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ASSESSING THE APPLICATION OF RENEWABLE ENERGY TECHNOLOGY IN COLLEGES OF EDUCATION FOR SUITABLE NATIONAL DEVELOPMENT AND COMMUNITY EMPOWERMENT IN NORTH CENTRAL NIGERIA

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ABSTRACT
This study assessed the application of renewable energy technology in colleges of education as a means to foster sustainable national development and community empowerment in North Central Nigeria. A descriptive survey research design was employed, involving all academic staff of Technical Education departments in seven selected colleges across the six states in the region and the Federal Capital Territory, Abuja. A census sampling technique was used to include the entire population of 115 academic staff due to its manageable size. Data were collected using a structured questionnaire based on a four-point rating scale and analyzed using mean scores and chi-square statistics. The findings revealed a moderate yet positive level of adoption of renewable energy technologies, notably solar panels, across the colleges, with respondents confirming visible efforts toward clean energy utilization and increased awareness among staff and students. However, the study also identified critical challenges hampering full implementation, including inadequate funding, limited technical expertise, policy-related issues and infrastructure vandalism. Despite these constraints, the integration of renewable energy was shown to significantly contribute to local employment, inspire community-level adoption, strengthen institutional collaboration with local communities and align with national sustainable development goals. Hypotheses testing revealed statistically significant results supporting the assertions of adoption levels, implementation challenges and the impact of renewable energy on sustainable development. The study concluded that renewable energy technology has a pivotal role to play in driving institutional sustainability and community empowerment and recommended strategic investments, capacity building and supportive policy frameworks to enhance its adoption.

Keywords: Renewable Energy, Technology, Colleges of Education, National Development, Community Empowerment, North Central Nigeria.

Introduction

The pressing need to battle climate change and make the shift to sustainable energy sources has led to the emergence of renewable energy technology as critical solutions. Besides climate change mitigation, other benefits including job creation, income generation, community ownership and local economic growth are fundamental components of the value proposition of renewable energy projects (Barabino, Fioriti, Guerrazzi, Mariuzzo & Poli, 2023). Energy transitions in remote communities have become a priority for climate change mitigation and adaptation, gaining the support of governments and organizations. Besides reducing Co_2 emissions, energy transitions can contribute to adaptation to a changing climate in communities temporarily isolated due to climate disasters, including wildfires, floods and storms. However, the effective adoption of renewable energy into our world's energy system involves more than the supply of technological improvements; it also calls for the support and active participation of local communities (Adeleye, Adebanji & Awogbemi, 2024). The empowerment and mobilization of neighborhood communities to participate actively in the conception, creation and administration of renewable energy project is made possible through community engagement and capacity building activities.

Involving local communities in renewable energy projects holds significant importance for various reasons such as: Social Acceptance and Support. Ajia (2025) stated that communities that actively participate in planning have more ownership over the programmes. The successful deployment and long-term viability of renewable energy project depend largely on social acceptability and support. The possibility that their projects will succeed in overcoming obstacles and achieving their intended aims increases when local communities actively support and embrace them. Local communities have important knowledge about the difficulties and requirements particular to them. Participation in the planning process enables renewable energy projects to be modified to meet local needs, resource availability and cultural considerations. Ajia (2025) emphasized that the viability and sustainability of renewable energy programmes depend on customized project design. Customization encourages collaboration, empowers the community and yields renewable energy solutions that are actually advantageous and significant. Engaging the local communities offers chances for economic expansion (Danjuma & Bileya, 2025). Projects involving renewable energy can boost the local economy, help small businesses locally and create jobs. Economic growth is fuelled by the creation of new jobs, the expansion of small businesses locally, revenue production and skill development, will decreased energy cost.

Sustainable development, which aims to combine environmental, social and economic factors for the welfare of both present and future generation, is at the core of renewable energy initiatives. To achieve sustainable results, local communities must be included in the planning, development and management of these programmes (Bauwens, 2019). These programmes pave the path for a more resilient, equitable and ecologically conscious energy future by combining social, economic and environmental issues. Building a sustainable environment for future generations depends on empowering local communities to actively take part in the switch to renewable energy.

Local people are quite knowledgeable about their ecosystems. Therefore, by including them in project planning, it is possible to conduct a thorough analysis of potential environmental effects and create mitigation plans. This strategy makes sure that local ecosystems are not severely harmed during the implementation of renewable energy projects which can reduce conflict. Local communities get a sense of ownership and empowerment when they actively participate in the initiation of the project. The shift from being passive recipients of benefits to active participants in sustainable development, which increases their dedication to the accomplishment of projects and their long-term viability. Participating neighborhood groups makes sure that the advantages of renewable energy projects are dispersed more fairly (Hoicka et al., 2021). To maximize the advantages of these initiatives, local communities must be included in the planning, implementation and management of the renewable projects.

Conflicts between project developers and local populations frequently occur as a result of perceived risks to livelihoods, cultural heritage or the environment (Hoicka et. al., 2021). Although vital for sustainable development, renewable energy projects can run into difficulties and conflicts during the design, development and administration phases. To Lottu, Ehiaguina, Ayodeji, Ndiwe and Izuka (2023), conflict resolution is facilitated by involving local communities and carrying out capacity-building programmes. Renewable energy initiatives might occasionally conflict with cultural customs and traditions. Project creators can fully comprehend cultural sensitivities and collaborate to come up with solutions that respect and incorporate local practices by consulting local population.

This study aims to offer useful insights into how renewable energy projects can successfully fit with local needs, goals and values by examining the significance of community participation and empowerment. Renewable energy initiatives that uphold the values of inclusivity and empowerment can promote long-lasting good effects on the environment, society and the economy, paving the way for a more sustainable and greener future for all.

Statement of the Problem

Despite the growing global emphasis on clean and sustainable energy solutions, many colleges of education in North Central Nigeria still rely heavily on unstable, non-renewable energy sources, which hinders their capacity to function efficiently and contribute meaningfully to national development and community upliftment. This persistent dependence on fossil fuels and erratic power supply not only affects the teaching and learning environment but also limits the exposure of future educators to innovative energy solutions that could be transferred to the wider society. Additionally, the lack of integration of renewable energy technologies in these institutions reflects a broader gap in policy implementation, infrastructural development and community engagement, thereby stalling progress toward achieving the Sustainable Development Goals (SDGs). While renewable energy offers a viable pathway to empower communities, reduce carbon emissions and stimulate economic growth, its application within educational institutions in this region remains underexplored and poorly documented. This study, therefore, seeks to investigate the extent to which renewable energy technology is applied in colleges of education in North

Central Nigeria, the challenges involved and its potential impact on sustainable national development and community empowerment.

Aim and Objectives of the Study

The aim of the study is to find out the application of Renewable Energy Technology in Colleges of Education in North Central Nigeria for Sustainable National Development and Community Empowerment. The specific objectives of the study are:

1. To examine the current level of adoption of renewable energy technology in colleges of education in North Central Nigeria.
2. To identify the challenges affecting the implementation of renewable energy technology in these institutions.
3. To evaluate how the use of renewable energy in colleges of education contributes to sustainable national development and community empowerment.

Research Question

The study seeks to answer this question;

1. What is the current level of adoption of renewable energy technology in colleges of education in North Central Nigeria?
2. What are the challenges affecting the implementation of renewable energy technology in these institutions?
3. In what ways does the use of renewable energy in colleges of education contributes to sustainable national development and community empowerment?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. There is no significant level of adoption of renewable energy technology in colleges of education in North Central Nigeria.
2. There is no significant challenge affecting the implementation of renewable energy technology in these institutions.
3. There is no significant relationship between the use of renewable energy in colleges of education and sustainable national development/community empowerment.

Theoretical Framework

A suitable theory for this study is the Sociotechnical Transitions Theory, developed by Frank W. Geels in 2002, grounded in the Multi-Level Perspective (MLP) framework. This theory explains how systemic transitions—especially in sectors like energy—occur through the interaction of niche innovations, socio-technical regimes and landscape pressures. The theory emphasizes that technological innovation alone is not sufficient for societal transformation; instead, a combination of cultural, institutional, economic and technological changes is necessary. Its core principles include multi-level interactions (niche, regime, landscape), co-evolution of technology and society and the strategic alignment of policies, practices and innovation. In applying this theory to the current study, the adoption of renewable energy technology in colleges of education represents a *niche innovation* that, with proper support and institutional alignment, can challenge and eventually transform the traditional fossil-fuel-dependent energy *regimes*. This

transformation not only enhances energy access in educational institutions but also contributes to *community empowerment and sustainable national development* by equipping future educators and their communities with the knowledge and infrastructure needed for transition towards clean energy systems.

Methodology

This research utilised the descriptive survey research design. The population of the study consisted of all the academic staff in Federal and State Colleges of Education in North Central Nigeria. The North Central Nigeria is made up of six states and the Federal Capital Territory (Abuja). These states include Benue, Kogi, Kwara, Nasarawa, Niger and Plateau. The random sampling technique was adopted to select one college of education from each of the states as well as the Federal Capital Territory, Abuja. These colleges include Federal College of Education, Pankshin; College of Education, Minna, College of Education (Tech.) Kabba; College of Education Lafiagi; College of Education, Katsina-Ala; College of Education Akwanga and FCT College of Education Zuba making a total of seven colleges of education. The total population of academic staff of Technical Education in the selected schools were 115. In selecting the sample of respondents, the census sampling technique was used where all the population was used, since it is small and manageable. The instrument for data collection included a structured questionnaire based on a four-point rating Scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The questionnaires were administered, filled and collected at spot to ensure that none was missing. The instrument for data analysis was the mean score which was used to answer the research questions and the chi-square was used to test the hypotheses.

Results and Discussion

Research Question 1: What is the current level of adoption of renewable energy technology in colleges of education in North Central Nigeria?

Table 1: Level of Adoption of Renewable Energy Technology

S/N	Items	SA	A	D	SD	Total Score	Mean ($\bar{x}$)	Decision
1	Renewable energy systems such as solar panels have been installed in this college.	30	40	25	20	310	2.69	Accepted
2	The college regularly utilizes renewable energy as a power source.	25	38	30	22	296	2.57	Accepted
3	There are visible efforts to promote the adoption of clean energy on campus.	28	42	27	18	310	2.69	Accepted
4	Staff and students are aware of the renewable energy technologies used in the college.	32	45	20	18	321	2.79	Accepted
5	Renewable energy has helped reduce dependence on non-renewable energy in the college.	35	40	25	15	325	2.82	Accepted

The findings in Table 1 reveal a moderate yet positive level of adoption of renewable energy technology across colleges of education in North Central Nigeria. All the items recorded mean scores above 2.50, indicating agreement among respondents. This suggests that solar panels and other renewable energy systems have been installed and are actively used as power sources. Furthermore, there are visible institutional efforts toward clean energy promotion and both staff and students show awareness of the renewable energy technologies employed. The highest mean (2.82) reflects that renewable energy has notably helped reduce dependence on non-renewable energy, highlighting a growing institutional commitment to sustainability.

Research Question 2: What are the challenges affecting the implementation of renewable energy technology in these institutions?

Table 2: Challenges in Implementing Renewable Energy Technology

S/N	Items	SA	A	D	SD	Total Score	Mean ($\bar{x}$)	Decision
6	Lack of funding limits the implementation of renewable energy projects.	50	35	20	10	355	3.78	Accepted
7	There is inadequate technical expertise to maintain renewable energy systems.	42	40	20	13	419	3.08	Accepted
8	Poor government policy support hinders the use of renewable energy in colleges.	45	39	18	13	346	3.00	Accepted
9	Awareness of renewable energy benefits among staff and students is low.	40	37	25	13	334	2.90	Accepted
10	Vandalism and theft of renewable energy infrastructure pose a major challenge.	47	38	20	10	352	3.06	Accepted

Table 2 indicates that various significant challenges hinder the effective implementation of renewable energy in the colleges. All items had mean scores above 2.50, with the most pressing issue being lack of funding (mean = 3.78), pointing to serious financial limitations. Other challenges include inadequate technical expertise (3.08), poor government policy support (3.00) and low awareness among stakeholders (2.90), all of which create bottlenecks in maintaining and maximizing renewable energy usage. Additionally, vandalism and theft of infrastructure (mean = 3.06) further exacerbate the situation. These findings collectively suggest that while adoption exists, it is constrained by systemic, policy and technical issues.

Research Question 3: In what ways does the use of renewable energy in colleges contribute to sustainable national development and community empowerment?

Table 3: Contribution to Sustainable Development and Empowerment

S/N	Items	SA	A	D	SD	Total Score	Mean ($\bar{x}$)	Decision
11	Local communities have gained employment opportunities through renewable energy projects.	36	44	22	13	333	2.89	Accepted
12	The college supports community training on the use of renewable energy technologies.	38	43	20	14	335	2.91	Accepted
13	Renewable energy use in the college has inspired similar adoption in nearby communities.	33	46	24	12	330	2.86	Accepted
14	Collaboration between the college and the community has improved due to energy projects.	35	42	25	13	329	2.86	Accepted
15	The adoption of renewable energy in education institutions contributes to reducing carbon emissions.	40	47	18	10	347	3.01	Accepted
16	The integration of renewable energy supports government policies on sustainable development.	42	45	20	8	351	3.05	Accepted

The responses in Table 3 affirm that renewable energy use in colleges of education contributes meaningfully to sustainable development and community empowerment. All items had mean scores above 2.50, indicating acceptance. Key areas of impact include employment creation (mean = 2.89), community training and capacity building (2.91) and the inspiration of renewable energy adoption in surrounding areas (2.86). Moreover, improved college-community collaboration (2.86) and a contribution to reducing carbon emissions (3.01) show alignment with broader environmental goals. The highest mean (3.05) for alignment with government sustainability policies underscores the strategic role of educational institutions in national development through renewable energy adoption.

Hypothesis One

H_0: There is no significant level of adoption of renewable energy technology in colleges of education in North Central Nigeria.

Table 4: Summary Table for Chi-square Test of Independence Analysis

Cells	Fo	Fe	df	Cal. X^2	Crit. X^2	Decision
5	310	62.0	4	4,921.00	9.49	Rejected

The calculated chi-square value of 4,921.00 is greater than the critical table value of 9.49 at 0.05 level of significance and 4 degrees of freedom. Therefore, the null hypothesis is rejected. This implies that there is a significant level of adoption of renewable energy technology in colleges of education in North Central Nigeria.

Hypothesis Two

H_0: There is no significant challenge affecting the implementation of renewable energy technology in these institutions.

Table 5: Summary Table for Chi-square Test of Independence Analysis

Cells	Fo	Fe	df	Cal. X^2	Crit. X^2	Decision
5	361.2	72.24	4	7,982.03	9.49	Rejected

The calculated chi-square value of 7,982.03 exceeds the critical value of 9.49. Hence, the null hypothesis is rejected. This indicates that there are significant challenges affecting the implementation of renewable energy technology in colleges of education in North Central Nigeria.

Hypothesis Three

H_0: There is no significant relationship between the use of renewable energy in colleges of education and sustainable national development/community empowerment.

Table 6: Summary Table for Chi-square Test of Independence Analysis

Cells	Fo	Fe	df	Cal. X^2	Crit. X^2	Decision
6	334.2	55.7	5	8,624.31	11.07	Rejected

Since the calculated chi-square value of 8,624.31 is significantly greater than the table value of 11.07, the null hypothesis is rejected. Therefore, there is a significant relationship between the use of renewable energy in colleges of education and sustainable national development/community empowerment in North Central Nigeria.

Discussion of Findings

The findings of this study revealed that there is a moderate yet growing level of adoption of renewable energy technology in colleges of education in North Central Nigeria. This is evident in the use of solar panels, institutional promotion of clean energy and awareness among staff and students. These findings are consistent with the study by Olanrewaju, Olugasa, Omodele and

Taiwo (2023), who found that renewable energy projects, particularly solar power, are gradually being integrated into educational institutions in Nigeria as a response to unreliable grid power and rising energy costs.

On the issue of implementation challenges, the study found that lack of funding, limited technical expertise, weak policy support, low awareness and vandalism are major impediments to effective deployment of renewable energy. These challenges reflect broader systemic barriers that have been identified in the literature. For instance, Oyedepo (2012) noted that the main obstacles to renewable energy development in Nigeria include financial constraints, policy inconsistency and inadequate technical manpower. His findings resonate with those of the present study, suggesting that without targeted interventions in these areas, the full potential of renewable energy in tertiary education may not be realized.

Regarding the contribution of renewable energy to sustainable development and community empowerment, the findings indicated that its use in colleges has provided employment, encouraged community training, fostered partnerships and supported environmental sustainability. These outcomes are in line with the findings of Shaaban and Petinrin (2014), who argued that renewable energy not only enhances energy access in underserved areas but also drives socio-economic benefits such as job creation, local innovation and environmental stewardship.

Summary of Findings

1. The study investigated the adoption, challenges and contributions of renewable energy technology in colleges of education in North Central Nigeria. The findings revealed that the level of adoption of renewable energy technologies—particularly solar energy—is moderate but positively progressing. Institutions have installed solar panels, made efforts to promote clean energy and created awareness among staff and students regarding renewable energy use.
2. The study also identified several significant challenges affecting the implementation of renewable energy. Major among them is the lack of funding, followed by inadequate technical expertise, poor government policy support, low awareness and infrastructure vandalism.
3. Lastly, the findings showed that renewable energy use in these colleges contributes meaningfully to sustainable national development and community empowerment. This is evident in the creation of local employment opportunities, provision of community training, promotion of environmental sustainability through reduced carbon emissions and support for national policies on sustainable development.

Conclusion

In conclusion, the study established that while the adoption of renewable energy technology in colleges of education in North Central Nigeria is moderate and growing, it is significantly hindered by challenges such as inadequate funding, lack of technical expertise, weak policy support and infrastructure vandalism. Despite these constraints, the use of renewable energy in these institutions has proven to be beneficial, contributing to sustainable development goals,

reducing environmental impact and fostering community empowerment through employment and training initiatives.

Recommendations

In line with the above findings, the following are recommended:

1. To overcome the financial barriers identified in the study, the government and education stakeholders should prioritize increased budgetary allocations and establish grant schemes specifically for renewable energy projects in colleges of education. This will enable the installation, maintenance and expansion of renewable energy infrastructure.
2. Institutions should invest in the training of technical staff and students on the maintenance and management of renewable energy systems. Partnerships with energy companies and vocational training centres can help build the technical expertise needed to sustain these technologies within educational environments.
3. While government formulate and enforce supportive policies, colleges should implement security strategies to protect renewable energy infrastructure from vandalism and theft, thereby ensuring sustainability and long-term effectiveness.

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