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REDESIGNING POLYTECHNIC CURRICULA FOR THE GREEN ECONOMY: A FOCUS ON RENEWABLE ENERGY AND ELECTRIC VEHICLE TECHNOLOGIES

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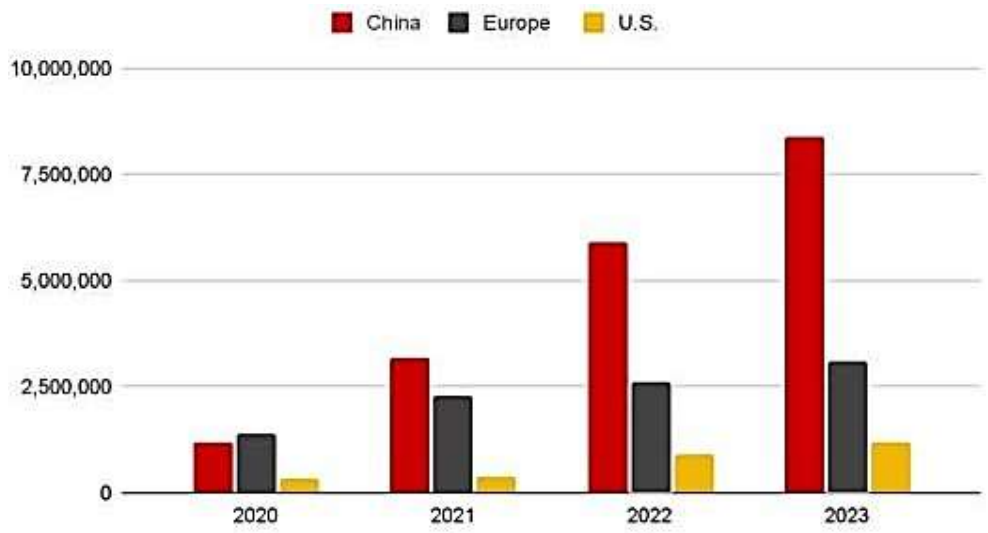
Abstract

The global shift towards renewable energy (RE) and electric vehicle (EV) technologies is reshaping engineering education, particularly in developed countries. This paper explores how these trends can be integrated into Nigerian polytechnic curricula, which largely remain focused on conventional power systems and outdated priorities. Utilizing a thematic literature review, the study examines international examples from Germany, the U.S., and South Korea, where successful curriculum reform has included RE and EV content. Nigerian polytechnics face challenges such as limited lecurers expertise, insufficient government policy support, and inadequate funding for infrastructure and training. The paper highlights opportunities for curriculum reform, including the potential for public-private partnerships, government-backed policy changes, and international collaborations to enrich the curriculum with RE and EV technologies. Recommendations include introducing modular courses that provide flexible and up-to-date content on green technologies, and fostering partnerships with industries for hands-on training. These steps are essential to equip Nigerian graduates with the necessary skills for the evolving global job market, particularly in sectors focused on sustainability and renewable energy.

Keywords: ***Renewable Energy (RE), Electric Vehicle (EV), Curriculum Reform, Sustainable Energy, Engineering Education.***

1.0 Introduction

In recent years, the global energy landscape has dramatically shifted towards renewable energy (RE) sources and electric vehicle (EV) technologies. This transition is driven by the urgent need to mitigate climate change, reduce carbon emissions, and develop sustainable energy systems. According to the International Renewable Energy Agency (IRENA, 2022), the renewable energy sector saw a 40% growth in global energy production between 2015 and 2020. Similarly, the EV market has expanded rapidly, with global sales reaching 6.6 million units in 2021 (International Energy Agency, 2022). EV sales are expected to continue strongly through 2024, with over 3 million electric cars sold in the first quarter, and sales expected to hit 17 million by the end of 2024 (International Energy Agency, 2024). Leading countries like Germany, the United States, and China are adopting policies to incentivize green technologies and integrate RE systems and EV infrastructure into daily life. Norway leads in EV adoption (93% sales share in 2023), while China dominates global EV sales (nearly 60%), and Canada has set ambitious targets for zero-



emission vehicle sales (International Energy Agency, 2024).

Figure 1: Electric car sales, 2012-2024 (Know How Hub, 2024).

The rise of RE and EV technologies necessitates a shift in the education and training of the future workforce, particularly in electrical engineering. Traditionally, electrical engineering curricula have focused on conventional power systems, machines, and basic electronics.

However, the growing demand for professionals skilled in RE systems and EV technologies, including electric motors, batteries, and charging infrastructure demonstrates the need for a more forward-thinking curriculum. Institutions in countries like Germany and the U.S. have integrated specialized courses in RE and EV technologies, ensuring graduates are prepared for the evolving energy landscape.

In contrast, Nigerian polytechnics largely maintain traditional curricula, focused on subjects like power systems, machines, control, and basic electronics. This approach reflects the outdated priorities of electrical engineering, primarily addressing 20th-century industrial demands. While these core subjects remain essential, the absence of specialized courses in RE and EV technologies, such as energy storage systems, energy management, and EV power electronics, limits the ability of Nigerian graduates to contribute to the global transition to green energy. Without immediate curriculum reform, Nigeria risks producing engineers who are not equipped to engage with the technological advancements shaping the future of energy.

This study aims to explore how international trends in integrating RE and EV technologies into electrical engineering education can inform reforms in Nigerian polytechnics. Specifically, it seeks to answer the following questions:

6. How have other countries successfully integrated RE and EV technologies into their engineering curricula, and what lessons can Nigeria learn?
7. What key challenges do Nigerian polytechnics face in adopting these technologies?
8. What opportunities exist for curriculum reform and innovation that can help align Nigerian institutions with global trends in RE and EV education?

The significance of this study lies in its potential to inform Nigerian policymakers and educators about the urgent need for curriculum reform to remain competitive in the global workforce. By aligning educational programs with global trends in RE and EV technologies, Nigeria can contribute to sustainable development goals and build a resilient green economy.

2.0 The Evolution of Electrical Engineering Curricula

2.1 Early Electrical Engineering Curricula (Global and Nigerian Contexts)

The evolution of electrical engineering curricula has been significantly influenced by the industrial landscape of the 20th century, dominated by reliance on fossil fuels and mechanical systems. This historical context is crucial for understanding the traditional courses still prevalent in educational institutions today.

Globally, electrical engineering education historically focused on principles and technologies that emerged during the industrial revolution, when industries were heavily reliant on thermal engines and fossil fuel-based energy generation. Curricula were designed to equip students with the skills necessary to design, operate, and maintain systems that powered this industrial growth. Core subjects such as circuit analysis, electromagnetism, and power systems became staples of electrical engineering programs, reflecting the energy demands and technological advancements of the time (Pokoski, 1989).

In Nigeria, the scenario mirrors global trends but is also shaped by local economic and infrastructural realities. The Nigerian electrical engineering curriculum has historically emphasized traditional power generation methods, in line with the country's reliance on fossil fuels. Nigerian institutions have prioritized courses that prepare students for conventional energy sectors, such as oil and gas, which dominate the national economy. This focus has resulted in a curriculum that lacks integration of renewable energy technologies or modern advancements in electrical engineering (Friman, 2024).

Several factors contribute to the persistence of these traditional courses:

1. Industry Demand: Many industries continue to operate on established technologies, creating a demand for graduates who are well-versed in these areas.
2. Curriculum Rigidity: Educational institutions often face challenges in rapidly updating curricula to reflect technological advancements. The inertia in curriculum development can lead to a disconnect between what is taught and what is needed in the evolving job market.

3. Resource Constraints: In many developing countries like Nigeria, limited resources hinder the adoption of new technologies and teaching methodologies that focus on renewable energy sources (Etukudoh *et al,* 2024; Badjou, 2019).

Despite these challenges, there is a growing recognition of the need to adapt curricula to include renewable energy sources and modern engineering practices. As global energy demands shift towards sustainability, educational institutions are beginning to integrate new content related to renewable energy systems alongside traditional courses. This shift aims not only to prepare students for current industry needs but also to foster innovation in emerging fields such as smart grids and sustainable energy solutions (Husanu et al., 2017; Friman, 2024).

2.2 The Emergence of Renewable Energy and Electric Vehicle Technologies

The emergence of RE and EV technologies is driven by global efforts to promote sustainability and mitigate climate change. Countries are implementing policies to reduce fossil fuel dependency and promote clean energy. The European Union's Energy and Climate Change Package, for example, sets ambitious targets for emission reductions and renewable energy integration by 2020, 2030, and 2050. Integrating renewable energy into EV charging infrastructure enhances energy reliability while reducing overall emissions, making transportation electrification a key component of a sustainable future (Reddy, 2024; Shiramagond & Lee, 2018).

Countries like Germany, the United States, and South Korea have revised their engineering curricula to incorporate comprehensive RE and EV education. Programs emphasize smart charging solutions, battery storage systems, and renewable resource integration into EV infrastructure. These shifts reflect broader commitments to equipping future engineers with the skills to address modern energy challenges (Al-Ghaili et al., 2022; Taghizad-Tavana et al., 2023; Haces-Fernandez, 2024).

2.3 Nigeria's Current Status

Nigerian polytechnic curricula lag in integrating modern RE and EV technologies, despite global trends emphasizing sustainability. Research shows that existing curricula lack practical

components and up-to-date knowledge on RE and EV technologies, limiting students' preparedness for the evolving job market. This educational gap not only curtails innovation in Nigeria but also places the country at a disadvantage compared to nations like Germany and South Korea, which have integrated RE and EV topics into their engineering programs (Sambo & Garba, 2023; Amadi, 2022).

Urgent reforms are necessary to align Nigerian polytechnic education with global trends in RE and EV technologies. These reforms should include hands-on training, interdisciplinary approaches, and partnerships with industry stakeholders to provide students with real-world experience. Emphasizing research and development in these fields can stimulate local innovation, contributing to advancements in Nigeria's energy infrastructure.

3.0 International Trends in the Integration of RE and EV into Engineering Education

Countries like Germany, the United States, and South Korea have effectively integrated RE and EV technologies into engineering education. Germany’s "Energiewende" initiative has encouraged universities to incorporate RE topics like solar and wind energy into their curricula. Industry partnerships provide practical experience for students through internships with leading automotive and energy companies. Similarly, U.S. institutions focus on battery technology and smart grid applications, supported by federal initiatives promoting clean energy innovation. South Korean programs emphasize vehicle-to-grid systems and renewable integration in their courses, preparing students for sustainable mobility (Hemmelder, 2023; Lee et al., 2021).

Government policies play a pivotal role in supporting these educational reforms. Substantial investments in green technology research and development have enabled universities to continuously update their programs. Partnerships between academia and industry are essential, as they allow students to engage in hands-on projects that reflect current technological advancements (Harrison et al., 2024; Vorapojpisut, 2023; Belu, 2017).

Nigeria can learn valuable lessons from these international examples by revising its engineering curricula to integrate RE and EV technologies comprehensively. Establishing partnerships with local industries and securing supportive government policies are critical to enhancing Nigeria's

capacity to develop a skilled workforce that can contribute to global sustainability goals (Yusuf, 2022).

4.0 Challenges, Opportunities, and Solutions for Integrating RE and EV Technologies in Nigerian Polytechnics

4.1 Key Challenges

Several challenges hinder the integration of RE and electric EV technologies into Nigerian polytechnic curricula:

1. Lack of Qualified lecturers: A major challenge is the shortage of qualified lecturers with expertise in RE and EV technologies, which limits effective teaching and curriculum development. Many lecturers require professional development and retraining programs to enhance their knowledge in these emerging fields.
2. Disconnect Between Academia and Industry: The lack of strong collaboration between educational institutions and industry stakeholders has resulted in curricula that are not responsive to evolving market needs. This disconnect hampers the integration of real-world technological advancements into the education system.
3. Policy and Government Support: National policies that mandate or incentivize the inclusion of RE and EV topics in polytechnic curricula are lacking. The absence of such policies, along with bureaucratic hurdles, complicates and slows down educational reforms. The National Board for Technical Education (NBTE) which plays a critical role in accrediting and overseeing polytechnic programs, sometimes contribute to the delay in curriculum changes. While the NBTE has the authority to mandate curriculum updates, slow response times and procedural bottlenecks often hinder timely reforms.
4. Funding Constraints: Limited financial resources prevent polytechnics from establishing modern laboratories and acquiring up-to-date equipment necessary for teaching RE and EV technologies. Increased financial support from both the government and private sectors is critical to address this issue.

4.2 Opportunities for Reform and Innovation

Despite these challenges, there are significant opportunities for reform and innovation in integrating RE and EV technologies into Nigerian polytechnics:

6. Policy Reform and NBTE Involvement: There is potential for new government policies that focus on green energy education and sustainability, supported by mandates from the NBTE. The NBTE could play a pivotal role by setting new accreditation standards that require the integration of RE and EV topics into the curriculum. Policy reforms could incentivize polytechnics to prioritize these areas, aligning with Nigeria's sustainability goals (Yang et al., 2022).
7. Curriculum Flexibility: Implementing modular courses on RE and EV technologies allows for more flexibility in the curriculum, making it easier to incorporate emerging technologies and industry needs (Ugwu et al., 2024).
8. International and Industry Partnerships: Collaboration with international institutions and industries in the RE and EV sectors can enhance knowledge transfer and curriculum design. Programs for student exchanges and lecturer training abroad can help enrich the educational experience (Achebe, 2022). Additionally, partnerships with local industries, facilitated by the NBTE, could create pathways for practical training and real-world applications.
9. Public-Private Partnerships and Funding: Public-private partnerships with energy companies, automotive firms, and technology enterprises could provide both funding and practical training opportunities. Such partnerships would also allow industry stakeholders to be involved in curriculum development to ensure that educational programs meet market demands. Furthermore, international grants and investments, such as those from the World Bank, could provide critical funding for green energy education, which the NBTE could help manage and allocate appropriately (Wogwu & Wogwu, 2023).

5.0 Conclusion and Recommendations

5.1 Conclusion

The integration of RE and EV technologies into Nigerian polytechnic curricula faces considerable challenges but also offers promising opportunities. International trends highlight the urgent need for Nigerian polytechnics to reform their curricula to align with global advancements, particularly as countries worldwide prioritize sustainability and green technology education. This reform is essential for equipping Nigerian students with the skills required in an evolving job market that increasingly demands expertise in RE and EV technologies.

Collaboration between educators, policymakers, and industry stakeholders including the NBTE, is essential to driving these reforms. Such partnerships will facilitate knowledge transfer, enhance curriculum relevance, and provide practical training opportunities that bridge the gap between theoretical learning and real-world applications. A cohesive approach, supported by the NBTE, that emphasizes innovation and adaptability, will position Nigeria to meet future energy challenges and contribute to global sustainability efforts.

5.1 Recommendations

To effectively integrate RE and EV technologies into Nigerian polytechnics, the following recommendations are made:

6. Policy Development: Nigerian policymakers should develop supportive policies that mandate the inclusion of RE and EV topics in polytechnic curricula, with the NBTE playing a central role in ensuring compliance and curriculum updates.
7. Staff Training: Training programs for lecturers and technologists should be established to enhance expertise in RE and EV technologies. The NBTE can facilitate this by accrediting professional development programs focused on green technology.
8. Industry Partnerships: Public-private partnerships should be developed to secure funding and practical training opportunities. Industry stakeholders, with guidance from the NBTE, should be involved in curriculum development to ensure educational programs meet industry needs.

9. Further Research: Further research should focus on assessing the effectiveness of curriculum reforms and identifying specific technical courses in RE and EV technologies that should be prioritized to maximize educational outcomes and industry relevance.

Implementing these recommendations, with oversight and support from the NBTE, will position Nigeria as a leader in green technology education in Africa, preparing graduates with the skills necessary to contribute to sustainable development goals and succeed in the rapidly evolving energy sector.

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