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ENERGY EFFICIENCY OPTIMIZATION IN KADUNA POLYTECHNIC: A CALL FOR SUSTAINABLE PRACTICES

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ABSTRACT

This study investigates energy efficiency optimization at Kaduna Polytechnic, focusing on demographic characteristics, behavioural practices, administrative strategies, and potential cost savings and environmental benefits. A total of 250 respondents participated, representing a balanced gender distribution, predominantly young age groups, and diverse religious affiliations. Findings reveal that frequent device usage and infrastructural systems such as cooling and lighting are the primary drivers of energy demand. Power outages significantly disrupt teaching and research, while conservation practices remain inconsistent, and awareness of institutional policies is limited. Administrative monitoring is perceived as weak, with policies often ineffective or absent, and infrastructural reliability rated only moderately. Despite these challenges, stakeholders demonstrate strong readiness for change, favouring renewable energy adoption, appliance upgrades, awareness campaigns, and college-led conservation initiatives. The study concludes that energy optimization can simultaneously reduce costs, improve academic productivity, and enhance environmental sustainability if technological upgrades, policy reforms, and behavioral interventions are prioritized. Recommendations include infrastructure modernization, renewable energy investment, systematic monitoring, and stakeholder engagement to foster a culture of sustainability in higher education institutions.

KEYWORDS: *Energy Efficiency, Sustainable Practices, Renewable Energy, Cost Savings*

1 INTRODUCTION

Energy efficiency is increasingly recognized as a cornerstone of sustainable development, particularly in academic institutions with substantial energy demands. Universities and polytechnics often operate extensive facilities, including classrooms, laboratories, administrative offices, and residential hostels, all of which contribute to significant energy consumption. Addressing energy efficiency not only reduces operational costs but also aligns with global efforts to mitigate climate change and achieve the United Nations' Sustainable Development Goals (SDGs) (Munaro & John, 2024). Institutions that prioritize energy efficiency set an example for their communities, fostering a culture of environmental responsibility and encouraging sustainable practices among students and staff. Furthermore, energy-efficient systems can enhance power supply reliability, ensuring uninterrupted academic and administrative activities.

Kaduna Polytechnic faces several energy-related challenges that hinder its operational efficiency and sustainability. Frequent power outages disrupt academic schedules and administrative functions, forcing the institution to rely on diesel generators as backup power. While these generators provide temporary relief, they are costly to operate and contribute to environmental degradation through greenhouse gas emissions (Laporte & Cansino, 2024). Additionally, many of the electrical appliances and systems in use at the Polytechnic are outdated and inefficient, leading to excessive energy consumption. Poor energy management practices further exacerbate the situation, with limited monitoring and control mechanisms in place to optimize usage. Similar challenges have been observed in other higher education institutions, highlighting the need for targeted interventions to improve energy efficiency (Almasri, Abu-Hamdeh, & Al-Tamimi, 2024). The absence of renewable energy solutions, such as solar panels or wind turbines, adds to the institution's dependence on the national grid, which is often unreliable.

Statement of the Problem

Kaduna Polytechnic faces persistent energy challenges that significantly hinder its operational efficiency and sustainability goals. The institution relies heavily on the national grid, which is prone to frequent power outages that disrupt academic and administrative activities. To mitigate these outages, the Polytechnic often relies on diesel generators, which are not only costly but also environmentally harmful due to their high carbon emissions. Furthermore, the absence of modern energy-efficient systems and practices exacerbates the issue, leading to unnecessary energy waste and increased operational costs.

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The campus is equipped with outdated electrical appliances and systems, such as incandescent lighting and inefficient HVAC (Heating, Ventilation, and Air Conditioning) units, which consume excessive energy. Additionally, there is limited awareness among staff, students, and administrators about energy conservation practices, further contributing to wasteful behaviors. These challenges are compounded by inadequate energy management strategies and the absence of renewable energy sources, such as solar panels, which could help reduce dependency on the unreliable grid.

Given these conditions, the Polytechnic faces the urgent need for an effective energy audit to assess its consumption patterns, identify inefficiencies, and recommend sustainable practices. This study seeks to address this gap by providing actionable solutions to optimize energy use, enhance cost efficiency, and foster environmental sustainability, both at Kaduna Polytechnic and as a model for similar institutions. Given this background and the problem statement, this study seeks to address the following research questions: What are the primary contributors to high energy consumption at Kaduna Polytechnic? How can energy inefficiencies be minimized through sustainable practices? Moreover, can energy optimization efforts improve cost savings and environmental outcomes?

The primary objective of this study is to conduct a comprehensive energy audit at Kaduna Polytechnic to identify areas of high energy consumption and propose sustainable practices for optimization. The research focuses on evaluating energy usage patterns across various campus facilities, assessing the efficiency of existing appliances and systems, and exploring the feasibility of integrating renewable energy solutions. By adopting a holistic approach, the study aims to provide actionable recommendations that can be implemented within the institution's budgetary constraints. Previous studies have demonstrated the effectiveness of energy audits in identifying inefficiencies and guiding the implementation of energy-saving measures (Munaro & John, 2024). The scope of this research extends beyond technical assessments to include the social and economic implications of energy efficiency, emphasizing the importance of stakeholder engagement and policy support.

2 LITERATURE REVIEW

Theoretical frameworks are essential in shaping and directing energy optimization strategies, providing structured approaches to address energy challenges effectively. These frameworks not only guide the implementation of technical solutions but also integrate social, economic, and environmental considerations to ensure holistic and sustainable outcomes.

The Energy Pyramid Framework

One of the most widely recognized frameworks in energy optimization is the Energy Pyramid. This model emphasizes a hierarchical approach, prioritizing energy conservation and efficiency measures before exploring renewable energy integration. By focusing on reducing energy waste and improving efficiency, institutions can maximize the impact of their energy optimization efforts while minimizing costs. Munaro and John (2024) advocate applying the Energy Pyramid in higher education institutions, highlighting its potential to reduce energy consumption and operational expenses significantly. They argue that this framework ensures a systematic progression, with foundational energy-saving measures implemented first, creating a solid base for integrating renewable energy technologies.

The Energy Pyramid framework has been successfully applied in various contexts, demonstrating its versatility and effectiveness. For instance, a study by Gong et al. (2023) explored its application in urban energy systems, revealing that prioritizing energy efficiency measures reduced overall energy demand by 30% before renewable energy sources were introduced. This approach not only optimized resource allocation but also enhanced the reliability of energy systems, making it a valuable tool for academic institutions aiming to achieve sustainability goals.

The Triple Bottom Line (TBL) Framework

Another critical framework in energy optimization is the Triple Bottom Line (TBL), which evaluates the economic, environmental, and social impacts of energy initiatives. This holistic approach aligns with the broader sustainability objectives of academic institutions, ensuring that energy optimization efforts contribute to societal well-being while addressing environmental concerns. Laporte and Cansino (2024) emphasize the importance of incorporating social sciences into energy research, arguing that understanding human behavior and societal dynamics is crucial for the success of energy optimization projects.

The TBL framework has been instrumental in guiding energy policies and practices in higher education. For example, a study by Saini et al. (2025) analyzed the application of TBL in renewable energy projects across universities in India, China, and Iran. The findings revealed that institutions adopting the TBL approach achieved higher levels of stakeholder engagement and community support, leading to more sustainable and impactful outcomes. By balancing economic feasibility, environmental responsibility, and social equity, the TBL framework provides a comprehensive roadmap for energy optimization.

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Smart Energy Management Systems (SEMS)

The advent of advanced technologies has revolutionized energy management, with Smart Energy Management Systems (SEMS) emerging as a key concept in energy optimization. SEMS leverages cutting-edge tools, including the Internet of Things (IoT) devices, data analytics, and artificial intelligence, to monitor and optimize energy use in real time. These systems enable institutions to identify inefficiencies, predict energy demand, and implement corrective measures proactively. Almasri et al. (2024) discuss the transformative potential of SEMS in educational facilities, highlighting their ability to achieve significant efficiency gains and cost savings.

Recent advancements in SEMS have expanded their capabilities, making them more accessible and effective. For instance, Salata and Golasi (2020) explored the integration of SEMS in industrial and educational settings, demonstrating that it can reduce energy consumption by up to 40% while enhancing operational efficiency. The study also emphasized the importance of user-friendly interfaces and training programs to ensure successful adoption and utilization of SEMS.

The Behavioral Change Model

In addition to technical frameworks, the Behavioral Change Model has gained prominence in energy optimization, focusing on the human dimensions of energy use. This model seeks to understand and influence individual and collective behaviors to promote energy conservation and sustainable practices. Brown et al. (2022) demonstrated the effectiveness of behavioral change strategies in university dormitories, where initiatives such as awareness campaigns, incentives, and feedback mechanisms led to a 25% reduction in energy consumption. The Behavioral Change Model emphasizes the role of education and engagement in driving sustainable energy practices. A study by Ferdinando et al. (2020) highlighted the importance of integrating behavioral change strategies into energy management programs, noting that institutions that actively involve students and staff in energy-saving initiatives achieve higher levels of participation and long-term success. By addressing the psychological and social factors influencing energy use, this model complements technical frameworks, creating a more comprehensive approach to energy optimization.

Integrating Frameworks for Comprehensive Energy Optimization

While each framework offers unique insights and strategies, integrating multiple frameworks can enhance the effectiveness of energy optimization efforts. For example, combining the Energy Pyramid with SEMS enables institutions to prioritize energy-efficiency measures while leveraging advanced technologies for real-time monitoring and optimization. Similarly, incorporating the TBL framework and the Behavioral Change Model ensures that energy initiatives address economic, environmental, and social dimensions while fostering a culture of sustainability.

Empirical Review

Research into energy efficiency and auditing within higher education institutions has gained prominence due to their substantial energy demands and the increasing importance of sustainability. Universities and polytechnics, often described as miniature cities, require significant energy resources to power lighting systems, heating, cooling, and equipment across campus. These institutions have a unique opportunity to serve as pioneers of sustainable practices, owing to their influence in shaping societal values and future generations. Munaro and John (2024) emphasize that although many universities have initiated energy efficiency programs, the adoption of renewable energy sources remains inadequate. Their findings suggest that an integrated approach combining detailed energy audits with active stakeholder involvement is critical to achieving significant reductions in energy consumption. They underscore the need to engage students, faculty, and administrative personnel in implementing energy-efficient measures, as technical improvements alone may be insufficient without collective commitment.

A bibliometric analysis conducted by Laporte and Cansino (2024) examined energy consumption trends in higher education institutions, revealing several pivotal factors influencing energy use, including building use, research activity intensity, and disciplinary focus. They argue that tailored strategies for improving energy efficiency are essential to account for each institution's unique attributes. For instance, research-driven universities tend to have higher energy demands due to the extensive use of laboratory equipment and extended operational hours. In contrast, institutions specializing in the humanities may exhibit lower and varied patterns of energy consumption. Additionally, Laporte and Cansino's findings highlight the influence of government policies on institutional behavior toward energy conservation. They report that institutions located in regions with stringent energy regulations are more likely to adopt proactive management practices to comply with requirements and optimize costs.

Similarly, Almasri et al. (2024) examined energy-efficient systems and renewable energy technologies, presenting findings that indicate the significant potential of innovations such as wind turbines and solar panels to reduce energy-related carbon emissions in higher education. However, their study notes that widespread adoption of these solutions is often hampered by high installation costs, limited expertise in operation and maintenance, and infrastructure incompatibilities. Almasri and colleagues advocate for fostering partnerships among academic institutions, governmental bodies, and private organizations to overcome these barriers. They also highlight the benefits

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of integrating energy-related modules into educational programs, ensuring students acquire practical knowledge of renewable energy technologies while contributing innovative solutions to campus energy challenges.

Energy audits continue to prove vital for pinpointing inefficiencies and developing actionable strategies to enhance sustainability. A study by John et al. (2025) demonstrated how comprehensive audits can identify inefficiencies, including outdated heating, ventilation, and air conditioning (HVAC) systems, poorly insulated structures, and excessive lighting. Their research highlights that implementing the recommendations derived from these audits requires financial and technical investments but delivers long-term savings on operational expenses. For instance, retrofitting incandescent bulbs with LEDs involves upfront costs but yields significant energy savings over time. Furthermore, the study emphasizes the importance of leveraging external funding opportunities, such as grants from renewable energy agencies or partnerships with technology firms, to address budgetary constraints in implementing energy-efficient upgrades.

Beyond technical evaluations, the integration of energy audits as an educational and participatory initiative within academic institutions has also been explored. Smith et al. (2023) investigated the impact of energy audits on behavioral attitudes toward energy conservation among students and staff members. Their findings illustrate that involving campus stakeholders in the auditing process fosters awareness and accountability, encouraging sustainable behaviors that support long-term institutional goals. Smith and colleagues advocate positioning energy audits as a learning platform to promote engagement and co-responsibility in implementing energy optimization strategies.

Moreover, recent technological advancements have strengthened the effectiveness and precision of energy audits. Brown and Lee (2022) explored the use of real-time analytics, smart metering technologies, and Internet of Things (IoT) devices to collect granular energy-consumption data. Their findings suggest that these tools enable the detection of subtle inefficiencies, such as energy wastage during off-peak hours or unscheduled equipment usage, which may escape traditional auditing techniques. The integration of analytics platforms within energy management systems is shown to facilitate continuous monitoring, ensuring institutions maintain optimized energy usage.

Gaps in Existing Literature

Although there is an extensive body of research on energy efficiency and audits, several important gaps remain. One of these is the limited availability of empirical studies that assess the long-term impacts of energy efficiency measures in higher education institutions. Most existing studies concentrate on the initial implementation phase, with insufficient attention to the durability and continued effectiveness of these interventions. Munaro and John (2024) emphasize the need for longitudinal research to address this shortcoming. Another gap in current research is the lack of emphasis on the roles of institutional culture and stakeholder participation in advancing energy efficiency. Laporte and Cansino (2024) highlight that while technical solutions are essential, their success largely depends on the active involvement and commitment of staff and students to adopt sustainable practices. This underscores the importance of investigating approaches that foster a culture of energy conservation within educational institutions.

Additionally, limited research is available on the integration of renewable energy systems in resource-constrained contexts. Almasri et al. (2024) highlight the challenges faced by institutions in developing countries, where financial constraints and technological limitations often impede the adoption of renewable energy solutions. They argue that addressing this gap requires tailored, context-specific research to identify practical and scalable solutions.

Emerging technologies such as artificial intelligence and blockchain also represent areas requiring further exploration in energy management. John et al. (2025) suggest that these technologies hold significant potential to transform energy audits and optimization processes. However, they note that a deeper investigation is necessary to understand their effectiveness and potential applications in real-world scenarios.

Finally, there is a compelling need for interdisciplinary research that bridges technical and social sciences. Smith et al. (2023) propose that integrating insights from psychology, sociology, and economics can yield a more comprehensive understanding of energy use and conservation in higher education institutions. This approach could help create solutions that are not only technically robust but also socially inclusive and economically sustainable.

3 METHODOLOGY

The study focused on Kaduna Polytechnic, a major academic institution located in Kaduna State, Nigeria. The polytechnic includes various facilities such as classrooms, laboratories, hostels, and administrative offices, all of which contribute to its overall energy consumption. The institution was chosen for its pressing need to optimize energy use, exacerbated by frequent power outages and

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reliance on diesel generators. The target population is all students within the institution. A total of 300 participants were selected using the Krejcie and Morgan (1970) method to ensure a balanced, representative sample. Structured questionnaires were developed to gather information about energy-use behaviours and awareness among students. To derive meaningful insights from the collected data, quantitative analytical techniques were employed. These methods enabled a comprehensive evaluation of energy usage patterns, inefficiencies, and potential optimization strategies.

DATA ANALYSIS AND DISCUSSION OF RESULTS

Table 1: Demographic Characteristics of the Respondents

Gender

Option	Frequency (f)	Percentage (%)
Male	120	48%
Female	110	44%
Other	10	4%
Prefer not to say	10	4%
Total	**250**	**100%**

Age

Option	Frequency (f)	Percentage (%)
Under 18	30	12%
18–30	150	60%
31–50	60	24%
Over 50	10	4%
Total	**250**	**100%**

Religion

Option	Frequency (f)	Percentage (%)
Christianity	140	56%
Islam	90	36%
Other religions	10	4%
Prefer not to say	10	4%
Total	**250**	**100%**

Level (for students)

Option	Frequency (f)	Percentage (%)
ND I	60	24%
ND II	70	28%
HND I	70	28%
HND II	50	20%
Total	**250**	**100%**

Source: Researchers' Computations 2026

The survey revealed a near balance between male (48%) and female (44%) respondents, with 4% identifying as "Other" and another 4% preferring not to disclose. This inclusivity reflects diverse identities and acknowledges that energy-use behaviors often vary by gender, influencing conservation practices. Age distribution was dominated by younger respondents (60% aged 18–30), consistent with the polytechnic student profile. This group is particularly relevant as they are heavy users of electronic devices, yet more adaptable to sustainability campaigns. Older respondents were fewer, with 24% aged 31–50, 12% under 18, and 4% over 50, suggesting that interventions should primarily target youth while incorporating staff and mature perspectives. Religious affiliation reflected Nigeria's sociocultural context, with Christians (56%) and Muslims (36%) forming the majority, alongside 8% from other or undisclosed faiths. This diversity highlights the potential for culturally sensitive conservation approaches. Academic level distribution was fairly even across ND I (24%), ND II (28%), HND I (28%), and HND II (20%), indicating shared concerns across all stages of study. The slightly higher representation of mid-level students suggests they may be more accessible for interventions, reinforcing the importance of embedding energy efficiency education across curricula to foster a culture of sustainability throughout students' academic journeys.

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SECTION B RESEARCH QUESTION 1: PRIMARY CONTRIBUTORS TO HIGH ENERGY CONSUMPTION

Device Usage Frequency

Option	Frequency	%
Frequently	180	72%
Occasionally	50	20%
Rarely	15	6%
Never	5	2%
Total	250	100%

Challenges During Outages

Option	Frequency	%
Significant Disruptions	160	64%
Minor Inconveniences	60	24%
No Impact	20	8%
Not Applicable	10	4%
Total	250	100%

Switching Off Appliances

Option	Frequency	%
Always	120	48%
Sometimes	80	32%
Rarely	30	12%
Never	20	8%
Total	250	100%

Lighting Efficiency Rating

Option	Frequency	%
Excellent	40	16%
Good	120	48%
Poor	70	28%
Very Poor	20	8%
Total	250	100%

Awareness Of Policies

Option	Frequency	%
Yes, Follow	60	24%
Yes, Don't Follow	40	16%
No, Want To Know	120	48%
No, Not Interested	30	12%
Total	250	100%

Suggested Improvements

Option	Frequency	%
Replace Appliances	70	28%
Use Renewable Energy	80	32%
Awareness Campaigns	90	36%
No Improvements	10	4%
Total	250	100%

Alternative Energy Dependence

Option	Frequency	%
Frequently	100	40%
Occasionally	80	32%
Rarely	50	20%
Never	20	8%
Total	250	100%

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Energy Wastage Noticed

Option	Frequency	%
Very Often	120	48%
Sometimes	90	36%
Rarely	30	12%
Never	10	4%
Total	250	100%

Training On Conservation

Option	Frequency	%
Yes, Effective	60	24%
Yes, Not Effective	40	16%
No, Want Training	120	48%
No, Don't Need	30	12%
Total	250	100%

Incentives For Efficiency

Option	Frequency	%
Rewards	80	32%
Training	90	36%
Penalties	60	24%
Do Nothing	20	8%
Total	250	100%

Source: Researchers' Computations 2026

The findings reveal that students' reliance on electronic devices is the primary driver of energy demand, with 72% reporting frequent usage in hostels and classrooms. Power outages emerged as a significant challenge, as 64% experienced major disruptions to academic activities, underscoring the need for a stable electricity infrastructure. Conservation practices were inconsistent: while 48% always switched off appliances, others did so irregularly, and lighting systems were rated only moderately efficient. Policy awareness was limited, with nearly half unaware of energy-saving measures, though many expressed interest in learning. Suggested improvements included awareness campaigns (36%), renewable energy adoption (32%), and appliance replacement (28%). Dependence on alternative energy sources was notable, with 40% frequently using generators and power banks, reflecting adaptation but also inefficiency. Nearly half observed energy wastage very often, reinforcing the urgency of interventions. Training on conservation was identified as a major need, with 48% requesting structured programs, while incentives for efficiency were preferred in the form of training (36%) and rewards (32%).

SECTION C: RESEARCH QUESTION 2: HOW CAN ENERGY INEFFICIENCIES BE MINIMIZED THROUGH SUSTAINABLE PRACTICES

Monitoring of Energy Management Practices

Option	Frequency	%
Very effectively	40	16%
Somewhat effectively	100	40%
Ineffectively	70	28%
Not monitored	40	16%
Total	250	100%

Energy-Intensive Processes/Equipment

Option	Frequency	%
Air conditioning	80	32%
Office appliances	70	28%
Lighting systems	70	28%
Other	30	12%
Total	250	100%

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Policies to minimize wastage

Option	Frequency	%
Yes, effective	60	24%
Yes, not effective	80	32%
No policies	70	28%
Not sure	40	16%
Total	250	100%

Challenges during interruptions

Option	Frequency	%
Major, generators	90	36%
Minor, planning	100	40%
No challenges	40	16%
Other	20	8%
Total	250	100%

Awareness of audit objectives

Option	Frequency	%
Fully aware	50	20%
Somewhat aware	80	32%
Minimally aware	70	28%
Not aware	50	20%
Total	250	100%

Appliance/system efficiency assessment

Option	Frequency	%
Regularly	60	24%
Occasionally	90	36%
Rarely	70	28%
Never	30	12%
Total	250	100%

Observed energy-saving measures

Option	Frequency	%
Yes, many	70	28%
Yes, a few	100	40%
None	50	20%
Not sure	30	12%
Total	250	100%

Infrastructure reliability feedback

Option	Frequency	%
Excellent	40	16%
Good	120	48%
Poor	70	28%
Very poor	20	8%
Total	250	100%

Administrator contributions

Option	Frequency	%
Campaigns	70	28%
Policies	90	36%
Resources	70	28%
Other	20	8%
Total	250	100%

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Steps to improve non-academic operations

Option	Frequency	%
Invest in appliances	80	32%
Train staff	70	28%
Renewable energy	80	32%
No steps	20	8%
Total	250	100%

Source: Researchers' Computations 2026

The Findings reveal that institutional energy inefficiencies stem largely from weak monitoring and ineffective policies. Most respondents rated monitoring of energy management practices as only somewhat effective (40%) or ineffective (28%), with just 16% considering it very effective. Energy-intensive processes were identified as air conditioning (32%), office appliances (28%), and lighting systems (28%), underscoring the need to target infrastructural systems. Policies to minimize wastage were perceived as ineffective, with 32% dismissing them and 28% reporting none existed, highlighting a gap between policy formulation and implementation. Interruptions in electricity supply compounded inefficiencies, with 36% of respondents relying on generators during major outages, reflecting resilience but also environmental concerns. Awareness of energy audit objectives was low, with only 20% fully aware, undermining stakeholder engagement. Efficiency assessments were irregular, and conservation initiatives were unevenly applied, while infrastructure reliability was rated "Good" by 48%, but dissatisfaction persisted. Administrators were recognized mainly for policy contributions (36%), though practical implementation was limited. Suggested improvements included renewable energy adoption (32%), appliance investment (32%), and staff training (28%), reflecting recognition of both technological and human-centered solutions. Overall, minimizing inefficiencies requires stronger oversight, infrastructural upgrades, and capacity-building initiatives to foster a sustainable energy culture.

SECTION D: RESEARCH QUESTION 3: ENERGY OPTIMIZATION EFFORTS IMPROVE COST SAVINGS AND ENVIRONMENTAL OUTCOMES

Main Sources of Consumption

Option	Frequency	%
Lighting	80	32%
Cooling/heating	90	36%
Devices	70	28%
Other	10	4%
Total	250	100%

Outage Impact on Teaching/Research

Option	Frequency	%
Significant	120	48%
Sometimes	80	32%
Rarely	30	12%
Never	20	8%
Total	250	100%

Replace Appliances with Efficient Options.

Option	Frequency	%
Yes, Many	90	36%
Yes, A Few	100	40%
None	40	16%
Not Sure	20	8%
Total	250	100%

Awareness of Practices

Option	Frequency	%
Very Aware	70	28%
Somewhat Aware	100	40%
Minimally Aware	60	24%
Not Aware	20	8%
Total	250	100%

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Observed Inefficiencies in Faculty Facilities

Option	Frequency	%
Frequently	100	40%
Occasionally	90	36%
Rarely	40	16%
Never	20	8%
Total	250	100%

Staff role in Conservation

Option	Frequency	%
Educating	80	32%
Leading by example	90	36%
Campaigns	60	24%
Other	20	8%
Total	250	100%

Alternative Energy Solutions

Option	Frequency	%
Renewable	100	40%
Backup systems	90	36%
None	40	16%
Not sure	20	8%
Total	250	100%

Infrastructure Effectiveness

Option	Frequency	%
Excellent	50	20%
Good	120	48%
Poor	60	24%
Very poor	20	8%
Total	250	100%

Contribution of Ideas

Option	Frequency	%
Implemented	70	28%
Not implemented	60	24%
Plan to	80	32%
Haven't	40	16%
Total	250	100%

Advocacy for Sustainability

Option	Frequency	%
Policy reforms	70	28%
Technology upgrades	80	32%
Awareness programs	70	28%
Other	30	12%
Total	250	100%

Source: Researchers' Computations 2026

The findings highlight that infrastructural systems, rather than personal devices, are the primary drivers of institutional energy demand, with cooling/heating (36%) and lighting (32%) being identified as the largest contributors. Power Reliability was a critical issue, as 48% of respondents reported significant disruption to teaching and research during outages, underscoring the need for stable infrastructure. A strong majority (76%) supported replacing appliances with energy-efficient alternatives, reflecting recognition of technology upgrades as essential for sustainability and cost reduction. Awareness of energy-saving practices was moderate but uneven, with 40% somewhat aware, 28% very aware, and 32% minimally or not aware, pointing to the need for targeted campaigns. Inefficiencies in faculty facilities were widely observed, reinforcing the urgency of infrastructural improvements. Teaching staff were seen as influential actors, both by leading through example (36%) and educating students (32%). Preferred solutions to outages included renewable energy (40%) and improved backup systems (36%). Infrastructure was rated "Good" by 48%, though dissatisfaction persisted. Stakeholder engagement was evident, with 28% reporting their ideas had been implemented and 32% planning to contribute, though responsiveness was limited.

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Advocacy for sustainability focused on technology upgrades (32%), policy reforms (28%), and awareness programs (28%), suggesting a balanced approach that integrates technological, policy, and behavioral interventions to optimize energy use and achieve environmental and economic benefits.

DISCUSSION

This study examined energy efficiency optimization at Kaduna Polytechnic, focusing on demographic characteristics, behavioral practices, administrative strategies, and potential cost savings and environmental benefits. The findings reveal that energy inefficiency is a multidimensional issue shaped by students' behaviours, infrastructural limitations, and weak policy enforcement, but also that there is strong stakeholder readiness for change. The population was predominantly young (60% aged 18–30), gender-balanced (48% male, 44% female), and religiously diverse (56% Christian, 36% Muslim). Academic levels were evenly distributed across ND and HND programs. Younger students, who dominate the sample, are both heavy consumers of electronic devices and receptive to sustainability interventions. This demographic profile provides a strong foundation for targeted awareness campaigns and for integrating energy conservation practices into the curriculum.

Frequent device usage (72%) was identified as the primary driver of energy demand. Outages caused significant disruptions for 64% of respondents, directly affecting academic productivity. Conservation practices were inconsistent: while 48% always switched off appliances, many did so only sometimes or rarely. Awareness of institutional policies was limited, with 48% reporting awareness but interest. Students suggested awareness campaigns (36%), renewable energy adoption (32%), and appliance replacement (28%) as key improvements. Incentives such as training (36%) and rewards (32%) were preferred over penalties, highlighting the importance of motivational approaches. Monitoring of energy management was perceived as only somewhat effective (40%), with many citing ineffective or absent oversight. Cooling systems, office appliances, and lighting were identified as the most energy-intensive processes. Policies were often seen as ineffective (32%) or absent (28%), and awareness of audit objectives was low. Interruptions were managed through generators (36%) or planning (40%), reflecting resilience but also inefficiency. Efficiency assessments were irregular, and observed energy-saving measures were limited. Infrastructure reliability was rated "Good" by 48% but "Poor" by 28%. Administrators were recognized for policy-setting (36%), but respondents emphasized the need for renewable energy (32%), appliance investment (32%), and staff training (28%).

Cooling/heating systems (36%) and lighting (32%) were the largest sources of consumption. Outages significantly disrupted teaching and research for 48% of respondents. Most agreed that appliances could be replaced with energy-efficient alternatives (76%). Awareness of energy-saving practices was moderate, but inefficiencies in faculty facilities were widely observed (40% frequently). Faculty were seen as key actors in conservation, particularly through leading by example (36%) and educating students (32%). Renewable energy (40%) and improved backup systems (36%) were the preferred solutions for addressing outages. Infrastructure was rated "Good" by 48% but "Poor" by 24%, showing mixed satisfaction. Advocacy focused on technology upgrades (32%), policy reforms (28%), and awareness programs (28%), reflecting a balanced approach to institutional transformation.

CONCLUSION AND RECOMMENDATIONS

The findings demonstrate that behavioral practices, infrastructural limitations, and weak policy enforcement drive energy inefficiency at Kaduna Polytechnic. Students are heavy users of electronic devices, and outages severely disrupt academic productivity. Administrative monitoring is inconsistent, policies are poorly communicated, and infrastructural systems such as cooling and lighting consume the majority of energy. Colleges and administrators are recognized as important actors but need to expand their roles in awareness, training, and implementation. At the same time, there is strong stakeholder readiness for change. Students and staff favour renewable energy adoption, appliance upgrades, awareness campaigns, and training. Incentives based on positive reinforcement are preferred, and many respondents are willing to contribute ideas for optimization. These findings suggest that Kaduna Polytechnic can achieve significant cost savings and environmental benefits by combining technological upgrades, policy reforms, and behavioral interventions. Based on the study's findings, the following recommendations are made for the Kaduna Polytechnic management.

Management should:

i. Prioritize efficiency improvements in cooling/heating systems and lighting.
ii. Reduce reliance on generators by investing in solar or other sustainable alternatives.
iii. Strengthen awareness of energy-saving policies and audit objectives.
iv. Implement awareness campaigns and conservation training for students and staff.
v. Establish systematic oversight of energy management practices.
vi. Use rewards and training rather than penalties to motivate energy-efficient behaviours.
vii. Create platforms for students and staff to contribute ideas and initiatives.

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