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Research Article

Forward-looking Visions Sustainability of Green Energy-based Learning

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Abstract

This study aimed to provide future insights into the sustainability of clean energy-based learning. It employed a rigorous descriptive methodology, compiling relevant studies and literature on green energy and sustainability for the period 2024-2026. This involved an inductive, exploratory, and evaluative analysis. Based on the researchers' perspectives, the study developed future visions. The findings revealed that transforming educational institutions into green schools is a significant challenge requiring intensive efforts and local, national, and international partnerships. Based on multiple studies, this research identifies key challenges and potential solutions that can leverage renewable energy sources. The study recommends accelerating the implementation of renewable energy solutions, such as solar panels, in educational institutions to improve energy efficiency and ensure the sustainability of operational processes. These initiatives should encompass all educational levels, from schools to universities, with financial and technical support from governments and civil society organizations.

Keywords

Green Energy, Environmental Technology, Sustainability, Sustainable Learning, Renewable Energy

1. Introduction

In light of the growing environmental challenges facing our planet, the transition to sustainability has become an urgent necessity to ensure the survival of future generations. Green energy is one of the most prominent solutions that contributes to mitigating the negative impacts of fossil fuel use. It consists of renewable energy sources such as solar, wind, and hydropower, which contribute to reducing carbon emissions and achieving sustainable development. The interest of countries and international organizations in developing renewable energy technologies stems from a desire to preserve the environment and reduce the risks that threaten life on Earth.

Most strategies for transitioning to green energy rely on technological innovation and expanding the use of clean energy sources, leading to radical changes in production and consumption patterns worldwide. With increasing awareness of the importance of these sources, environmental and economic policies are being adopted that encourage investment in renewable energy projects. These transformations are not limited to environmental aspects alone, but extend to the economic benefits that countries can achieve by adopting these technologies.

At the same time, educational institutions around the world

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have begun to integrate green energy concepts into their curricula and educational programs, with the aim of motivating younger generations to adopt sustainable practices. Education is a powerful tool for shaping environmental awareness and empowering individuals to make informed decisions about energy consumption and use it more efficiently. This is where green energy-based learning emerges as a modern educational approach that contributes to environmental sustainability.

The sustainability of green energy-based learning is central to building a knowledge-based society capable of meeting future challenges. This type of learning provides an educational environment that encourages exploration and innovation, enhancing students' ability to address environmental issues and their renewable solutions. Integrating green energy technologies into the educational process strengthens students' ability to analyze and understand climate change and the environmental impacts of using traditional energy sources.

Ultimately, a forward-looking vision for the future of green energy-based learning lies in fostering an innovative academic community that anticipates sustainable solutions and participates in promoting a clean environment. By motivating individuals to adopt a sustainable lifestyle, we cultivate a generation that understands the value of renewable energy and believes in the importance of adopting sustainable strategies to ensure the preservation of our planet for future generations.

1.1. Problem Statement

Green energy is a cornerstone of achieving sustainable development in light of the environmental challenges facing the world, such as climate change and pollution. Despite significant progress in renewable energy technologies, a considerable gap exists in the effectiveness of environmental education related to green energy and its practical applications across various fields, particularly within educational curricula. Many educational systems struggle to systematically and effectively integrate green energy concepts, impacting the ability of younger generations to adopt sustainable practices that can contribute to mitigating the effects of climate change and achieving the Sustainable Development Goals.

The problem addressed in this study lies in the limited effectiveness of green energy-based learning in many educational institutions and the lack of educational strategies geared towards promoting environmental awareness and the practical application of renewable energy. Furthermore, traditional curricula often focus on theoretical aspects without emphasizing practical applications that connect students to sustainable practices in their daily lives. This leads to a lack of in-depth understanding of green energy, its importance, and how to effectively apply it in their future lives [3, 11, 15].

This study aims to analyze the effectiveness of green energy-based [10, 17] learning as an educational tool for enhancing students' environmental awareness and to explore innovative teaching methods for integrating renewable energy concepts into school curricula. The study also seeks to identify the challenges facing educational institutions in adopting these practices and to offer forward-looking solutions that contribute to improving the role of education in promoting green energy sustainability and its applications in society.

1.2. Study Questions

How can green energy concepts be integrated into current curricula to achieve effective educational sustainability in the 21st century?

What challenges do educational institutions face in transforming their infrastructure into green schools, and how can these challenges be overcome using renewable energy sources?

How can adopting green energy in educational institutions contribute to promoting equal educational opportunities in remote areas and achieving educational equity through the use of solar energy solutions and digital learning?

1.3. Significance of the Study

1.3.1. Scientific Significance

The significance of this study lies in its presentation of a new theoretical framework that enhances understanding of the symbiotic relationship between education and green energy, and provides a scientific basis for understanding how to integrate renewable energy into the educational process. It contributes to the development of academic literature related to sustainable education, particularly concerning the transition to using renewable energy sources in educational institutions. It also promotes research into how adopting green energy improves the learning environment, both in terms of infrastructure and in enhancing students' environmental awareness. Furthermore, the study contributes to providing innovative solutions to the challenges facing educational institutions in integrating renewable energy into sustainable education strategies, thus opening new avenues for future research in this field.

1.3.2. Practical Significance

On a practical level, the study offers practical solutions that can be implemented to transform educational institutions into green and sustainable environments. It provides a comprehensive framework that helps policymakers and administrators in schools and universities implement renewable energy strategies and achieve environmental and economic sustainability. By focusing on developing smart infrastructure that utilizes solar energy and other renewable energy sources, the study contributes to improving resource efficiency and reducing the operational costs of educational institutions. Furthermore, integrating green energy concepts into the curriculum is a practical step towards enhancing students' environmental skills and motivating them to apply these concepts in their daily lives. Overall, this approach serves as a practical tool for achieving a balance between environmental sustainability, cost savings, and educational equity, thereby contributing to improved educational

quality and the development of society as a whole.

1.4. Study Objectives

This study aims to explore the symbiotic relationship between green energy concepts and educational practices, and how these concepts can be integrated into the educational process to promote environmental sustainability.

The study seeks to identify how renewable energy sources can be used to transform educational institutions into green schools, achieving operational and economic sustainability through renewable energy solutions.

The study aims to analyze the role of solar energy in ensuring continuous internet connectivity and powering digital educational devices in remote areas, thus contributing to the principle of equal opportunities in education.

The study aims to provide solutions for developing curricula that address climate change and renewable energy issues, thereby enhancing students' environmental awareness and developing their skills in science, technology, engineering, and mathematics (STEM).

The study seeks to explore how educational institutions can prepare students for the growing job market in green economy sectors by promoting sustainable education and integrating green energy concepts into curricula.

The study aims to foster a culture of green leadership in educational institutions by presenting educational leadership models that believe in the value of sustainable learning and encourage effective and responsible resource management.

2. Previous Studies

Table 1. *Previous studies during (2024-2026) are classified by researcher, objective, methodology, main findings, and main recommendations.*

M	Researcher(s) and Year	Study Objective	Methodology	Key Results	Recommendations
1	[8]	Exploring the role of digital education in achieving the concept of a green campus by reducing energy consumption and ensuring sustainability.	Descriptive analytical methodology based on survey analysis and digital assessment tools.	The results showed that digital education contributes to reducing the carbon footprint and improving energy efficiency in educational institutions.	The need to adopt digital tools to promote sustainable education, and to train academic staff on green education practices.
2	[7]	Analyzing contemporary research trends in the field of educational sustainability through bibliometric analysis.	Bibliometric analysis of Web of Science data.	A global increase in research output with a shift from environmental education to education for sustainable development.	Encouraging applied research and integrating sustainable development goals at all levels of education.
3	[3]	Studying the impact of green transformational leadership on the success of sustainable projects through green learning in renewable energy projects.	Quantitative survey methodology using an electronic questionnaire from a sample of 325 participants.	A strong positive effect of green transformational leadership on the success of projects through green learning, with a regulatory impact from government legislation.	Enhancing transformational leadership in green institutions, and activating regulatory frameworks to support sustainable learning.
4	[13]	Assessing the impact of project-based learning in teaching renewable energy to engineering students in Latin America.	Applied case study using project-based learning at a Peruvian university.	The project improved students' practical skills by 100% and highlighted energy potential in fish farms.	Adopting project-based learning to train engineers on sustainability concepts and renewable energy.
5	[15]	Studying the relationship between digital learning environments, academic achievement, and motivation towards sustainability in Saudi universities.	Quantitative methodology using a multi-stage survey of students from different disciplines.	The results showed a positive impact of the digital environment on academic achievement and achieving Saudi Vision 2030.	Integrating motivation towards sustainability in the design of digital learning environments to achieve sustainable education quality.
6	[18]	Developing AI models to predict energy consump-	Experimental comparative methodology be-	The Gradient Boosting model outperformed with the least prediction error	Integrating AI in energy management in educational institutions as a practical model for

M	Researcher(s) and Year	Study Objective	Methodology	Key Results	Recommendations
		tion in educational buildings for sustainability.	tween algorithms (Decision Tree, KNN, LSTM, Gradient Boosting).	(3.58%) and identified the most impactful variables (school size and air conditioning capacity).	sustainable environmental learning.
7	[12]	Identifying effective teaching methods to enhance awareness and sustainability among university youth.	Triangulation methodology (survey + interviews + comparison between experimental and control groups).	The study results showed that inquiry-based learning was effective in enhancing sustainable development education.	Integrating inquiry-based strategies into university curricula to raise student awareness of sustainability.
8	[1]	Exploring green professions teaching strategies and enabling students to engage in the green economy.	Analytical study based on a literature review and application of Carroll's model of sustainable responsibility.	The study highlighted the importance of project-based learning and community involvement in preparing students for sustainability careers.	Integrating green economy skills into educational curricula and developing sustainable leadership among educators.
9	[20]	Analyzing the global research perspective on environmental sustainability education in primary education.	Bibliometric analysis of 391 articles using VOSviewer tool.	The number of studies has increased, and the topics have expanded towards interdisciplinary systems thinking skills.	Encouraging integrative research to enhance the incorporation of sustainable development in primary education.
10	[1]	Examine the role of AI in enhancing sustainable marketing for green products and clean energy.	Literature review and marketing campaign analysis.	Analytical Literature Review	AI is effective in content personalization and targeted marketing; facilitates matching influencers with sustainability campaigns.
11	[6]	Present the *Sustainability Singularity Theory* (SST) to accelerate sustainable transformation.	Conceptual + Applied Examples	Analytical and Theoretical Methodology	SST illustrates the intersection of AI, green innovation, and environmental governance to accelerate sustainable transitions.
12	[17]	Improve green energy forecasting to increase grid reliability.	Solar and wind energy production data.	DTCN + Feature Selection + Metaheuristic Optimization	Significant reduction in MSE and increased accuracy for energy forecasting; supports decision-making in energy management.
13	[11]	Forecast production and consumption needs for green energy.	US Data (1965–2023)	Gated Recurrent Unit (GRU)	High accuracy in energy forecasts; integration of economic and weather data improves prediction.
14	[2]	To examine how artificial intelligence enhances sustainable green influencer marketing practices and supports environmentally responsible digital promotion.	Conceptual and analytical chapter within a sustainability and AI framework discussing emerging digital marketing practices.	AI-driven influencer marketing improves audience targeting, enhances sustainability awareness, and supports environmentally conscious consumer behavior. The study highlighted the growing integration of AI technologies in green branding strategies.	Organizations should adopt AI-supported green marketing strategies, strengthen ethical digital practices, and encourage sustainable consumer engagement through intelligent technologies.
15	[4]	To investigate the relationship between green	Meta-analytic review synthesizing findings from previous empirical	The study found a strong positive relationship between GHRM practices and	Institutions should integrate green HR policies, employee environmental training, and

M	Researcher(s) and Year	Study Objective	Methodology	Key Results	Recommendations
		human resource management (GHRM) and green innovation in promoting environmental sustainability.	studies on GHRM and green innovation.	green innovation performance. Strategic HR practices significantly contribute to environmental sustainability and organizational green transformation.	sustainability-oriented leadership to enhance innovation and long-term sustainability outcomes.
16	[14]	To explore the impact of green innovation and green sustainability practices on manufacturing firms' performance.	Empirical sustainability-focused research examining manufacturing firms and environmental performance indicators.	Green innovation positively influenced organizational performance and strengthened sustainable manufacturing practices. Firms adopting green sustainability strategies achieved higher environmental and operational efficiency.	Manufacturing firms should invest in green innovation technologies and embed sustainability principles into strategic planning and production systems.
17	[19]	To examine the role of digital education in achieving sustainable green campuses in educational institutions.	Educational and analytical study focusing on digital transformation and sustainability practices in higher education.	Digital education contributes to reducing paper consumption, improving environmental awareness, and supporting sustainable campus management. Technology integration enhanced eco-friendly educational practices.	Universities should expand digital learning environments, adopt sustainable educational technologies, and promote environmental awareness through digital education initiatives.

2.1. Commentary on Previous Studies

Previous studies can be analyzed and discussed through their similarities and differences, highlighting what distinguishes this chapter from them as follows:

2.2. First: Similarities with Previous Studies

This chapter shares with many previous studies a focus on the concept of educational sustainability and the integration of green energy principles within the educational environment, whether at the infrastructure or curriculum level. It also intersects with research that addressed the relationship between education and environmental awareness, as well as the importance of promoting environmentally responsible behaviors within educational institutions. Furthermore, it aligns with studies that emphasize the role of green technology in education, particularly regarding energy conservation and achieving higher operational efficiency in educational institutions.

2.3. Second: Differences from Previous Studies

This chapter distinguishes itself from previous studies by not being limited to the environmental or technical aspects alone. Rather, it addresses green energy as a comprehensive strategic approach to redesigning the structure of education. This is achieved through its integration with the curriculum, educational leadership, and the building of an institutional culture based on environmental responsibility. While most previous studies have focused on limited applications such as solar energy or energy efficiency in educational buildings, this chapter expands the framework to include the interactive relationship between green energy and educational practices across three key levels: operational, structural, and methodological.

Third: What distinguishes this chapter from previous studies: This chapter uniquely presents a forward-looking vision that considers green energy a strategic necessity, not merely an environmental choice. It also offers a comprehensive theoretical and applied framework that links four dimensions of sustainability: environmental, economic, educational, and social. Furthermore, it addresses the role of green educational leadership in promoting sustainability values within educational institutions and aims to transform learners from mere energy consumers into responsible global citizens. This comprehensive integration makes this chapter more contemporary and in-depth than previous studies, which have typically focused on only one dimension of sustainability.

Table 2. What Makes This study Unique.

No.	Similarities with This study	Differences	What Makes This study Unique
1	Focus on reducing emissions and achieving operational sustainability	Focused only on the technical aspect	This study links green energy with curricula and educational values
2	Focus on sustainable learning environments	Did not address green educational leadership	This study adds a dimension of leadership and environmental citizenship
3	Integration of green energy in curricula	Limited to a specific scientific subject	This c study adopts an integrated approach at the whole educational system level
4	Focus on environmental awareness among students	Focused only on awareness without practical infrastructure	This study offers a comprehensive theoretical and practical framework
5	Integrating education and the environment	Focused on content rather than infrastructure	This study integrates infrastructure, content, and curriculum
6	Use of technology to achieve sustainability	Focused only on higher education	This study includes education at all levels
7	Enhancing green digital learning	Did not link green energy with educational equity	This study adds an element of educational equity in remote areas
8	Integrating energy into experiential learning	Did not provide a comprehensive philosophical framework	This study offers an integrated philosophical and forward-looking perspective
9	Inclusion of sustainability in curricula	Did not focus specifically on green energy	This study clearly connects energy with curricula
10	Highlighting policies supporting clean energy	Focused on policies rather than educational practices	This study blends policies with practices within the institution

3. Study Results

3.1. Results of the First Question: How Can Green Energy Concepts Be Integrated into Current Curricula…, etc.

The integration of green energy concepts into current curricula is a crucial step toward fostering sustainable education in the 21st century. Based on the insights drawn from the previous studies, [5, 9, 16, 20] several strategies emerge to effectively weave these concepts into educational frameworks:

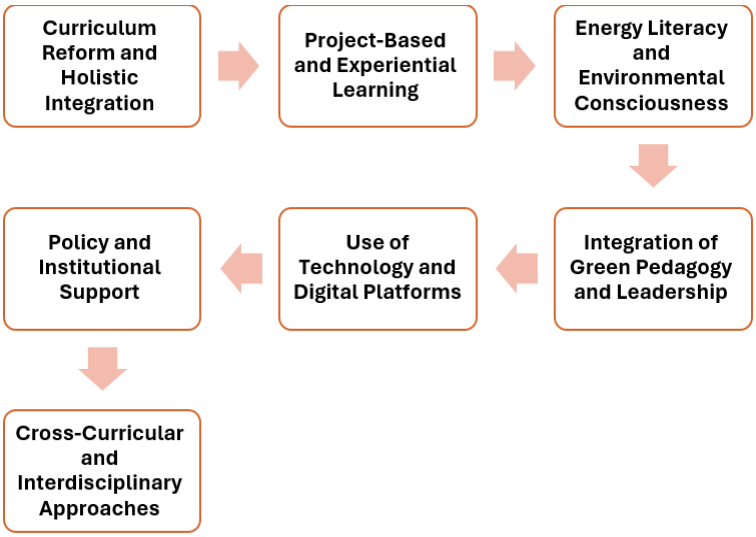

Figure 1. Strategies for effectively integrating these concepts into educational frameworks.

Curriculum Reform and Holistic Integration: As seen in studies like Sustainability and Curriculum Reform (2024), incorporating sustainability concepts into curricula involves not only adding new content but reforming existing educational structures to embrace green principles. This reform should not be limited to science or environmental studies but should be interdisciplinary, touching on various subjects such as mathematics, technology, economics, and the arts. This can involve designing projects that use renewable energy systems (e.g., solar panels or wind turbines) to teach both scientific and practical skills, linking theoretical knowledge with real-world applications.

Project-Based and Experiential Learning: From the Educational Transformation through Renewable Energy (2024) study, it's clear that project-based learning is an effective method for integrating green energy. By providing students with hands-on experiences, such as building small-scale renewable energy systems (e.g., solar-powered devices), students gain both technical knowledge and practical problem-solving skills. Such experiences align with the growing trend of STEM (Science, Technology, Engineering, and Mathematics) education, where students are encouraged to learn by doing. This approach strengthens students' understanding of green energy while developing critical thinking and innovation skills.

Energy Literacy and Environmental Consciousness: The study Energy Literacy and Pedagogical Innovation (2024) highlights the importance of environmental literacy in shaping responsible citizens. Integrating green energy concepts requires that students understand not only the technologies involved but also the broader environmental, economic, and social implications of energy consumption. Schools can incorporate modules that cover energy production, consumption, environmental impacts, and sustainability challenges. This could include teaching the carbon footprint of different energy sources and the significance of transitioning to renewable sources. Furthermore, fostering an environmental consciousness can empower students to make informed decisions about energy use in their daily lives and future careers.

Integration of Green Pedagogy and Leadership: Studies like Green Pedagogy in the Digital Age (2025) emphasize the significance of combining green energy education with leadership training. This integration ensures that students are not only informed about green energy but are also prepared to become leaders in promoting sustainable practices. Educators can model leadership through sustainable practices in schools—such as energy-efficient lighting and waste reduction initiatives—while also encouraging students to initiate and lead sustainability projects. This approach builds a sense of environmental stewardship, where students become agents of change within their communities.

Use of Technology and Digital Platforms: Digital technologies can play a vital role in integrating green energy concepts into curricula, as outlined in Green Pedagogy in the Digital Age (2025). Online platforms and digital tools can be used to create interactive lessons, simulations, and virtual tours of renewable energy projects. These technologies can provide access to real-time data on energy consumption and sustainability efforts, allowing students to analyze and draw conclusions about energy usage patterns. Furthermore, integrating renewable energy technologies into e-learning platforms helps students understand how digital platforms themselves can be powered by green energy, promoting a more sustainable approach to digital education.

Policy and Institutional Support: The study Green Education Policies and Practices (2025) underscores the role of educational policies in facilitating the integration of green energy into curricula. Schools and universities can adopt policies that encourage the inclusion of renewable energy topics and sustainable practices. Additionally, institutions can form partnerships with green energy companies, local governments, and NGOs to provide real-world data, guest speakers, and collaborative projects. Such partnerships enhance the relevance of green energy concepts, ensuring that students receive an education that aligns with current industry standards and societal needs.

Cross-Curricular and Interdisciplinary Approaches: As reflected in Sustainable Learning Environments and Energy Efficiency (2025), integrating green energy concepts should not be confined to individual subjects but should be approached from a cross-curricular perspective. For example, lessons in mathematics can incorporate energy calculations, physics can explore the principles of renewable energy systems, and social studies can analyze the impacts of energy policies on society. By creating interdisciplinary projects, students can see the interconnectedness of green energy across various domains of knowledge, allowing for a deeper understanding of its role in achieving sustainable development.

Incorporating green energy concepts into current curricula is not just about adding new content; it's about transforming the entire educational ecosystem. By adopting a holistic, project-based, and interdisciplinary approach, integrating green pedagogy, and leveraging technological tools, educational institutions can empower students to become responsible stewards of the environment. Additionally, institutional and policy support can enhance the effectiveness of these efforts. Ultimately, integrating green energy into curricula is a strategic move that not only prepares students for the challenges of the future but also contributes to a more sustainable, equitable, and resilient world.

3.2. Results of the Second Question, Which Reads: What Challenges Do Educational Institutions Face in Transforming…, etc.

Transforming educational institutions into green schools is a complex process that involves addressing a range of challenges. Based on insights from various studies, the following

key challenges and their potential solutions using renewable energy sources emerge:

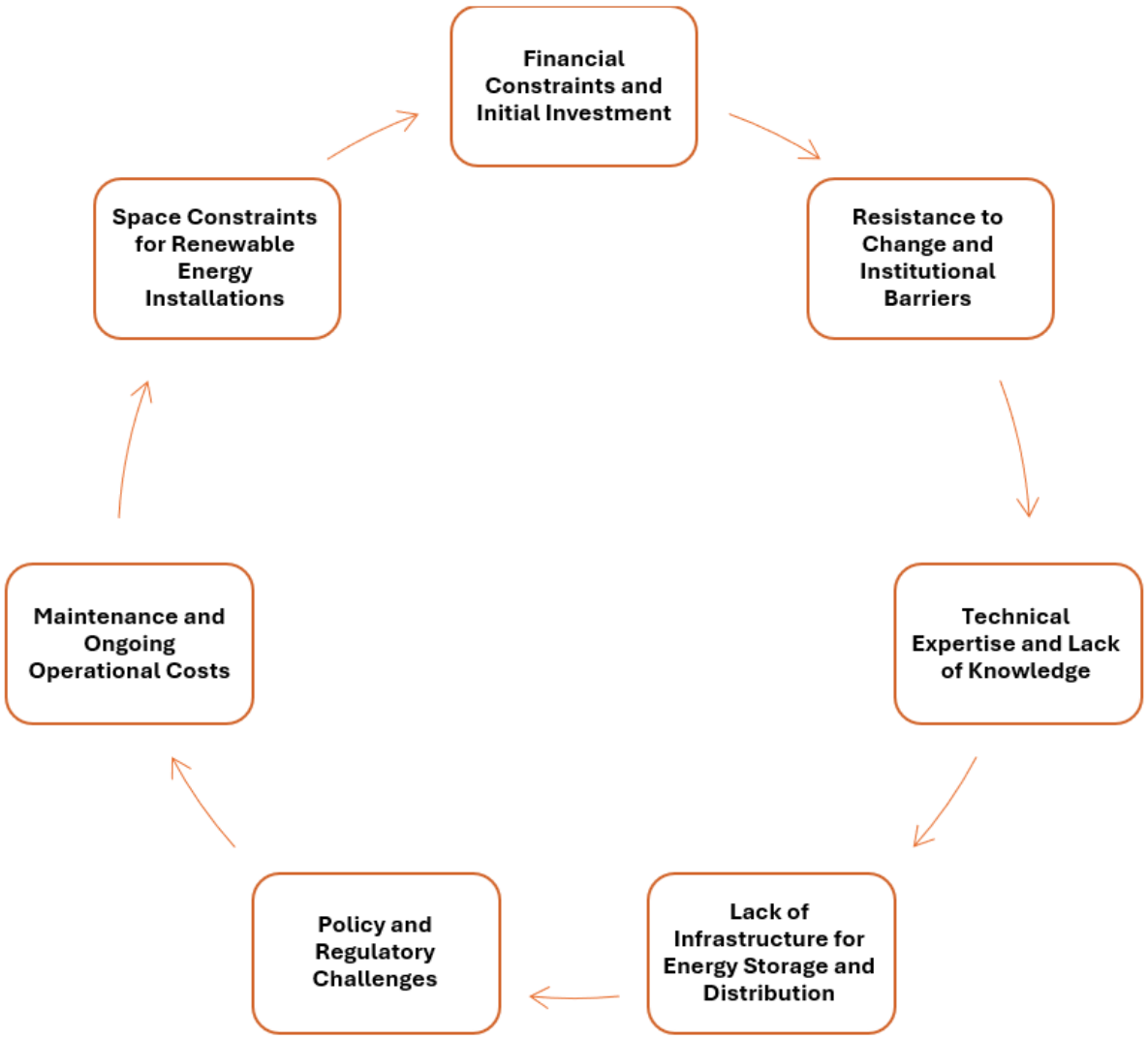

Figure 2. *The main challenges in transforming educational institutions into environmentally friendly schools and their potential solutions using renewable energy sources.*

Table 3. *The Main Challenges In Transforming Educational Institutions Into Environmentally Friendly Schools And Their Potential Solutions Using Renewable Energy Sources.*

No.	challenges	Solution
1	Financial Constraints and Initial Investment :One of the primary challenges educational institutions face when transitioning to green schools is the high initial cost of implementing renewable energy systems, such as solar panels, wind turbines, and energy-efficient infrastructure. This includes the costs of purchasing and installing the necessary technologies, as well as retrofitting existing buildings to meet green standards.	To overcome financial barriers, educational institutions can seek government grants, subsidies, and incentives designed to promote green energy adoption. Programs such as tax credits for renewable energy systems or funding for energy-efficient building upgrades can help reduce initial capital expenditure. Additionally, adopting a phased approach to implementation allows schools to gradually introduce renewable energy technologies while spreading the costs over time. Long-term savings in energy bills from the use of renewable energy can also offset the initial investment.
2	Resistance to Change and Institutional Barriers: Many educational institutions, particularly those with	Overcoming resistance requires a strong commitment from educational leaders and policymakers. This involves creating awareness and understanding of the long-term benefits of renewable energy and sustainability

No.	challenges	Solution
	limited resources or those operating in traditional environments, may face resistance to change. This can come from various stakeholders, including administrators, faculty members, and even students, who may be unfamiliar with green technologies or reluctant to alter established routines	practices. Professional development programs for teachers and administrators can be essential in increasing their capacity to lead green initiatives effectively. Moreover, engaging students in green school projects can foster a culture of environmental responsibility, with students themselves acting as advocates for the change. Providing real-world examples of successful green schools can help overcome skepticism and build support across the institution
3	Technical Expertise and Lack of Knowledge: Many educational institutions lack the technical expertise needed to design, install, and maintain renewable energy systems. This can be a significant barrier to the adoption of solar panels, geothermal heating systems, or wind turbines, as well as the integration of energy-efficient technologies into existing infrastructures.	Collaborating with renewable energy experts, consultants, and technology providers is crucial. Educational institutions can partner with local renewable energy firms or universities with expertise in sustainable technologies to design and implement these systems. Additionally, institutions can offer training for their staff and maintenance teams to ensure that the systems are properly operated and maintained. Incorporating green energy education into the curriculum itself could also equip students with the knowledge to support these transitions and maintain the systems over time
4	Lack of Infrastructure for Energy Storage and Distribution: While renewable energy sources like solar and wind can provide sustainable energy, the variability of these sources can create challenges in ensuring a consistent energy supply. Schools often lack the necessary infrastructure for energy storage (e.g., batteries) or energy distribution systems to ensure that the energy generated is used efficiently and consistently	The installation of energy storage systems, such as batteries, can help ensure that the energy generated during peak production times (e.g., sunny or windy days) can be stored and used later. This will allow educational institutions to rely on renewable energy even when the energy supply is intermittent. Additionally, integrating smart grid systems can optimize the use and distribution of energy within the school, ensuring that energy is distributed efficiently throughout the campus
5	Policy and Regulatory Challenges: In many regions, the policy and regulatory framework may not be conducive to the rapid adoption of renewable energy in educational institutions. These challenges can include outdated energy codes, lack of incentives, or bureaucratic hurdles that slow down the approval and implementation processes	Advocacy for policy change and closer collaboration with local and national governments can help address regulatory challenges. Educational institutions can work with policymakers to align energy codes with modern renewable energy technologies and ensure that green schools are incentivized through tax credits or subsidies. Establishing green certification programs, such as LEED (Leadership in Energy and Environmental Design), can also provide institutions with frameworks for making renewable energy adoption a central part of their building plans.
6	Maintenance and Ongoing Operational Costs: While renewable energy systems generally offer long-term cost savings, they require regular maintenance and occasional upgrades to remain efficient. This ongoing cost can be a concern for schools with tight operational budgets.	Developing maintenance schedules and partnerships with local energy firms can help reduce the cost and complexity of maintaining renewable energy systems. Educational institutions can also consider implementing energy performance contracts (EPCs) with energy service companies (ESCOs), which offer guaranteed energy savings over time, helping to mitigate maintenance costs. Schools can also invest in energy-efficient appliances and systems, reducing the overall demand on renewable energy infrastructure and lowering long-term operational costs.
7	Space Constraints for Renewable Energy Installations: Many educational institutions, especially those in urban areas, may face space limitations that prevent them from installing large-scale renewable energy systems such as solar panels or wind turbines.	To overcome space constraints, schools can explore creative solutions such as installing solar panels on rooftops, using vertical wind turbines, or incorporating energy-efficient solutions in underutilized spaces (e.g., parking lots or outdoor areas). Urban schools could also consider community partnerships to access shared renewable energy installations, or participate in local energy-sharing initiatives that allow schools to benefit from renewable energy generation without having to manage it independently.

Conclusion:

The transformation of educational institutions into green schools faces several challenges, ranging from financial constraints to technical expertise gaps. However, these challenges are not insurmountable. By leveraging renewable energy sources, implementing phased investments, providing technical training, and fostering policy changes, educational institutions can effectively transition to sustainable energy models.

With continued support from government, industry, and educational leaders, schools can overcome these barriers and create learning environments that promote both environmental stewardship and educational sustainability in the 21st century.

3.3. Results of the Third Question, Which Reads: How Can Adopting Green Energy in Educational Institutions…, etc.

Adopting green energy in educational institutions, particularly through the integration of solar energy solutions and digital learning platforms, can play a transformative role in promoting equal educational opportunities in remote areas and achieving educational equity. Based on the findings from previous studies, the following contributions can be identified:

1. Reliable Energy Access for Remote Areas:

One of the primary challenges faced by educational institutions in remote areas is the lack of consistent and reliable access to electricity, which hinders the ability to use digital learning tools, operate classrooms efficiently, and support modern teaching methods. Solar energy solutions offer a sustainable and independent source of power, reducing reliance on unstable grid connections or expensive fuel-based generators.

Contribution to Educational Equity: By installing solar panels and energy storage systems, schools in remote areas can ensure a consistent power supply, enabling them to operate digital learning devices such as computers, tablets, and interactive whiteboards. This allows for the integration of e-learning platforms and access to online resources, thereby bridging the digital divide and providing students in remote areas with the same learning opportunities as those in urban settings.

2. Cost-Effective and Sustainable Energy Solutions:

Traditional electricity sources in remote areas are often costly and may require significant resources for transportation and infrastructure development. Solar energy, on the other hand, offers a long-term, cost-effective solution by significantly reducing operational costs related to electricity. The installation of solar panels may require an initial investment, but over time, the savings from reduced electricity bills can be reinvested into educational resources or expanded infrastructure.

Contribution to Educational Equity: The cost savings generated from solar energy can be used to enhance the quality of education in remote areas. Schools can allocate these savings toward purchasing educational materials, hiring qualified teachers, or improving school facilities. This redistribution of resources helps promote equity by ensuring that financial constraints do not limit educational quality in underserved regions.

3. Empowering Digital Learning and Bridging the Educational Gap:

The integration of solar-powered digital learning platforms is particularly beneficial in areas where traditional education infrastructure is lacking or outdated. By adopting solar energy systems, educational institutions can power digital tools that facilitate interactive learning, virtual classrooms, and access to global knowledge through the internet.

Contribution to Educational Equity: Solar energy-powered digital learning platforms allow students in remote areas to participate in online courses, access educational videos, conduct research, and connect with peers and educators globally. This digital access helps break down geographic barriers, providing students with opportunities to engage in high-quality learning content that might otherwise be unavailable due to location or resource limitations. Additionally, remote learning tools can be crucial for students in areas with limited access to educational institutions, enabling them to continue their education without the need for long-distance travel.

4. Promoting Environmental Awareness and Sustainability:

Integrating solar energy into the curriculum not only provides a reliable energy source but also offers an opportunity to educate students about renewable energy and sustainability. Students in remote areas, who may have limited exposure to advanced environmental concepts, can benefit from learning how solar energy works, its environmental impact, and its role in reducing carbon footprints.

Contribution to Educational Equity: Educating students about green energy solutions empowers them with knowledge that can improve their future prospects and contribute to sustainable community development. It also fosters a sense of responsibility and environmental stewardship, encouraging them to adopt green practices in their daily lives. This integration of environmental education, coupled with digital learning, can create future leaders who are not only well-versed in sustainability but also capable of driving positive change in their communities.

5. Enhancing Teacher Training and Professional Development:

The adoption of green energy solutions, [10, 17] including solar-powered digital tools, requires educators to undergo training to effectively integrate these technologies into their teaching methods. Teachers in remote areas often lack access to professional development programs that incorporate new technologies and modern educational practices.

Contribution to Educational Equity: Providing training for teachers on how to use solar-powered digital tools ensures that they can fully utilize these resources to enhance their teaching methods and better engage students. Teacher training programs, supported by green energy solutions, contribute to improving the quality of education and promoting educational equity by equipping educators with the skills and knowledge necessary to teach in an increasingly digital and sustainable world.

6. Enabling Off-Grid Learning in Crisis Situations:

In regions that are prone to natural disasters, political instability, or economic difficulties, schools often experience interruptions in their operations due to power shortages or infrastructure damage. Solar energy offers a resilient solution by providing schools with a self-sustaining power source, reducing their dependency on external power grids. Contribution to

Educational Equity:
During periods of crisis or instability, schools with solar-powered systems can continue to function, ensuring that students in remote areas do not miss out on their education. This consistency in education delivery is critical for maintaining educational progress and promoting long-term equity in the face of adversity.

Conclusion:

The integration of solar energy solutions in educational institutions, particularly in remote areas, holds significant potential for promoting educational equity. By providing reliable and cost-effective energy, enhancing digital learning opportunities, supporting teacher training, and fostering environmental awareness, solar energy helps bridge the gap between urban and rural education systems. Through these measures, educational institutions in remote areas can offer students equal access to quality education, enabling them to compete on a global scale while contributing to the sustainable development of their communities. Ultimately, adopting green energy in education is a powerful tool for achieving long-term equity and sustainability in education, ensuring that all students, regardless of location, have access to the opportunities they deserve.

4. Recommendations

It is recommended to accelerate the implementation of renewable energy solutions, such as solar panels, in educational institutions to improve energy efficiency and ensure the sustainability of operational processes. These initiatives should encompass all educational levels, from schools to universities, with financial and technical support from governments and relevant institutions to facilitate the transition to green learning environments.

Green energy concepts and sustainable environmental practices should be integrated into curricula across all disciplines. This includes offering educational programs aimed at raising environmental awareness and teaching students how to use and apply renewable energy sources, including practical applications such as solar or wind-powered projects.

It is recommended to provide comprehensive training programs for teachers to develop their skills in using green energy-powered digital learning technologies. This will enable them to integrate sustainable digital learning tools into their teaching, enhancing the effectiveness of education in remote areas and contributing to educational equity.

Governments and educational institutions should adopt environmental policies and legislation that support the use of renewable energy in schools and universities, while encouraging research and innovation in sustainable education. Financial incentives should also be provided to support these transformations in educational infrastructure to achieve comprehensive educational sustainability.

Abbreviations

AI	Artificial Intelligence
SST	Sustainability Sin-gularity Theory

Conflicts of Interest

The author declares no conflicts of interest.

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