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ENHANCING SUSTAINABLE MARKET DIFFUSION OF RESIDENTIAL ENERGY-EFFICIENT TECHNOLOGIES IN NIGERIAN HOUSEHOLDS: DETERMINANTS OF ADOPTION AND TECHNOLOGY MANAGEMENT

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Abstract
This study examines the determinants of the adoption and technology management of Residential Energy-Efficient Technologies (REETs) for enhancing sustainable market diffusion in Nigerian households. Rising global energy consumption and its associated environmental challenges have increased the need for energy-efficient solutions, particularly in the residential sector. While developed countries have recorded substantial progress in the adoption of energy-efficient technologies due to supportive policies, financial incentives, technological advancement, and consumer awareness, adoption rates in Nigeria remain relatively low. The study sought to determine the extent to which key factors influence the widespread adoption and diffusion of REETs among Nigerian households. Three research questions guided the study. A mixed-methods approach, combining descriptive survey research and qualitative interviews, was adopted to provide a comprehensive understanding of REET adoption. The study covered the six geopolitical zones of Nigeria, with a target population of 476,450 homeowners. Using Cochran's formula with Finite Population Correction (FPC), a sample size of 2,090 homeowners was selected. Findings revealed that economic constraints, inadequate awareness, and unfavourable government policies are the major barriers to the adoption and diffusion of REETs. The study further identified socio-economic limitations, weak policy frameworks, and infrastructural deficiencies as significant challenges hindering widespread uptake. The study concludes that sustainable market diffusion of REETs can be enhanced through integrated policy reforms, improved infrastructure, accessible financing mechanisms, and sustained public awareness campaigns. Addressing these barriers will accelerate REET adoption and contribute to sustainable energy consumption and environmental sustainability in Nigeria.

Keywords: *Residential Energy-Efficient Technologies (REETs), Technology Management, Adoption, Market Diffusion, Nigerian Households.*

Introduction

Rising global energy consumption and its environmental impacts have increased the need for energy-efficient solutions, particularly in the residential sector. Residential Energy-Efficient Technologies (REETs), such as solar photovoltaic systems, LED lighting, energy-efficient appliances, smart meters, and insulation systems, play a vital role in reducing energy demand, lowering greenhouse gas emissions, improving energy security, and reducing household energy costs (IEA, 2022).

While the adoption of REETs has advanced significantly in developed countries due to supportive policies, financial incentives, technological infrastructure, and high consumer awareness, uptake in developing countries such as Nigeria remains relatively low. Nigeria continues to face challenges including unreliable electricity supply, dependence on fossil-fuel

generators, limited financing opportunities, weak policy implementation, inadequate local manufacturing capacity, and low public awareness of energy-efficient technologies.

A major barrier to the widespread diffusion of REETs is the absence of a coordinated technology management approach that supports innovation, acquisition, deployment, utilization, and maintenance throughout the technology life cycle. Effective technology management can help overcome these challenges by aligning technological innovation with market needs, policy frameworks, financing mechanisms, and stakeholder interests.

Against this backdrop, this study examines the determinants of REET adoption and explores technology management strategies for enhancing their sustainable market diffusion in Nigerian households. The study provides empirical evidence and proposes a technology management framework tailored to the Nigerian context, aimed at accelerating REET adoption and supporting sustainable energy transitions.

Background of the Study

The residential sector accounts for a significant proportion of global energy consumption and greenhouse gas emissions, making energy efficiency a critical component of sustainable development. Residential Energy-Efficient Technologies (REETs), such as solar photovoltaic systems, energy-efficient lighting, smart meters, insulation materials, and high-efficiency appliances, offer effective solutions for reducing energy consumption, lowering carbon emissions, and improving energy security.

In developed countries, the adoption of REETs has been driven by supportive policies, technological innovation, financial incentives, and high consumer awareness. However, in Nigeria, the diffusion of these technologies remains limited despite their considerable benefits. The country continues to face challenges such as unreliable electricity supply, dependence on fossil-fuel generators, rising energy demand, limited financing opportunities, weak policy implementation, low public awareness, and inadequate technical infrastructure. Technology management provides a strategic approach to addressing these challenges by integrating technological innovation, policy support, market mechanisms, and consumer needs. Effective technology management can facilitate the adoption and sustainable diffusion of REETs within the residential sector.

Against this backdrop, this study seeks to develop a technology management framework for enhancing the sustainable market diffusion of Residential Energy-Efficient Technologies in Nigerian households. The study examines the determinants of REET adoption and proposes strategies for accelerating their widespread uptake to support sustainable energy development in Nigeria.

Statement of the Problem

Residential Energy-Efficient Technologies (REETs) have been widely recognized as effective solutions for reducing household energy consumption, improving energy efficiency, lowering energy costs, and mitigating environmental degradation. Despite these benefits and Nigeria's growing energy challenges, the adoption and diffusion of REETs among Nigerian households remain relatively low. This situation has limited the contribution of energy-efficient technologies to sustainable energy consumption and environmental sustainability within the residential sector.

The slow uptake of REETs in Nigeria is associated with several interrelated barriers, including high initial investment costs, inadequate access to financing, low public awareness, insufficient technical expertise, weak policy implementation, and inadequate infrastructural support. These challenges have constrained the widespread acceptance and market diffusion of energy-efficient technologies despite their proven economic and environmental advantages.

Furthermore, existing approaches to technology management have not adequately addressed the unique socio-economic, technological, institutional, and cultural realities of the

Nigerian environment. As a result, efforts aimed at promoting the adoption and diffusion of REETs have yielded limited success. The absence of a comprehensive technology management framework that integrates technological innovation, policy support, financing mechanisms, stakeholder engagement, and consumer awareness has further hindered sustainable market diffusion.

Therefore, there is a need to investigate the determinants of REET adoption and develop effective technology management strategies capable of enhancing their sustainable market diffusion in Nigerian households. Addressing these issues is essential for accelerating the uptake of energy-efficient technologies, improving energy security, reducing environmental impacts, and supporting Nigeria's transition towards sustainable energy development.

Purpose of the Study

The major purpose of this study is to examine the determinants of adoption and technology management for enhancing the sustainable market diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households.

Specifically, the study seeks to:

1. Determine the extent to which economic barriers hinder the adoption, market growth, and diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households.
2. Examine the extent to which consumer awareness influences the sustainable market diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households.
3. Determine the extent to which government policies affect the adoption and diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households.

Scope and Delimitation of the Study

This study was conducted in Nigeria, covering selected urban and peri-urban communities across the six geopolitical zones to capture variations in energy access, infrastructure, socio-economic conditions, and attitudes toward technology adoption. The study focused on the residential energy sector due to its significant contribution to national energy demand and its central role in promoting sustainable energy consumption. It examined selected Residential Energy-Efficient Technologies (REETs), including solar home systems, LED lighting, energy-efficient appliances, smart meters, insulation technologies, and home energy management systems.

To ensure focus and depth, the study excluded industrial, commercial, and public-sector energy applications, as these sectors have distinct operational and technological characteristics. It also did not undertake a comparative analysis of technology management frameworks from other countries, although international best practices informed the study.

Furthermore, the study was limited to identifying the determinants of REET adoption and developing technology management strategies for enhancing their sustainable market diffusion in Nigerian households, rather than addressing broader issues of energy access, poverty reduction, or national electrification.

Significance of the Study

The significance of this study lies in its contribution to addressing one of Nigeria’s most pressing developmental challenges: improving access to reliable, affordable, and sustainable energy within the residential sector.

Researchers and Academics: From an academic perspective, this study contributes to the growing body of knowledge on technology management, innovation diffusion, and sustainable energy transitions, particularly within the under-researched context of developing countries. It also offers a foundation for future research on technology adoption, market diffusion, and sustainable energy development in similar socio-economic environments.

Policymakers and Stakeholders: The findings of this study will be valuable to policymakers, government agencies, energy regulators, development partners, and non-

governmental organizations involved in energy planning and sustainability initiatives. The study can support evidence-based policymaking and facilitate the design of programmes that encourage wider adoption of energy-efficient technologies at the household level.

Private Sector and Financial Institutions: The study will also benefit energy service providers, technology developers, investors, and financial institutions by identifying market opportunities. The findings may guide the development of innovative financing models, credit facilities, and investment programmes that improve household access to energy-efficient technologies.

Households and Society: At the household level, the study seeks to promote greater awareness and adoption of energy-efficient technologies that can reduce energy costs, improve energy reliability, enhance indoor comfort, and support environmental sustainability. It creates green employment opportunities, reduce greenhouse gas emissions, and improve the overall quality of life of Nigerian households.

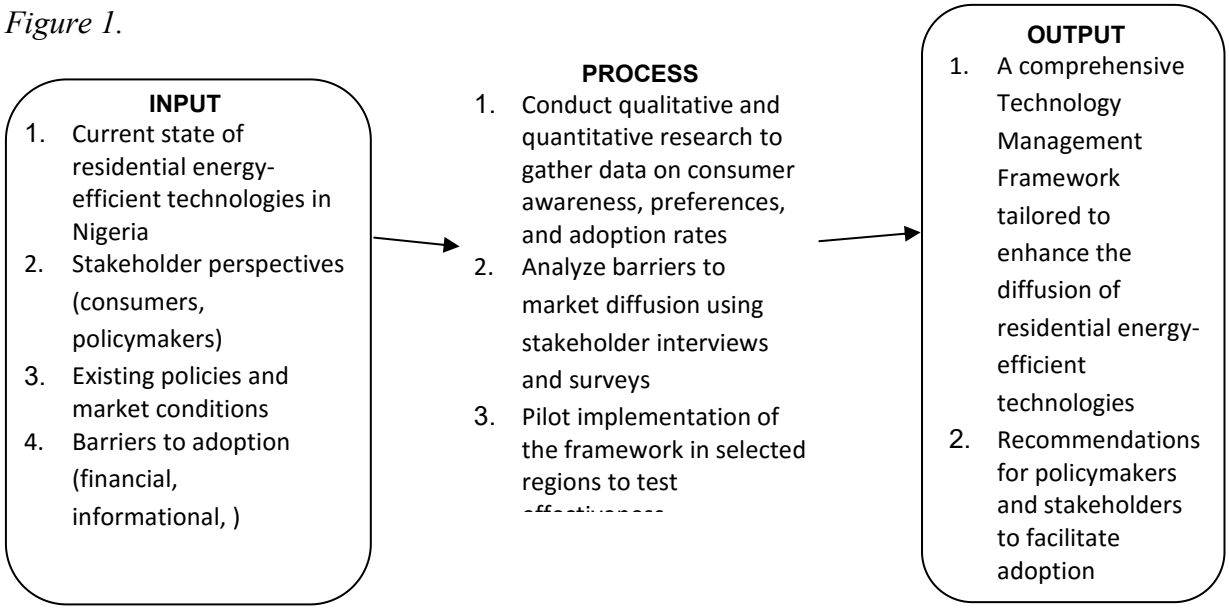
Theoretical Framework

This presents the conceptual framework, theoretical foundation underpinning the study. A robust theoretical framework is essential to guide the conceptualization, analysis, and interpretation of findings.

Conceptual Framework

The conceptual framework for this study is based on the Input-Process-Output (IPO) model:

Figure 1.



Concept of Technology Management: Refers to the systematic planning, acquisition, development, deployment, utilization, and control of technological resources to achieve organizational, economic, and societal objectives. It involves coordinating technological innovations with human, financial, and institutional resources to enhance productivity, competitiveness, and sustainable development.

According to Khalil (2000), technology management encompasses five key processes: technology identification, selection, acquisition, exploitation, and protection. These processes ensure that technologies are effectively integrated into systems and utilized to generate maximum value.

Within the context of this study, technology management provides a strategic framework for understanding how Nigeria can promote, implement, and scale the adoption of residential Energy Efficiency Technologies (EETs). It emphasizes the alignment of

technological innovations with institutional structures, market dynamics, consumer behavior, and policy interventions necessary for widespread technology uptake.

Furthermore, technology management underscores the importance of aligning technology deployment with broader national development objectives. In developing economies such as Nigeria, where challenges related to electricity access, energy affordability, and infrastructural deficits persist, technology management extends beyond the pursuit of technical efficiency. It incorporates stakeholder collaboration, supportive regulatory and policy frameworks, innovation ecosystems, financing mechanisms, capacity building, and user engagement strategies. These elements are essential for fostering the successful adoption, diffusion, and sustained use of residential EETs, thereby contributing to improved energy security, environmental sustainability, and socioeconomic development.

Residential Energy-Efficient Technologies (REETs): Refers to appliances, devices, systems, equipment and energy-management designed for household use that minimize energy consumption while maintaining or improving the quality of comfort, convenience, and performance provided to users of residential energy services. These technologies enable households to achieve the same or better energy services using less electricity or fuel, thereby promoting energy affordability, efficiency, and reducing environmental impacts and sustainability in Nigerian homes.

Strategic Management: The formulation and execution of major goals and initiatives by an organization's top management. In Nigeria, the adoption of EETs requires a strategic approach that considers the technological capabilities, organizational readiness, and strategic objectives of stakeholders involved in the energy sector.

SWOT Analysis of Residential Energy-Efficient Technologies in Nigeria

Strengths	Weaknesses
Energy Savings:* EETs reduce energy consumption, leading to cost savings for households.	Lack of Awareness: Limited public knowledge about the benefits and availability of EETs hampers adoption.
Environmental Benefits:* Adoption of EETs contributes to the reduction of greenhouse gas emissions.	Technical Challenges:* Inadequate technical expertise and infrastructure can impede the effective implementation of EETs.
Job Creation: The EET sector has the potential to create employment opportunities in manufacturing, installation, and maintenance	

Table 1.

Opportunities and Threats in EETs

Opportunities	**Threats**
Government Policies: Supportive policies and incentives can encourage the adoption of EETs.	Economic Instability: Fluctuations in the economy can affect the affordability and investment in EETs.
Technological Advancements: Innovations in EETs can lead to more affordable and efficient solutions.	Policy Inconsistencies: Changes in government policies can create uncertainty for EET programs.
International Support: Access to international funding and expertise can bolster EET initiatives.	Market Competition: The presence of low-cost, less efficient alternatives can undermine the market for EETs.

Table 2.

Concept of Adoption: Adoption refers to the process by which individuals or households decide to accept, acquire, and continuously use an innovation after evaluating its perceived benefits and costs. In technology and innovation studies, adoption is considered the point at which a user decides to make full use of a new technology as the preferred solution to a particular need.

In the context of Residential Energy-Efficient Technologies (REETs), adoption involves the willingness and actual decision of households to purchase, install, and regularly utilize energy-efficient appliances, systems, and practices that reduce energy consumption while maintaining or improving household comfort and functionality. Examples include the use of LED lighting, energy-efficient refrigerators, solar home systems, smart energy management devices, and improved cooking technologies.

The adoption of REETs is influenced by several factors, including affordability, awareness, perceived benefits, ease of use, access to financing, government policies, social influence, and the availability of technical support. Successful adoption occurs when households not only acquire these technologies but also integrate them into their everyday energy-use behaviors over time.

Market Diffusion: Market diffusion refers to the extent and rate at which a new technology spreads and becomes widely adopted within a target market over time. It describes the process through which an innovation moves from initial adoption by a small group of users to widespread acceptance among the broader population.

In the context, market diffusion refers the process and extent of the widespread adoption and penetration of Residential Energy-Efficient Technologies (REETs) appliances and systems among households, resulting in increased market growth. Market diffusion is influenced by factors such as consumer awareness, technology costs, availability, affordable, government policies, infrastructure, distribution networks, social influence, and the perceived benefits of the technologies. Effective when it is commonly used by a substantial proportion of households.

Input-Process-Output (IPO) Model: A framework that describes the structure of a process, where inputs are transformed through processes to produce outputs.

Diffusion of Innovation Theory

The Diffusion of Innovation (DOI) Theory, developed by **Challenges in the Adoption of Residential Energy-Efficient Technologies**

Financial Constraints: Limited access to financing options for both consumers and suppliers restricts the uptake of EETs.

Policy and Regulatory Barriers: Inadequate or inconsistent policies can deter investment and adoption.

Infrastructure Deficiencies: Poor infrastructure, including unreliable power supply and distribution networks, affects the performance and appeal of EETs.

Cultural and Behavioral Factors: Resistance to change and lack of trust in new technologies can slow adoption rates.

Security and Risk Challenges Associated with Energy-Efficient Technologies

Cybersecurity Risks: Smart EETs connected to networks are vulnerable to cyber-attacks. The practice of protecting systems, networks, and programs from digital attacks.

Data Privacy Concerns: The collection and use of data by EETs raise privacy issues.

Operational Risks: Technical failures or malfunctions can disrupt energy supply and affect user trust.

Supply Chain Vulnerabilities: Dependence on imported components can expose the EET sector to global supply chain disruptions.

explains how new technologies and ideas spread within a social system over time. The theory categorizes adopters into five groups: innovators, early adopters, early majority, late majority, and laggards. It further identifies key innovation attributes—relative advantage, compatibility, complexity, trialability, and observability—that influence adoption decisions.

In the context of residential Energy Efficiency Technologies (EETs) in Nigeria, the DOI theory helps explain variations in household adoption behaviour. Factors such as high initial costs, limited awareness, inadequate demonstration opportunities, and low trust in new technologies can hinder the diffusion of EETs.

Conversely, effective communication, visible benefits, and positive experiences of early adopters can accelerate acceptance. The theory is particularly relevant to Nigeria's energy sector, where energy poverty and low consumer awareness remain significant challenges. It provides a useful framework for identifying strategies to enhance EET adoption through improved information dissemination, stakeholder engagement, demonstration projects, and the reduction of financial and technical barriers.

Methodology

Research Design: This study adopts a mixed-methods research design, integrating quantitative and qualitative approaches to investigate the adoption of Residential Energy-Efficient Technologies (REETs). The quantitative component employs a descriptive survey design to assess the level, patterns, and determinants of REET adoption among households, while the qualitative component utilizes interviews and focus group discussions to gain deeper insights into stakeholders' experiences, perceptions, and challenges. The choice of a mixed-methods approach aligns with the study objectives by facilitating both the statistical analysis of adoption trends and a comprehensive understanding of the contextual factors influencing adoption.

Area of the Study: The study covers the six geopolitical zones of Nigeria: North Central, North East, North West, South East, South South, and South West. To ensure broad geographical and socio-economic representation, two Local Government Areas (LGAs): one urban and one peri-urban were purposively selected from each geopolitical zone. Within the South East geopolitical zone, particular attention was given to the Owerri Zone of Imo State, comprising Aboh Mbaise, Ikeduru, Mbaitoli, Ngor Okpala, Owerri North, Owerri South, and Owerri Municipal Local Government Areas. The inclusion of these LGAs is intended to capture variations in infrastructure development, socio-economic characteristics, energy access, and cultural contexts that may influence the adoption of Residential Energy-Efficient Technologies (REETs).

The selection of study areas across the six geopolitical zones provides a comprehensive basis for examining regional differences and identifying factors that influence REET adoption among Nigerian households.

Population of the study The total population of the study is 26,450 Sourced from 2019–2022 state estimates and aggregated by geopolitical zone businessday.ng+8. The Cochran's finite population correction (FPC) formula was used. This formula is widely used in survey-based research when the population is large and finite. It also offers more precise control, tuning results based on confidence (z) level, variability (p) and margin of error (5%), as well works best when N (population size) is so large and no longer impacts n. The population size for this study is large, known and not infinite, therefore adjusted Cochran's Finite-population correction is considered optionally applied. So, the FPC-adjusted sample size is around **344**.

Summary Table of Homeowners Sample Size (n)

Zone	Population (N)	FPC denominator	FPC-adjusted	Rounded
North Central	3,980	≈ 1.09648	≈351.1	351
North East	4,550	≈ 1.0844	≈355.0	355

North West	9,500	≈ 1.04042	≈370.0	370
South East	2,260	≈ 1.1699	≈**329.1**	**329**
South South	2,960	≈ 1.1297	≈340.8	341
South West	3,200	≈ 1.12	≈343.75	344
Total				2,090

Table

Therefore, total Sample size for all households in the selected LGAs with exposure to energy services is **2,090**

Sources of Data Collection: Data for this study were obtained from primary, secondary, and interview sources. A structured questionnaire containing closed-ended items (Likert scale and multiple-choice questions) was developed to gather information on economic, consumer awareness and government policies hinder the adoption, market growth, and diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian. Responses were rated on a four-point scale: Very High Extent (VHE) = 4, High Extent (HE) = 3, Low Extent (LE) = 2, and Very Low Extent (VLE) = 1. Semi-structured interviews with open-ended questions were conducted to obtain deeper insights into stakeholders' experiences, perceptions, challenges, and needs. The research instrument was validity by experts to establish its content and construct validity.

The reliability of the research instrument was established through a pilot study conducted in selected urban and peri-urban areas within the study zones. Internal consistency was assessed using Cronbach's Alpha, with a coefficient of 0.70 or above considered acceptable. Instrument stability was further determined through the test–retest method using the Spearman Correlation Coefficient (r), with values of 0.50 and above indicating satisfactory reliability. The pilot study also helped refine the questionnaire and interview protocol to ensure clarity, consistency, and cultural relevance of the items.

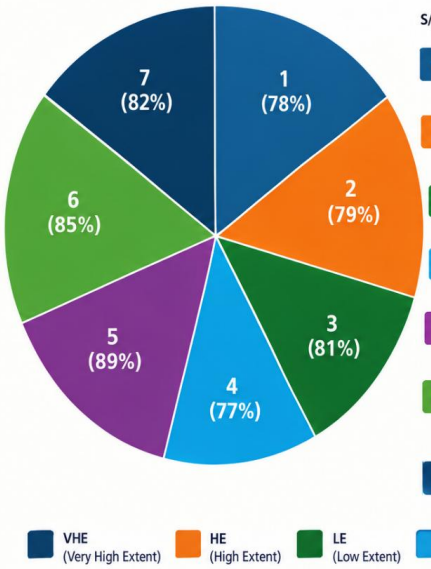
Data were collected through the face-to-face administration of questionnaires by trained research assistants using standardized procedures for respondent selection. Ethical principles such as informed consent, confidentiality, anonymity, secure data management, and ethical compliance were strictly maintained.

Quantitative data were coded, and analyzed using SPSS and Stata. Descriptive statistics, including frequencies, percentages, and means, were used while inferential statistics such as chi-square and regression analyses were employed to identify factors influencing the adoption of Residential Energy-Efficient Technologies (REETs). Qualitative data from 10 item interviews were analysised and interpreted.

Data Presentation and Analysis

Research Questions: Determine the extent to which economic barriers, consumer awareness and government policies hinder the adoption, market growth, and diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households. **(N = 2,090)**.

Table 4.1: Economic Barriers, Consumer Awareness and Government Policies Factors Influencing (REETs) Adoption in Nigeria (N = 2,090)



S/No	Items	VHE n (%)	HE n (%)	LE n (%)	VLE n (%)	Decision Rule (Remark)
1	REETs adoption is likely limited to only higher-income households due to high initial costs.	1,630 (78%)	209 (10%)	167 (8%)	83 (4%)	Accepted
2	Lower-income households often find it difficult to afford the initial high investment associated with REETs.	1,651 (79%)	229 (11%)	167 (8%)	41 (2%)	Accepted
3	Households with greater financial capacity can afford to invest in REETs technologies.	1,692 (81%)	250 (12%)	104 (5%)	41 (2%)	Accepted
4	REETs commitment often necessitates prolonged financial planning and savings.	1,609 (77%)	313 (15%)	146 (7%)	20 (1%)	Accepted
5	Raising awareness campaigns and educating consumers about the benefits can promote and increase REETs adoption.	1,860 (89%)	167 (8%)	41 (2%)	20 (1%)	Accepted
6	Regulatory framework, government initiatives, and policies can impact the availability, affordability, accessibility and cost of REETs.	1,776 (85%)	188 (9%)	62 (3%)	62 (3%)	Accepted
7	Consumers' knowledge and understanding of the benefits of the technology and its performance can impact their decision to adopt REETs.	1,713 (82%)	209 (10%)	146 (7%)	20 (1%)	Accepted

Discussion of Findings: Enhancing sustainable market diffusion of residential energy-efficient technologies in Nigerian households: determinants of adoption and technology management

Item 1: High-cost limits adoption to wealthier households: This indicates that the high initial cost of REETs is a major and significantly barrier, creating inequality in access as well as restricts adoption to wealthier households.

Item 2: Lower-income households find it difficult to afford the initial investment: reinforces the financial barrier faced by low-income households, confirming affordability as a major constraint.

Item 3: Financial capacity drives adoption: The result highlights the strong influence of income level on adoption decisions. Households with more resources are significantly more likely to adopt REETs.

Item 4: Adoption requires long-term financial planning: This suggests that households perceive REETs as long-term investments requiring deliberate financial preparation. REETs are seen as capital-intensive investments, not spontaneous purchases.

Item 5: Awareness campaigns and education can promote REETs adoption: This demonstrates that Information, awareness campaigns and education are critical drivers of adoption.

Item 6: Government policies and regulatory frameworks: This indicates strong recognition of the role of government intervention in facilitating adoption. Policy environment strongly influences availability, affordability, and access to REETs.

Item 7: Consumers' knowledge and understanding of benefits: This suggests that informed consumers are more likely to adopt REETs. Consumer understanding and perceived value of REETs are key motivators.

Theoretical Framework for REET Adoption

The findings of this study were anchored in established theories of technology adoption, innovation systems, and socio-technical transitions, which provide a foundation for understanding the adoption, market growth, and diffusion of Residential Energy-Efficient Technologies (REETs). The Diffusion of Innovation Theory (Rogers, 2003) explains how innovations spread through a social system over time via communication channels. The theory highlights the importance of awareness, social influence, and institutional support in

shaping adoption decisions. In the context of REETs, effective information dissemination and stakeholder engagement are essential for accelerating market diffusion**.**

Summary of Findings: This study investigated the enhancement of sustainable market diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households, with emphasis on economic barriers, consumer awareness, and government policies as determinants of adoption.

Analysis of data collected from 2,090 respondents revealed the following key findings:

1. **Economic Barriers:** Financial constraints were identified as major obstacles to the adoption and diffusion of REETs. High acquisition and installation costs, coupled with limited access to affordable financing, significantly reduce adoption rates, particularly among low-income households. Consequently, household financial capacity remains a critical factor influencing REET adoption decisions.
2. **Consumer Awareness and Knowledge:** Awareness and knowledge emerged as strong drivers of REET adoption. Respondents indicated that consumer education, awareness campaigns, and a clear understanding of the benefits and performance of energy-efficient technologies positively influence acceptance and adoption. This suggests that informed consumers are more likely to embrace REETs.
3. **Government Policies and Support:** Government regulations, incentives, and intervention programmes were found to play a significant role in promoting REET adoption and market diffusion. Supportive policy and regulatory frameworks enhance accessibility and affordability, thereby encouraging wider uptake of energy-efficient technologies among households.

Conclusion

In conclusion, the adoption and diffusion of Residential Energy-Efficient Technologies (REETs) in Nigerian households is a multidimensional process significantly constrained by several interrelated systemic factors. These include socio-economic constraints, limited public awareness, inadequate policy frameworks, technical challenges, and other institutional and environmental barriers. Collectively, these factors continue to impede the widespread adoption and diffusion of REETs across the residential sector.

However, these barriers can be addressed through a concerted and integrated approach that emphasizes sustainable development in the twenty-first century. Such an approach requires collaborative innovation, increased investment in energy-efficient technologies, enhanced consumer awareness, effective government policies and regulatory frameworks, and the strategic application of digital technologies. Strengthening stakeholder collaboration, promoting technological accessibility and affordability, and building societal resilience are also essential for creating an enabling environment for the sustainable adoption and diffusion of REETs in Nigerian households.

Ultimately, addressing these interconnected challenges will contribute to improved household energy efficiency, environmental sustainability, economic well-being, and Nigeria's broader transition towards a resilient and sustainable energy future.

Recommendations

To enhance the sustainable adoption and market diffusion of REETs:

1. Improve Access to Financing: Government, financial institutions, and private investors should provide low-interest loans, subsidies, tax incentives, green financing schemes, and flexible payment options such as pay-as-you-go and microfinance to reduce affordability barriers.
2. Promote Household Savings for Energy Investments: Structured savings programmes, cooperative financing, and community-based funding initiatives should be encouraged to help households gradually invest in REETs.

3. Strengthen Consumer Awareness and Education: Sustained public awareness campaigns should be implemented to educate citizens on the economic, environmental, and social benefits of REETs. Information should be disseminated through schools, community platforms, mass media, and indigenous languages.
4. Enhance Policy and Regulatory Frameworks: Government should establish clear, stable, and enforceable policies that promote the availability, affordability, quality assurance, and standardization of REETs while encouraging innovation and private-sector participation.
5. Invest in Local Research and Development: Greater support should be given to the development of energy-efficient technologies tailored to Nigeria's climatic, economic, and social realities.
6. Implement Demonstration and Pilot Projects: Practical demonstration projects should be undertaken to showcase the effectiveness and long-term benefits of REETs, thereby increasing public confidence and adoption.
7. Promote Smart Energy Management Systems: Adoption of smart meters, automation technologies, and demand-responsive energy systems should be encouraged to optimize energy consumption and improve efficiency.

Limitations of the Study:

The findings were based on self-reported data collected through a Likert-scale questionnaire, which may be influenced by personal bias, social desirability, misunderstanding of items, or inaccuracies in respondents' perceptions and experiences.

Finally, although the sample size (N = 2,090) was adequate and robust, regional differences in infrastructure, socio-economic conditions, and energy access across Nigeria may affect the generalizability of the findings.

Contributions to Knowledge

Notwithstanding these limitations, the study offers valuable evidence on the determinants of adoption and technology management strategies for enhancing the sustainable market diffusion of Residential Energy-Efficient Technologies in Nigerian households. This study highlighted the critical roles of stakeholder collaboration, supportive policy and regulatory frameworks, innovative financing mechanisms, consumer awareness, and technological adaptability in enhancing the adoption and sustainable market diffusion of Residential Energy-Efficient Technologies (REETs) in Nigeria.

The study provides empirical evidence on the key determinants influencing household adoption decisions. These findings enrich the growing body of literature on sustainable energy transitions and serve as a valuable reference for researchers, policymakers, industry practitioners, and development partners seeking to promote energy efficiency and sustainable development in Nigeria and other developing economies.

Implications of the Findings: Context-Specific and Locally Relevant: Designed to address Nigeria's climatic, economic, infrastructural, and socio-cultural conditions while supporting the development of local manufacturing capacity**.**

Suggestions for Further Research

1. **Digital Technologies and Energy Efficiency:** Future studies should investigate the potential of emerging digital technologies, such as Artificial Intelligence (AI), the Internet of Things (IoT), and smart grid systems, to enhance energy efficiency and support the adoption and management of Residential Energy-Efficient Technologies (REETs) in Nigeria.
2. **Policy Effectiveness and Regional Implementation:** Further research should evaluate the effectiveness of government policies, incentives, and technology management frameworks in promoting REET adoption across different regions of Nigeria, with a

view to identifying implementation challenges, regional disparities, and scalable best practices.

References

Adelaja, A. O. (2020). Barriers to national renewable energy policy adoption: Insights from a case study of Nigeria. *Energy Strategy Reviews, 30*(2), 100519. https://doi.org/10.1016/j.esr.2020.100519

African Development Bank. (2021). *African economic outlook 2021*. Abidjan: Author.

Agyekum, E. B., Amjad, F., & Mohsin, M. (2020). Evaluating the determinants of renewable energy technology adoption in developing countries. *Renewable and Sustainable Energy Reviews, 133*, 110-115. https://doi.org/10.1016/j.rser.2020.110115

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Akinwale, Y. O., & Ogundari, I. O. (2017). Exploration of renewable energy resources for sustainable development in Nigeria: A study of the adoption barriers. *International Journal of Energy Economics and Policy, 7*(1), 1–10.

Akinyemi, F. O., & Olatunji, O. O. (2022). Financing renewable energy technologies in developing economies: Barriers and policy solutions. *Renewable Energy Policy Review, 15*(3), 211–225.

Bhattacharya, A., & Opara, I. (2021). Technology diffusion and sustainable energy transition in Sub-Saharan Africa. *Energy Economics and Policy Journal, 9*(2), 134–149.

Christopher Freeman. (1987). *Technology policy and economic performance: Lessons from Japan*. London: Pinter.

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

Energy Commission of Nigeria. (2016). *National energy efficiency action plan (NEEAP)*. Abuja, Nigeria. Abuja: Author

Erebor, E. M., & Adedire, F. M. (2023). Energy transition policy, efficiency and implementation strategies in the Nigerian built environment. *Journal of Environmental Sciences*. https://doi.org/10.5281/zenodo.10051225

United Nations Development Programme. (2021). *Scaling up energy access in Nigeria*. UNDP. https://www.undp.org

World Bank. (2023). *Scaling up renewable energy investment in Africa*. https://www.worldbank.org