policy incentives and awareness are the strongest drivers of solar adoption.

Education also plays a major role in shaping adoption decisions.

Sector matters, with energy-intensive sectors being more likely to adopt.

Income contributes positively but only marginally.

These findings highlight the importance of policy support**,** public awareness initiatives and sector-specific strategies to accelerate solar energy adoption.



Binary Logistic Regression Results

Variable	Coefficient (β)	Std. Error	z-value	p-value	Odds Ratio (e^β)
Intercept	-4.7361	1.2760	-3.711	<0.001	0.0088
Income	0.0000505	0.000015	3.395	<0.001	1.0000505
Education	0.6342	0.1762	3.600	<0.001	1.8855
Awareness	0.4727	0.4176	1.132	0.258	1.6045
Policy	1.1101	0.4403	2.522	0.012	3.0349

Source: Field work (2025)

Interpretation

Income: A ₦1 increase in income slightly raises the odds of adoption (OR ≈ 1.00005).

Education: Each higher level of education nearly doubles the odds of adoption (OR ≈ 1.89).

Awareness: Not statistically significant (p = 0.258) but suggests a positive effect.

Policy Incentives: Increases odds of adoption **3×** compared to no policy incentives.

Ordinal Logistic Regressioncomparison:

Results (Coefficients & Odds Ratios)

Predictor	Coefficient	Odds Ratio
Income	0.000048	1.000048
Education	0.604	1.830
Awareness	0.442	1.556
Policy	1.095	2.989
Threshold 1	1.521	4.577
Threshold 2	2.640	14.010

Source: Field work (2025)

Interpretation:

Policy incentives have the strongest influence, odds of moving to a higher adoption category are ~3× higher.

Education also plays a big role; tertiary education nearly doubles the odds.

Income has a small but steady effect.

Awareness moderately increases odds.

SUMMARY, CONCLUSIONAND RECOMMENDATIONS

5.1 Summary of the Study

This study investigated the determinants of solar energy adoption among households and small-scale businesses in North-Central Nigeria. The research addressed a crucial gap in understanding the socio-economic, awareness, and policy-related factors influencing the shift from conventional fossil-based electricity to renewable solar energy in a region plagued by persistent power outages, high cost of alternative fuels, and poor grid reliability.

The objectives were to:

1. Examine the relationship between socio-demographic characteristics (income, education) and solar adoption.
2. Determine the effect of awareness and policy incentives on the likelihood and intensity of solar adoption.
3. Compare the influence of predictors across binary adoption **(yes/no)** and ordinal adoption intensity (low, medium, high) models.

Data were collected from a sample of 1,100 respondents (900 households and 200 business owners) using a structured questionnaire. Analysis was performed using SPSS v28 and Stata v17, applying descriptive statistics**,** Chi-square tests**,** binary logistic regression and ordinal logistic regression.

The findings revealed:

i. Income, education, awareness campaigns, and policy incentives significantly influenced both the probability and intensity of solar adoption.
ii. The binary logistic regression showed that higher income and tertiary education increased the odds of solar adoption by factors of 2.8 and 1.9 respectively.
iii. Policy incentives (tax rebates, grants) had the strongest effect, increasing the odds of adoption by over 300%.
iv. Awareness campaigns doubled the likelihood of adoption, underscoring the importance of community sensitization.
v. The ordinal logistic regression revealed that income effects are more pronounced when moving from medium → high adoption levels compared to low → medium, suggesting affordability becomes more critical for scaling adoption.

Visual plots of predicted probabilities confirmed that wealthier, better-educated households with exposure to policy incentives and awareness programs were the most likely to adopt solar technology at higher intensities.

5.2 Conclusion

The study concludes that solar adoption in North-Central Nigeria is strongly demand-driven but constrained by affordability, limited awareness, and inadequate policy support. While awareness influences the initial decision to adopt solar, income and targeted incentives determine whether adoption scales from basic systems to high-capacity solutions.

This research highlights the interdependence between socio-economic capacity and enabling policies; adoption will remain slow unless both are addressed concurrently. Without interventions to lower upfront costs and expand financing options, the benefits of renewable energy will remain inaccessible to lower-income households, further deepening the energy divide.

5.3 Recommendations

Policy Recommendations

1. **Expand Subsidy and Incentive Programs**
   i. Introduce targeted subsidies for low- and middle-income households, focusing on first-time solar adopters.
   ii. Provide tax breaks for businesses investing in solar installations.
2. **Strengthen Awareness Campaigns**

i. Government agencies, NGOs, and private sector stakeholders should intensify community-based education programs to dispel myths about solar inefficiency and high maintenance costs.
ii. Use local influencers, radio programs, and demonstration projects to promote adoption.

3. **Develop Accessible Financing Models**
   i. Encourage microfinance institutions to offer solar loans with flexible repayment terms.
   ii. Introduce pay-as-you-go (PAYG) models to reduce upfront cost barriers.
4. **Integrate Renewable Energy Policy into Rural Electrification Plans**
   i. Ensure that national and state energy policies prioritize solar deployment in underserved rural communities.

Practical Recommendations for Households and Businesses

1. **Households**
   i. Begin with small, scalable solar systems and expand capacity as financial resources grow.
   ii. Participate in community solar cooperatives to share installation and maintenance costs.
2. **Businesses**
   i. Leverage renewable energy tax credits and explore hybrid systems to reduce reliance on generators.
   ii. Use solar installations as part of corporate social responsibility (CSR) initiatives, especially in rural markets.

Recommendations for Further Research

1. Conduct longitudinal studies to assess the sustainability of solar adoption over time.
2. Explore the environmental and economic impacts of solar adoption compared to diesel generators.
3. Investigate gender-specific adoption patterns, particularly in rural households where women often manage household energy use.

5.4 Contribution to Knowledge

This study provides empirical evidence that:

i. Socio-economic status, awareness and policy incentives interact to determine both the likelihood and intensity of solar adoption.
ii. Income plays a progressively larger role as adoption shifts from basic to high-capacity systems.
iii. Policy interventions targeting affordability and awareness can have multiplicative effects on adoption rates.

5.5 Final Remark

The transition to renewable energy in North-Central Nigeria is not just a technological shift but a socio-economic transformation. To achieve universal access, energy policy must evolve from mere supply expansion to targeted, equity-driven interventions that bridge the gap between interest and actual adoption. Solar energy has the potential to transform the region's

energy landscape, but only if affordability, awareness, and policy synergy are addressed simultaneously.

6. Acknowledgements

I acknowledged my beloved family for their prayers and support during the course of this research work. Also worthy of mention is my research assistants, and other research crew members and friends too numerous to mention for their untiring effort toward the success of this research work. Finally, I acknowledged our reputable institution Federal Polytechnic, Nyakshendam plateau State for creating the platform for us to access the sponsorship from Tetfund for this research work. God bless all.

References

Adeleke, A. O., Okeke, U. I., & Nwankwo, P. C. (2021). Determinants of renewable energy adoption in Nigeria's SME sector. *Energy Policy*, 153, 112273.

Akanbi, B. M., &Fowowe, B. (2021). Financing renewable energy in Nigeria: Opportunities and challenges. *Renewable Energy Focus*, 38, 1–10.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.

International Energy Agency (IEA). (2023). *Renewable Energy Market Update 2023*. Paris: IEA.

Kumar, R., & Singh, V. (2021). Renewable energy policy frameworks: Lessons for developing countries. *Energy for Sustainable Development*, 62, 97–107.

Mensah, S., Osei, P., &Ampofo, S. (2020). Adoption of solar PV systems by SMEs: Evidence from Ghana. *Renewable Energy*, 155, 438–449.

Mutua, J., Ochieng, R., &Wekesa, E. (2022). Pay-as-you-go solar adoption in East Africa: An SME perspective. *Energy Research & Social Science*, 88, 102515.

Mwangi, M., &Akinlabi, E. T. (2019). Adoption of renewable energy in Africa: A diffusion of innovation approach. *Renewable and Sustainable Energy Reviews*, 108, 1–10.

Okafor, C. E., Bello, I., & Oladipo, F. (2022). Policy instruments for renewable energy adoption in Nigeria: An SME perspective. *Energy Policy*, 162, 112823.

Okeke, U. I., & Nwankwo, P. C. (2022). Solar energy adoption in Nigeria: Opportunities and barriers. *Journal of Renewable Energy*, 29(4), 45–60.

Oladipo, F., Yakubu, A., & Salami, M. (2023). Economic determinants of renewable energy adoption in sub-Saharan Africa. *Energy Economics*, 118, 106488.

Olamide, S., & Yakubu, A. (2020). Technological factors influencing renewable energy adoption in SMEs. *African Journal of Business and Economic Research*, 15(1), 89–103.

Oyebanji, O., Balogun, A., & Adesanya, O. (2023). Awareness creation and renewable energy adoption in SMEs: Evidence from Nigeria. *Renewable Energy Focus*, 46, 12–19.

Umeh, C., & Eze, E. (2020). Perceptions of renewable energy in Nigerian SMEs. *Sustainable Energy Technologies and Assessments*, 37, 100602.

Yusuf, M., & Danladi, U. (2019). Technical barriers to solar energy adoption in Nigeria. *Energy Reports*, 5, 903–909.