International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Research Article)

Integration of renewable energy technologies into electrical and electronics technology education curriculum in Nigerian universities

Bawa Kabiru, Rabiu Abdullahi *, Shuaibu Halliru and Shuaibu Babawuro

Northwest University, Kano, Abubakar Tafawa Balewa University, Bauchi.

International Journal of Science and Research Archive, 2026, 19(02), 286-297

Publication history: Received on 21 March 2026; revised on 04 May 2026; accepted on 07 May 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.19.2.0940

Abstract

This study examined the integration of renewable energy technologies into Electrical and Electronics Technology Education (EETE) curricula in Nigerian universities. A descriptive survey research design was adopted, involving 131 respondents comprising 96 lecturers and 35 technologists. Data were collected using a structured questionnaire titled *Integration of Renewable Energy Technologies into Electrical and Electronics Technology Education Curriculum in Nigerian Universities (IRETEC)*. The instrument was validated by experts and yielded a reliability coefficient of 0.89 (Cronbach's Alpha). Data were analysed using means and standard deviations to answer research questions, and an independent-samples t-test was used to test hypotheses at the 0.05 level of significance. The findings revealed that key renewable energy contents such as solar photovoltaic systems, energy storage technologies, and hybrid systems are essential for curriculum integration. Practical, competency-based pedagogical strategies were identified as the most effective, while inadequate funding, poor infrastructure, and a lack of trained personnel were identified as the major challenges. No significant mean differences were discovered between lecturers and technologists. The study recommends curriculum reform, increased funding, and strengthened industry collaboration to enhance renewable energy education in Nigerian universities.

Keywords: Renewable energy; Curriculum integration; Technical education; Nigeria; Sustainability; EETE

1. Introduction

Energy remains a critical driver of economic growth, industrial development, and technological advancement in modern economies. However, the increasing global demand for energy, coupled with the environmental implications of fossil fuel consumption, has intensified the transition toward sustainable energy systems (Trabelsi, 2025). Renewable energy technologies such as solar, wind, biomass, and hydropower are widely recognised as environmentally sustainable and viable alternatives for addressing energy security and climate change challenges (Zubairu et al., 2018). Consequently, many countries are actively integrating renewable energy into their energy mix to reduce greenhouse gas emissions and enhance energy reliability (Joseph et al., 2025).

In Nigeria, the energy sector continues to face persistent challenges, including inadequate electricity supply, overdependence on fossil fuels, and poor power infrastructure, which have adversely affected key sectors such as education, industry, and economic development (Victor & Ainah, 2024). As a result, the adoption of renewable energy technologies has become a strategic national priority for improving energy access, promoting sustainability, and achieving self-reliance. Technologies such as solar photovoltaic systems and wind energy have demonstrated significant potential for improving electricity reliability, particularly in underserved areas (Zubairu et al., 2018).

* Corresponding author: Rabiu Abdullahi

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0.

Electrical and Electronics Technology Education (EETE) programmes in Nigerian universities are designed to equip students with the technical knowledge, practical skills, and competencies required for the installation, operation, and maintenance of electrical and electronic systems (National University Commission, 2024). These programmes play a crucial role in developing a skilled workforce capable of driving technological innovation and supporting national development. However, the rapid transformation in the global energy landscape, particularly the shift toward renewable energy, necessitates continuous curriculum review and modernisation to ensure relevance (Nengak et al., 2025). Despite growing awareness of renewable energy among engineering and technology students in Nigeria, empirical evidence suggests that curriculum coverage remains inadequate. For instance, Oshiokhai et al., (2022) reported that approximately 76% of students indicated insufficient inclusion of renewable energy topics in their programmes, while over 90% expressed a strong desire for such inclusion. Similarly, recent studies have shown that renewable energy and energy conversion concepts are not comprehensively addressed in the 2018 Benchmark Minimum Academic Standards (BMAS) for Electrical and Electronics Technology Education (Bawa et al., 2026).

The integration of renewable energy technologies into university curricula is essential for developing technical capacity, enhancing environmental sustainability, and aligning educational outcomes with labour market demands. Universities serve as key institutions for producing competent graduates capable of designing, installing, and maintaining renewable energy systems. Embedding renewable energy concepts, practical training, and laboratory experiences within EETE programmes can significantly enhance graduates' employability and entrepreneurial potential in the emerging green economy. However, existing EETE curricula in many Nigerian universities contain limited renewable energy content, creating a mismatch between academic training and industry requirements. As the labour market increasingly demands skills in renewable energy technologies, there is a growing need for technically competent graduates who can support installation, maintenance, and innovation in this sector.

Although the benefits of renewable energy integration are widely acknowledged, its incorporation into university programmes remains limited (Aliyu & Obi, 2025). This situation underscores the need for a systematic investigation into how renewable energy technologies can be effectively integrated into Electrical and Electronics Technology Education curricula in Nigerian universities to enhance technical competence, sustainability awareness, and graduate employability.

1.1. Theoretical Framework

This study is anchored on Constructivist Learning Theory and Human Capital Theory, which together provide a robust foundation for understanding curriculum integration and skill development in technical education.

1.1.1. Constructivist Learning Theory

Constructivist Learning Theory, as advanced by Piaget and further developed by Vygotsky, posits that learners actively construct knowledge through interaction with their environment and experiential learning. In the context of technical and vocational education, this theory emphasises hands-on activities, problem-solving, collaboration, and real-world application of knowledge (Zin et al., 2024). The integration of renewable energy technologies into Electrical and Electronics Technology Education (EETE) aligns strongly with constructivist principles. Renewable energy systems such as solar photovoltaic installations, wind turbines, and hybrid systems require practical engagement, experimentation, and contextual learning, rather than passive theoretical instruction. Studies in engineering education have shown that project-based and experiential learning significantly improve students' technical competence and retention of knowledge (Kolb, 2015; Prince & Felder, 2006). Thus, the adoption of pedagogical strategies such as project-based learning, simulation, laboratory work, and industry-based training (SIWES) in this study is grounded in constructivist theory, which supports the development of great and transferable technical skills.

1.1.2. Human Capital Theory

Human Capital Theory, popularised by Becker (1993), asserts that investment in education and training enhances individuals' productivity, employability, and economic value. Within the context of national development, education serves as a critical mechanism for building a skilled workforce capable of driving innovation and economic growth (Toner, 2011). The integration of renewable energy technologies into EETE curricula represents a strategic investment in human capital development. As the global economy transitions toward sustainable energy systems, the demand for skilled professionals in renewable energy technologies continues to grow (Ram et al., 2019). By equipping students with relevant competencies in solar, wind, and energy management systems, universities can enhance graduates' employability and entrepreneurial potential. Furthermore, the mismatch between existing curriculum content and labour market demands in Nigeria highlights a gap in human capital development (Rabiu, S. C. J., et al., 2025). Addressing this gap through curriculum reform will contribute to workforce readiness and support the country's transition to a sustainable energy economy.

1.1.3. Theoretical Implication for the Study

The integration of Constructivist Learning Theory and Human Capital Theory provides a complementary, dual perspective on renewable energy education. While constructivism informs how renewable energy concepts should be taught, emphasising learner-centred, experiential, and interactive pedagogical approaches, Human Capital Theory explains why such education is essential by highlighting its economic significance and relevance to workforce development. Together, these theoretical perspectives justify the need for a practical-oriented curriculum design that equips learners with hands-on skills, fosters strong collaboration between educational institutions and industry, encourages sustained investment in instructional resources, and supports continuous curriculum review to ensure alignment with evolving technological and labour market demands.

2. Statement of the Problem

Nigeria is currently facing significant energy challenges, including unreliable electricity supply, rising energy demand, and environmental concerns arising from its heavy reliance on fossil fuels. Renewable energy technologies offer sustainable solutions to these challenges due to their environmental compatibility and long-term viability. However, the successful adoption and maintenance of these technologies depend largely on the availability of skilled professionals with adequate technical knowledge and practical competencies. Universities, particularly those offering Electrical and Electronics Technology Education programmes, are expected to play a central role in developing such competencies. Nevertheless, existing evidence indicates that renewable energy concepts are either insufficiently covered or absent in many technical and engineering curricula in Nigeria. Consequently, graduates often lack the practical skills and technical expertise required to function effectively in the rapidly evolving renewable energy sector.

This deficiency has resulted in a significant mismatch between the competencies graduates acquire and the skills demanded by the labour market. As a result, many graduates are unable to actively participate in renewable energy development, installation, maintenance, and entrepreneurial ventures within the sector. Furthermore, the absence of structured and comprehensive renewable energy training within EETE programmes may hinder Nigeria's progress toward sustainable energy development and technological innovation. Without deliberate curriculum integration, the country risks a shortage of a competent workforce necessary to support its transition to a sustainable energy future. Therefore, the problem this study addresses is the inadequate integration of renewable energy technologies into Electrical and Electronics Technology Education curricula in Nigerian universities, which limits the development of the relevant technical competencies required for sustainable energy development. This study, therefore, seeks to investigate effective approaches to integrating renewable energy technologies into the curriculum to enhance students' competencies and support national development goals.

3. Purpose of the Study

This study aims to facilitate the integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum in Nigerian universities.

Specifically, the study seeks to:

- Identify relevant renewable energy technology contents for integration into the Electrical and Electronics Technology Education curriculum in Nigerian universities.
- Determine appropriate pedagogical strategies for the effective teaching of renewable energy technologies in Electrical and Electronics Technology Education programmes.
- Determine the instructional resources required for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum.
- Identify the challenges associated with the integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum in Nigerian universities.
- Propose strategies for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum.

4. Research Questions

The following research questions guided the study:

- What renewable energy technology contents are appropriate for integration into the Electrical and Electronics Technology Education curriculum in Nigerian universities?
- What pedagogical strategies are appropriate for the effective teaching of renewable energy technologies in Electrical and Electronics Technology Education programmes?
- What instructional resources are required for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum?
- What challenges are associated with the integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum in Nigerian universities?
- What strategies can be adopted for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum?

5. Research Hypotheses

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

- $\mathbf{H_{01}}$: There is no significant difference in the mean responses of lecturers and technologists on the renewable energy technology contents appropriate for integration into the Electrical and Electronics Technology Education curriculum.
- $\mathbf{H_{02}}$: There is no significant difference in the mean responses of lecturers and technologists on the pedagogical strategies for effective teaching of renewable energy technologies.
- $\mathbf{H_{03}}$: There is no significant difference in the mean responses of lecturers and technologists on the instructional resources required for integrating renewable energy technologies into the curriculum.
- $\mathbf{H_{04}}$: There is no significant difference in the mean responses of lecturers and technologists on the challenges associated with integrating renewable energy technologies into the curriculum.
- $\mathbf{H_{05}}$: There is no significant difference in the mean responses of lecturers and technologists on the strategies for effective integration of renewable energy technologies into the curriculum.

6. Methodology

This study adopted a descriptive survey research design, which is appropriate for collecting and analysing data from a defined population to describe existing conditions and identify patterns without manipulating variables (Creswell, 2012). The design enabled the researcher to obtain relevant information on stakeholders' perceptions regarding the integration of renewable energy technologies into Electrical and Electronics Technology Education curricula.

The study was conducted in Nigerian universities offering Electrical and Electronics Technology Education programmes across selected states, including Adamawa, Anambra, Bauchi, Benue, Ekiti, Imo, Kano, Kebbi, Lagos, Niger, Plateau, and Zamfara. These institutions include Modibbo Adama University, Yola; Nnamdi Azikiwe University, Awka; Abubakar Tafawa Balewa University, Bauchi; Benue State University, Makurdi; Ekiti State University; Alvan Ikoku University of Education; Bayero University, Kano; Northwest University, Kano; Aliko Dangote University of Science and Technology; Kebbi State University of Science and Technology; Lagos State University; Federal University of Technology, Minna; University of Jos; and Federal University, Gusau.

The target population comprised 131 respondents, including 96 lecturers and 35 technologists involved in Electrical and Electronics Technology Education programmes. Due to the manageable size of the population, a census sampling technique was employed, allowing all members of the population to participate in the study (Creswell, 2012).

Data were collected using a structured questionnaire titled Integration of Renewable Energy Technologies into Electrical and Electronics Technology Education Curriculum in Nigerian Universities (IRETEC). The instrument consisted of five sections corresponding to the study variables: renewable energy contents, pedagogical strategies, instructional resources, challenges, and integration strategies. Responses were measured using a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1).

The instrument was subjected to face and content validation by four experts in Electrical and Electronics Technology Education drawn from Nnamdi Azikiwe University, Modibbo Adama University, Ekiti State University, and Bayero

University, Kano. Their inputs ensured clarity, relevance, and adequacy of the instrument items. All suggested modifications were incorporated into the final version of the questionnaire.

To establish the instrument's reliability, a pilot study was conducted, and the data obtained were analysed using Cronbach's alpha. An overall reliability coefficient of 0.89 was obtained, indicating high internal consistency and confirming the instrument's suitability for the study.

Data were analysed using mean and standard deviation to answer the research questions, and an independent-samples t-test was used to test the null hypotheses at the 0.05 level of significance. A decision rule of 3.50 was adopted as the benchmark for accepting or rejecting items.

7. Results

7.1. Decision Rule

A 5-point Likert scale was employed in the study to measure respondents' levels of agreement with the statements. The scale was structured as follows: Strongly Agree (SA) was assigned a value of 5, Agree (A) was assigned 4, Undecided (U) was assigned 3, Disagree (D) was assigned 2, and Strongly Disagree (SD) was assigned a value of 1.

7.2. Cut-off mean

A cut-off mean of 3.50 was adopted as the decision criterion for the study. Accordingly, any item with a mean score of 3.50 and above was accepted, while items with a mean score below 3.50 were rejected.

Mean ≥ 3.50 → Accepted

Mean < 3.50 → Rejected

7.3. Renewable Energy Contents

7.3.1. What renewable energy technology contents are appropriate for integration into the Electrical and Electronics Technology Education curriculum in Nigerian universities?

Table 1 Mean Responses on Renewable Energy Contents

Item	Description	Mean	SD	Decision
1	Solar PV systems	4.58	0.62	Accepted
2	Solar thermal systems	4.21	0.71	Accepted
3	Wind energy systems	4.33	0.68	Accepted
4	Biomass technologies	4.05	0.74	Accepted
5	Small hydro systems	4.02	0.77	Accepted
6	Energy storage systems	4.51	0.64	Accepted
7	Hybrid systems	4.29	0.69	Accepted
8	Smart grid systems	4.18	0.73	Accepted
9	Installation & maintenance	4.47	0.66	Accepted
10	Safety standards	4.49	0.61	Accepted

Grand Mean = 4.31

All identified renewable energy technology contents in Table 1 were accepted, indicating a strong consensus that these components are essential for curriculum integration.

7.4. Pedagogical Strategies

7.4.1. What pedagogical strategies are appropriate for the effective teaching of renewable energy technologies in Electrical and Electronics Technology Education programmes?

Table 2 Mean Responses on Pedagogical Strategies

Item	Description	Mean	SD	Decision
1	Project-based learning	4.49	0.65	Accepted
2	Hands-on training	4.62	0.58	Accepted
3	Simulation tools	4.28	0.70	Accepted
4	Field trips	4.11	0.75	Accepted
5	SIWES	4.45	0.67	Accepted
6	Problem-solving methods	4.33	0.69	Accepted
7	Demonstration method	4.30	0.68	Accepted
8	Collaborative learning	4.22	0.72	Accepted
9	Multimedia tools	4.19	0.74	Accepted
10	Competency-based teaching	4.41	0.66	Accepted

Grand Mean = 4.34

All pedagogical strategies in Table 2 were accepted, with emphasis on hands-on and project-based learning, confirming the importance of experiential teaching approaches.

7.5. Instructional Resources

7.5.1. What instructional resources are required for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum?

Table 3 Mean Responses on Instructional Resources

Item	Description	Mean	SD	Decision
1	Solar PV kits	4.55	0.63	Accepted
2	Functional laboratories	4.48	0.65	Accepted
3	Workshop equipment	4.36	0.69	Accepted
4	Simulation software	4.27	0.71	Accepted
5	Manuals & textbooks	4.05	0.76	Accepted
6	Internet access	4.33	0.70	Accepted
7	Trained instructors	4.52	0.62	Accepted
8	Demonstration models	4.29	0.69	Accepted
9	Funding availability	4.10	0.75	Accepted
10	Equipment maintenance	4.38	0.68	Accepted

Grand Mean = 4.33

All instructional resources in Table 3 were considered necessary, particularly training kits, laboratories, and skilled instructors**.**

7.6. Challenges

7.6.1. What challenges are associated with the integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum in Nigerian universities?

Table 4 Mean Responses on Challenges

Item	Description	Mean	SD	Decision
1	Inadequate funding	4.71	0.54	Accepted
2	Lack of personnel	4.52	0.63	Accepted
3	Insufficient training	4.46	0.66	Accepted
4	High equipment cost	4.63	0.58	Accepted
5	Poor infrastructure	4.49	0.65	Accepted
6	Weak curriculum	4.28	0.70	Accepted
7	Institutional barriers	4.32	0.69	Accepted
8	Low industry link	4.35	0.68	Accepted
9	Power supply issues	4.41	0.67	Accepted
10	Rapid tech changes	4.26	0.71	Accepted

Grand Mean = 4.44

All listed challenges in Table 4 were confirmed as major challenges, with funding and equipment cost being the most critical.

7.7. Strategies

7.7.1. What strategies can be adopted for the effective integration of renewable energy technologies into the Electrical and Electronics Technology Education curriculum?

Table 5 Mean Responses on Strategies

Item	Description	Mean	SD	Decision
1	Increased funding	4.75	0.52	Accepted
2	Lecturer training	4.60	0.60	Accepted
3	Industry collaboration	4.55	0.64	Accepted
4	Modern laboratories	4.58	0.61	Accepted
5	Curriculum review	4.50	0.65	Accepted
6	Government policy	4.47	0.66	Accepted
7	International partnerships	4.42	0.68	Accepted
8	Entrepreneurship training	4.39	0.69	Accepted
9	Research centers	4.36	0.70	Accepted
10	Competency-based curriculum	4.53	0.63	Accepted

Grand Mean = 4.52

All strategies in Table 5 were strongly supported, particularly funding, training, and infrastructure development.

7.8. Hypotheses testing analysis

Table 6 Independent Samples t-test Summary

Hypothesis	t-value	p-value	Decision
H_{01}	1.12	0.26	Not Rejected
H_{02}	0.98	0.33	Not Rejected
H_{03}	1.21	0.23	Not Rejected
H_{04}	0.87	0.38	Not Rejected
H_{05}	1.05	0.29	Not Rejected

All null hypotheses in Table 6 were not rejected ($p > 0.05$), indicating that there is no significant difference between the mean responses of lecturers and technologists across all variables.

This suggests strong stakeholder consensus, enhancing the reliability and generalizability of the findings.

8. Discussion of Findings

8.1. Renewable Energy Technology Contents

The findings revealed strong consensus among respondents on the inclusion of key renewable energy technologies, including solar photovoltaic systems, energy storage systems, hybrid systems, and renewable energy installation and maintenance. The high mean ratings indicate that these components are considered essential for equipping students with relevant technical competencies.

This finding aligns with global trends emphasising the inclusion of renewable energy systems in engineering and technical education to meet emerging workforce demands (Joseph et al., 2025). It also supports previous studies that highlight the need for curriculum restructuring to incorporate modern energy technologies (Zubairu et al., 2018). The prominence of solar photovoltaic systems reflects Nigeria's high solar potential and the growing adoption of solar-based solutions nationwide. From a theoretical perspective, this finding supports Human Capital Theory, which emphasises the role of education in developing market-relevant skills (Toner, 2011). Integrating these contents enhances graduates' capacity to contribute effectively to the renewable energy sector.

8.2. Pedagogical Strategies

The results showed that respondents strongly agreed on the effectiveness of pedagogical strategies such as hands-on training, project-based learning, industry-based training (SIWES), and competency-based approaches. Among these, hands-on training recorded the highest mean score, indicating its critical role in technical education.

This finding is consistent with Constructivist Learning Theory, which advocates for experiential and student-centred learning approaches (Zin et al., 2024). Renewable energy technologies are inherently practical, requiring learners to engage in real-world problem-solving and system design. Therefore, traditional lecture-based methods alone are insufficient for developing the required competencies. The emphasis on industry-based training also highlights the importance of bridging the gap between theoretical knowledge and practical application, ensuring that students acquire relevant industry skills (Alao et al., 2022).

8.3. Instructional Resources

The study identified essential instructional resources required for effective integration, including solar PV training kits, functional laboratories, modern workshop equipment, simulation software, and trained instructors. These resources are critical for supporting practical learning and ensuring effective curriculum delivery.

The findings suggest that the availability of infrastructure and skilled personnel is a key determinant of successful curriculum implementation. This aligns with existing literature, which identifies resource availability as a major factor influencing the quality of technical education (Akintola, 2020). The high rating of trained instructors further underscores the importance of continuous professional development in enhancing teaching effectiveness and curriculum delivery (Bawa et al., 2026).

8.4. Challenges to Integration

The findings revealed that inadequate funding, the high cost of equipment, a lack of qualified personnel, and poor infrastructure are major challenges to integrating renewable energy technologies into EETE curricula. Among these, inadequate funding emerged as the most critical challenge.

These findings are consistent with previous studies that identify financial constraints and infrastructural deficits as significant barriers to educational innovation in developing countries (Akinola et al., 2020). The high cost of renewable energy equipment further limits the ability of institutions to provide adequate practical training (Zubairu et al., 2018). Additionally, the lack of industry collaboration and insufficient training opportunities for lecturers were identified as constraints, indicating systemic weaknesses in curriculum implementation and stakeholder engagement (Rabiu, Lee, et al., 2025).

8.5. Strategies for Effective Integration

The study identified several strategies to enhance integration, including increased funding, training and retraining of lecturers, industry collaboration, the provision of modern laboratories, and curriculum review. Increased funding was ranked as the most critical strategy.

These findings suggest that effective integration requires a multidimensional approach that includes policy support, institutional commitment, and stakeholder collaboration. Industry partnerships, in particular, are essential for ensuring curriculum relevance and providing students with practical exposure (Okolie et al., 2019). The emphasis on competency-based curriculum development further underscores the need to align educational outcomes with labour market demands.

8.6. Discussion of Hypotheses Tested in the Study

The results of the hypotheses testing indicated no significant difference between the mean responses of lecturers and technologists across all variables. This suggests strong consensus among stakeholders in favour of integrating renewable energy technologies into the curriculum. Evidence from TVET studies shows that when lecturers, technologists, and industry stakeholders share similar perceptions, it often reflects alignment between curriculum expectations and workplace skill needs.

This uniformity of opinion strengthens the validity of the findings and indicates that the proposed curriculum reforms are widely acceptable among both academic and technical staff. Similar studies in Technical and Vocational Education and Training (TVET) systems report that stakeholder agreement is a key indicator of curriculum relevance and successful implementation, particularly when curriculum design reflects industry expectations and shared professional standards (Kana & Letaba, 2024).

9. Conclusion

This study has demonstrated that integrating renewable energy technologies into Electrical and Electronics Technology Education curricula in Nigerian universities is both necessary and widely supported by stakeholders. The findings reveal that relevant renewable energy contents, effective pedagogical strategies, and adequate instructional resources are essential components for successful curriculum integration.

However, the study also identified significant challenges, particularly inadequate funding, insufficient infrastructure, and a lack of trained personnel, which hinder effective implementation. Despite these constraints, the strong agreement among respondents on proposed strategies indicates a clear pathway for addressing these challenges.

The absence of significant differences between lecturers and technologists further reinforces the reliability of the findings and suggests a unified perspective on the need for curriculum reform. Generally, integrating renewable energy technologies into EETE curricula will enhance students' technical competencies, improve graduate employability, and contribute to Nigeria's transition toward sustainable energy development.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

- **Curriculum Review and Reform**

Relevant regulatory bodies and universities should revise the Electrical and Electronics Technology Education curriculum to incorporate comprehensive content on renewable energy technologies, including solar, wind, and energy storage systems.

- **Increased Funding**

Government and institutional stakeholders should allocate adequate funding for the procurement of renewable energy training equipment, laboratory facilities, and instructional materials.

- **Capacity Building for Lecturers**

Regular training and retraining programmes should be organised for lecturers and technologists to enhance their competence in renewable energy technologies and modern teaching methods.

- **Provision of Modern Laboratories and Equipment**

Universities should establish well-equipped renewable energy laboratories with functional training kits, simulation tools, and workshop facilities to support practical learning.

- **Strengthening Industry Collaboration**

Strong partnerships should be developed between universities and renewable energy industries to facilitate student internships, industrial training (SIWES), and curriculum development.

- **Policy Support and Implementation**

The government should develop and enforce policies that promote the integration of renewable energy education into higher education institutions.

- **International Collaboration**

Universities should engage in international partnerships to facilitate knowledge exchange, research collaboration, and access to advanced technologies.

- **Establishment of Research and Innovation Centres**

Institutions should establish renewable energy research centres to promote innovation, entrepreneurship, and practical skill development.

- **Adoption of Competency-Based Education**

Educational programmes should adopt competency-based approaches to ensure that graduates acquire practical, industry-relevant skills.

- **Improvement of Infrastructure**

Efforts should be made to improve power supply and general infrastructure within institutions to support effective teaching and learning.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

"Informed consent was obtained from all individual participants included in the study."

References

[1] Akinola, A. S., Eze, G. E., Ali, C. C., Afred, O. F., & Attah Blessing, I. (2020). Challenges Facing TVET Institution-Industry Collaboration in Skills Acquisition for Sustainable Growth in Nigeria. *Vocational and Technical Education Journal*, *2*(2), 231–238.

[2] Akintola, S. A. (2020). Influence of Teaching and Learning Resources on Student's Performance in Senior Secondary Schools in Gusau Local Government, Zamfara State. *The Eurasia Proceedings of Educational & Social Sciences (EPESS)*, *18*, 124–131. www.isres.org

[3] Alao, O. E., Osanyinro, J. B., & Alao, P. O. (2022). Achieving the effectiveness of the Students Industrial Work Experience Scheme for sustainability of the Nigerian economy. *International Journal of Work-Integrated Learning*, *23*(3), 393–404.

[4] Aliyu, A. Y., & Obi, U. (2025). The Effects of Solar Energy Curriculum Lesson Module on Senior Secondary School Physics Students ' Awareness of Air Pollution in. *Indonesian Journal of Pedagogy and Teacher Education*, *3*(2), 66–72. https://doi.org/https://doi.org/10.58723/ijopate.v3i2.498

[5] Bawa, K., Duhu, P. C., & Bashir, M. (2026). Improvement Needs of Electrical and Electronics Technology Education Curriculum for Sustainable Self-Employment of Graduates of Universities in Northern Nigeria. *International Journal of Research and Innovation in Social Science (IJRISS)*, *X*(2454), 7888–7900. https://doi.org/https://dx.doi.org/10.47772/IJRISS.2026.10200563

[6] Creswell, J. W. (2012). *Educational Research Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (Fourth edi). Pearson Education.

[7] Joseph, U. J., Obuah, E. C., Clement, K. B., Ekwere, W. A., Akang, S., & Edet, E. U. (2025). Grid Integration of Renewable Energy for Reliable and Efficient Power Supply in Nigeria To cite this version : HAL Id : hal-05422560 Grid Integration of Renewable Energy for Reliable and Efficient Power Supply in Nigeria. *Journal of Engineering Research and Reports*, *27*, .97-118.

[8] Kana, N., & Letaba, P. (2024). The Reshaping of Curriculum Transformation to Address The 21st -Century Skill Sets and Employment Prospects During the Fourth Industrial Revolution Era : A Case of the South Africa TVET Colleges. *South African Journal of Higher Education*, *38*(2), 157–175. https://doi.org/https://dx.doi.org/10.20853/38-2-5854

[9] Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development*.

[10] National University Commission. (2024). *NUC Committee of Experts Finalise CCMAS | National Universities Commission*. National University Commisssion. https://www.nuc.edu.ng/nuc-committee-of-experts-finalise-ccmas

[11] Nengak, J., Christiana, Z., & Ben, L. (2025). Assessing The Application of Renewable Energy Technology in Colleges of Education for Suitable National Development and Community Empowerment in North Central Nigeria. *Impact International Journals and Publications*, *1*(3), 171–182.

[12] Okolie, U. C., Nwosu, H. E., & Mlanga, S. (2019). Graduate employability: How the higher education institutions can meet the demand of the labour market. *Higher Education, Skills and Work-Based Learning*, *9*(4), 620–636. https://doi.org/10.1108/HESWBL-09-2018-0089

[13] Oshiokhai, S., Ighalo, J. O., & Banji, T. I. (2022). Knowledge , perception and awareness of renewable energy by engineering students in Nigeria : A need for the undergraduate engineering program adjustment. *Cleaner Engineering and Technology*, *6*, 100388. https://doi.org/10.1016/j.clet.2021.100388

[14] Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education*, *95*(2), 123–138. https://doi.org/http://dx.doi.org/10.1002/j.2168-9830.2006.tb00884.x

[15] Rabiu, A., Lee, M. F., & Lim, S. C. J. (2025). DACUM Approach for Integrating AI Competencies and Product Design Skills in Nigeria's TVET Programs. *International Journal of Research and Innovation in Social Science (IJRISS)*, *9*(7), 2454–6186. https://doi.org/https://dx.doi.org/10.47772/IJRISS.2025.907000293

[16] Rabiu, A., S. C. J., L., & Lee, M. F. (2025). Mapping the TVET Advancement in Nigeria : A Text Mining Analysis from Scopus and Web of Science Databases. *2025 IEEE 14th International Conference on Engineering Education (ICEED)*, 464–469. https://doi.org/10.1109/ICEED66794.2025.11400242

[17] Ram, M., Aghahosseini, A., & Breyer, C. (2019). Job creation during the global energy transition towards 100 % renewable power system by 2050. *Technological Forecasting & Social Change*, *June*, 1–19. https://doi.org/10.1016/j.techfore.2019.06.008

[18] Toner, P. (2011). Workforce Skills and Innovation: An Overview of Major Themes. *OECD Directorate for Science , Technology and Industry (STI) Centre for Educational Research and Innovation (CERI)*, 1–73.

[19] Trabelsi, R. (2025). Impact of renewable and fossil energy on sectoral CO 2 emissions : empirical evidence from the United States and China. *Discov Sustain*, *6*(1448). https://doi.org/https://doi.org/10.1007/s43621-025-02320-4

[20] Victor, A., & Ainah, P. K. (2024). Addressing Nigeria ' s Electricity Challenges : Past , Present , And Future Strategies. *American Journal of Applied Sciences and Engineering*, *5*(2), 1–16. https://doi.org/https://doi.org/10.5281/zenodo.12633012

[21] Zin, Z. M., Abdullah, A. S., Ahmad, H., & Sahib, F. H. (2024). The Constructivist Learning Theory: Exploring Key Technological Advancements In Learning. *International Journal of Modern Education*, *6*(23), 585–597. https://doi.org/10.35631/IJMOE.623040

[22] Zubairu, I., Rabiu, A., & Saminu, S. (2018). Role Of TVET in Proliferating Solar Electricity for Sustainable Economic Recovery in Nigeria. *Kano 2018 – Proceedings of the 31st TEPAN Annual National Conference*, 29–35.