

# An Overview of Solar Energy as Eco-Sustainable Renewable Energy Solution to Energy Crisis in Nigeria.

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## ABSTRACT

### Original research paper

Nigeria's energy crisis, characterized by unreliable power supply and overreliance on fossil fuels, hinders socioeconomic development and industrial growth, with over 45% of the population lacking reliable electricity access. The study assesses solar energy's potential as a sustainable, eco-friendly energy solution to the country's energy crisis, examining current policies, challenges, and available technologies. It discusses the socio-political and infrastructural barriers preventing Nigerians from adopting solar energy, highlighting its environmental, economic, and social benefits, including reducing greenhouse gas emissions and creating employment opportunities. Nigeria's abundant solar irradiance, ranging from 3.5 to 7.0 kWh/m<sup>2</sup>/day, presents a strategic opportunity to incorporate solar technology into its energy mix, thereby reducing power supply challenges and promoting environmental sustainability. The study suggests that Nigeria's solar potential can be effectively utilized through targeted policy reforms, increased funding, public awareness, and investment in local solar manufacturing industries.

**Keywords:** Solar energy, renewable energy, energy crisis, sustainability, energy policy.

## 1. Introduction

Nigeria faces a severe energy crisis, with 43% of its 90 million people living without electricity, disproportionately affected in rural areas, despite abundant resources (Ezeanya & Onuorah, 2023). Frequent blackouts in the national grid force

individuals, businesses, and public institutions to rely on costly, hazardous fossil-fuel generators, causing economic and social inequalities. Nigeria's heavy reliance on fossil fuels significantly contributes to greenhouse gas emissions, deforestation, and climate change, posing threats to environmental sustainability and human health (Balogun et al., 2024).

However, Nigeria's solar energy offers a clean, sustainable, and abundant alternative, with daily radiation of 4.5-7.0 kWh/m<sup>2</sup> and annual sunshine of over 2,000 hours (Kure et al., 2023). Solar power, a versatile and geographically inclusive energy source, is becoming increasingly affordable due to falling global prices and local innovation in Nigeria. Modern devices can be utilized in both off-grid and on-grid configurations, offering flexibility for decentralized rural electrification and urban power backup (Ibrahim & Sule, 2022). Solar systems are modular and scalable, enabling gradual expansion based on user demand and financing capacity, making them crucial for rural communities where grid expansion is economically unfeasible. Nigeria's high solar insolation levels make solar energy an environmentally friendly and accessible renewable energy option. The daily average solar radiation in coastal regions is 3.5 kWh/m<sup>2</sup>, while in the northern part it is around 7.0 kWh/m<sup>2</sup>, with an average sunshine duration of 6-8 hours (Aliyu et al., 2024). Solar energy offers a sustainable solution for powering homes, industries, schools, health centers, and off-grid communities, addressing the persistent electricity supply-demand gap in Nigeria. Solar energy technologies, like PV and thermal systems, offer a promising solution to energy security and environmental sustainability, reducing costs and health risks associated with frequent blackouts. Nigeria, a signatory to the Paris Climate Agreement, is committed to reducing emissions by 20% unconditionally and 47% with international support by 2030 (Nnaji & Ugochukwu, 2022). Nigeria's transition to solar energy aligns with the UN's Sustainable Development Goals 7 and 13, as well as Goals 13 and 9, promoting affordable and clean energy.

Nigeria's solar technology adoption faces challenges such as inconsistent policies, lack of financing, high capital costs, low public awareness, and inadequate technical capacity (Olawale & Iweka, 2021). Existing electricity tariffs in Nigeria don't accurately reflect generation costs, limiting investment in clean energy alternatives. However, programs like NEP, EEP, and Solar Power Naija demonstrate practical viability and socio-economic benefits (Yakubu & Musa, 2024). In addition, the rapid growth of Nigeria's youthful population and the increasing engagement of private sector innovators in clean-tech solutions can drive a bottom-up revolution in solar energy deployment. Solar energy not only addresses Nigeria's energy issues but also serves as a socio-economic catalyst, improving

healthcare, education, small-scale industries, and environmental sustainability. A strategic transition to solar energy, supported by sound policies, investments, and public awareness, presents a long-term solution to Nigeria's energy poverty and climate vulnerability.

This paper explores solar energy as an eco-sustainable renewable energy solution to tackle Nigeria's energy crisis. It aims to analyze Nigeria's energy sector, assess its technical and economic potential, evaluate its environmental and socio-economic benefits, identify barriers to implementation, and recommend policy strategies for effective solar energy deployment. This study uses a qualitative and descriptive research methodology, analyzing secondary sources like journal articles, government reports, and case studies from 2020-2025, to critically evaluate Nigeria's solar energy landscape, identifying recurring themes in energy access, policy implementation, infrastructure development, and sustainability.

Nigeria's renewable energy challenges were analyzed using academic databases and policy reviews. It also compared Nigeria's solar energy adoption rates with other developing countries, focusing on the practical viability of solar energy in different regions. Nigeria's solar energy future depends on robust policy support, public-private partnerships, and consumer education, promoting inclusive energy access, poverty reduction, and national development.

## 2. Importance of Energy to Man

Energy is a vital driver of human civilization, economic growth, and technological advancement, supplying power to homes, industries, healthcare systems, transportation, and various modern life sectors. Energy scarcity hinders economic growth, inefficiencies in healthcare, weakens education systems, and perpetuates poverty (Chukwu et al., 2023). Energy consumption patterns in human societies are linked to development, health, literacy, and productivity, improving water supply, food preservation, and enabling modern communication technologies. (Adefolu & Olanrewaju, 2021).

Energy availability and quality are linked to the Human Development Index, with countries with high per capita energy consumption achieving better health, education, and income, especially in rural and underdeveloped communities (Ogundipe et al., 2024). Energy is not just a technical commodity; it's crucial for equitable development and human dignity. It's central to technological innovation, industrial competitiveness,

and job creation. Countries investing in sustainable energy strategies are likely to succeed in the fourth industrial revolution (Yahaya & Osagie, 2025). Energy is crucial for disaster resilience and climate adaptation, supporting emergency services, early warning systems, and climate control systems in various buildings, ensuring daily functioning and societal survival during environmental crises (Munir et al., 2023).

### **3. Current Energy and Power Situations in Nigeria**

Nigeria's energy sector faces challenges due to poor maintenance, gas supply issues, and transmission bottlenecks, despite its vast energy resources, hindering national development and limiting the country's electricity generation capacity (Bello & Akanbi, 2024). 47% of Nigerians lack grid electricity, particularly in rural areas, due to unreliable grid, frequent blackouts, and limited geographical reach (Salihu et al., 2023). Nigeria's energy situation is paradoxical, with abundant resources but widespread poverty due to policy inconsistencies, mismanagement, and corruption (Nwankwo & Ibrahim, 2022).

Nigeria's electricity tariff structure, despite government efforts, discourages investment, financial losses, and infrastructure expansion due to subsidized rates, high electricity theft, and billing inefficiencies (Udo & Hassan, 2024). Nigeria's dependence on fossil fuels leads to global oil price volatility, poverty, and inequality, necessitating reform and diversification of the country's energy sector (Adewole et al., 2021). Unreliable power impacts education, healthcare, manufacturing, and small-scale enterprises, stagnating national development. Without robust energy portfolio, digital transformation and economic competitiveness will be hindered (Kalu & Okoro, 2023).

### **4. Energy Crisis in the Globe and Nigeria**

The global energy crisis is a growing imbalance between demand and sustainable supply, driven by factors such as overdependence on fossil fuels, geopolitical conflicts, aging infrastructure, and population growth (Munir et al., 2023). Climate change and carbon emission concerns prompt international efforts to reduce fossil fuel reliance, with Nigeria grappling with a multifaceted crisis, including low electricity grid utilization and polluting generators (Udo & Hassan, 2024). Nigeria's energy crisis, exacerbated by rising diesel costs, insecurity, and limited renewable

investment, has led to reduced industrial productivity, increased operational costs, and job losses (Adewole et al., 2021).

The energy crisis has exacerbated social inequalities and environmental degradation, exposing vulnerable populations to indoor air pollution, fire hazards, and noise, emphasizing the need for clean, decentralized, and affordable energy solutions (Ogundipe et al., 2024). The Russia-Ukraine conflict and supply chain disruptions are accelerating global fuel price volatility, prompting countries like Nigeria to accelerate their transition to renewables for energy independence and sustainability (Chigozie et al., 2024). The International Energy Agency (IEA) and the United Nations Framework Convention on Climate Change (UNFCCC) stress the need for Nigeria to rapidly adopt renewable energy sources to ensure climate resilience and sustainable development, aligning with global trends (IRENA, 2023).

### **5. Need for Alternative Energy Source Harness**

The urgent need for sustainable development and alternative energy sources is growing due to the finite nature of fossil fuels and the increasing environmental impact of climate change (Yahaya & Osagie, 2025). Nigeria's vast renewable energy potential is largely untapped, making it crucial for reducing carbon emissions and achieving energy security, especially in remote and underserved areas. According to the International Renewable Energy Agency (IRENA), the country has the potential to generate over 427,000 MW from solar alone (IRENA, 2023). Alternative energy solutions like solar, wind, hydro, and biomass diversify energy, reduce import dependency, and decentralize access, necessitating increased investment and innovation for energy access and environmental sustainability.

Alternative energy promotes innovation, job creation, and skills development, fostering local industries like solar panel manufacturing. Governments can encourage private sector investment through incentives and subsidies. A well-coordinated national energy roadmap that incorporates renewables will help Nigeria meet its energy needs while fulfilling its climate obligations (Ogbonna & Uduma, 2024). Alternative energy technologies promote resilience and adaptability in the face of environmental and economic shocks. Solar microgrids offer reliable power in disaster-prone or conflict-affected areas, crucial for survival and inclusive

growth amid rising temperatures and climate extremes (Emeh et al., 2025). Nigeria can diversify its economy, build a more inclusive society, and empower communities to participate in energy generation and governance through renewable energy integration (Nnaji & Ugochukwu, 2022).

## 6. Alternative Energy Sources and Their Environmental Effects and Cost of Conversion

Alternative energy sources like solar, wind, hydro, biomass, and geothermal are renewable and environmentally friendly, but they have their own environmental implications and conversion costs (Ajiboye et al., 2024). Similarly, wind turbines can affect bird migration patterns and generate noise pollution, while hydropower plants may disrupt aquatic ecosystems and displace communities (Eze & Maduekwe, 2023). Converting to alternative energy sources can be costly, requiring significant investment in solar panels, batteries, inverters, wind turbines, and hydroelectric plants. Biomass energy costs include feedstock collection, storage, and processing, but these are offset by long-term environmental benefits and reduced operational expenses, particularly with subsidies or policy incentives (Ishola & Adeyemi, 2023). Renewable energy provides a stable pricing structure and is becoming more competitive with fossil fuels due to technological advancements and economies of scale. Nigeria can reduce costs and enhance accessibility by utilizing locally manufactured solar components, international partnerships, microfinancing, tax incentives, and public awareness campaigns.

## 7. Potentials in Solar Energy System

Nigeria enjoys one of the world's highest solar radiation levels, with an average solar insolation of 5.5 kWh/m<sup>2</sup>/day and 6 to 7 hours of sunshine daily (IRENA, 2023). Solar energy is a suitable solution for addressing energy challenges in the country due to its widespread use across both rural and urban areas.

. Rural electrification using solar mini-grids and solar home systems is particularly feasible, providing communities with clean, reliable, and affordable electricity (Ogbonna & Uduma, 2024). Nigeria's solar energy can diversify its energy mix, reduce dependence on fossil fuels, and revolutionize agriculture, with solar farms, rooftop installations, and streetlights reducing grid pressure (James et al., 2025). Nigeria's integration of solar into its energy policy is crucial for economic

empowerment, as it creates job opportunities in installation, maintenance, research, and equipment distribution. Solar energy can promote local entrepreneurship and accelerate economic diversification in sectors like textiles, agro-processing, and ICT, through solar kiosks, charging stations, and water purification systems (Bamidele et al., 2024).

## 8. Solar Energy as a Sustainable and Surest Eco-Friendly Energy Source

Solar energy is a sustainable and environmentally friendly energy source, as it does not emit greenhouse gases or pollutants during operation, unlike fossil fuels. Nigeria is transitioning to solar energy, a renewable and abundant resource, to meet international climate commitments and reduce carbon emissions (Chigozie et al., 2024). Solar energy offers eco-sustainability beyond emissions reduction, reducing water usage, noise pollution, and requiring minimal land clearing for modular installations. Solar panels on rooftops reduce land footprint, promote urban resilience, and offer decentralized energy solutions, empowering communities in off-grid locations and promoting self-reliance (Udo & Hassan, 2024). Solar energy systems are adaptable to climate change, providing power during natural disasters and enhancing energy independence, reducing reliance on imported fuels and strengthening national security. Solar energy is seen as a promising path for sustainable development and environmental stewardship in Nigeria and globally due to its unique characteristics.

## 9. Solar Energy System Technology

Solar energy systems, including photovoltaic (PV) systems, convert sunlight into electricity, ranging from rooftop installations to large utility-scale farms, harnessing solar radiation for electricity and heat. Advances in PV efficiency, storage technology, and inverter design have made solar systems more reliable, affordable, and scalable (Kalu & Okoro, 2023). Solar thermal systems, concentrated solar power (CSP) systems, solar water heaters, dryers, and hybrid solar-wind systems are gaining popularity in Nigeria's rural and semi-urban areas for industrial processes and electricity generation (James et al., 2025).

The integration of smart technologies, such as IoT-enabled monitoring systems, enhances the efficiency and management of solar energy. Battery storage innovations, like lithium-ion and saltwater batteries, ensure continuous supply during non-sunlight hours.



The growing solar technology market in Nigeria will require local manufacturing, training programs, and research and development to establish a self-sustaining industry (Bello & Akanbi, 2024). Nigeria's solar energy future depends on robust policy support, public-private partnerships, and consumer education, promoting inclusive energy access, poverty reduction, and national development.

## 10. Conclusion

The review explores energy's crucial role in Nigerian development, addressing power sector issues like electricity shortages and fossil fuel reliance. The paper explores the significance of energy in human development and socio-economic transformation, focusing on Nigeria. It reveals that despite abundant energy resources, Nigeria faces chronic electricity shortages due to inadequate infrastructure, policy inconsistencies, and overreliance on fossil fuels. It also highlights the global energy crisis and climate change impacts as justification for renewable energy transition. A national commitment to solar energy will bridge the energy gap, foster economic inclusion, and ensure sustainable development for future generations. The transition to renewable energy will not only decrease carbon emissions and environmental degradation but also improve national energy security, economic diversification, and overall quality of life. Nigeria needs robust policies, financing mechanisms, public education, and capacity building to promote solar energy adoption. The review is summarized as stated thus;

- i. The paper discusses the global energy crisis, focusing on climate change, geopolitical tensions, and increasing energy demands, recommending solar energy as the most eco-sustainable option for Nigeria.
- ii. Nigeria has the potential to transition its energy paradigm towards solar-based renewable energy systems, leveraging its geographic, environmental, and technological potential to address its energy crisis.
- iii. Solar energy is identified as Nigeria's most sustainable and economically viable alternative energy source, emphasizing its solar potential, benefits, and the need for infrastructure and policy reforms to lead Africa's solar revolution.
- iv. A decentralized approach, driven by government incentives, private sector investments, and community-based models, aligns with global trends

for a clean and resilient energy future is recommended.

- v. The study highlights the importance of solar energy in Nigeria for clean, sustainable power, decentralized access, rural electrification, and economic inclusion. It emphasizes the need for advanced solar technologies, policy frameworks, public-private investments, and community participation.

## References

1. Balogun, T. A., Uchenna, D. I., & Oladimeji, K. A. (2024). Climate-smart energy policy and the future of renewables in sub-Saharan Africa: A Nigerian perspective. *Renewable Energy Policy Journal*, 58(3), 112–124. <https://doi.org/10.1016/j.repj.2024.04.003>
2. Ezeanya, F. C., & Onuorah, P. I. (2023). Electricity poverty and socio-economic development in Nigeria: A rural-urban analysis. *Energy and Development Studies*, 45(2), 89–102. <https://doi.org/10.1080/eds.2023.03.004>
3. Ibrahim, A. Y., & Sule, M. T. (2022). Decentralized solar energy systems for rural electrification in Nigeria: Opportunities and barriers. *Journal of Renewable Energy Deployment*, 11(1), 34–47. <https://doi.org/10.1177/2022JRED1032>
4. Kure, N. J., Ojo, B. M., & Lawal, A. F. (2023). Mapping solar radiation for sustainable energy transition in Nigeria. *Nigerian Journal of Sustainable Engineering*, 7(4), 212–223. <https://doi.org/10.4314/njse.v7i4.005>
5. Nnaji, E. C., & Ugochukwu, M. I. (2022). Climate commitments and renewable energy adoption in Nigeria: A policy-path analysis. *African Energy Research Review*, 10(2), 76–91. <https://doi.org/10.1080/aerr.2022.02.009>
6. Olawale, R. T., & Iweka, S. O. (2021). Barriers to solar PV adoption in Nigeria: Perspectives from policymakers and investors. *Journal of Energy and Environmental Planning*, 39(1), 15–28. <https://doi.org/10.1016/jeep.2021.01.002>
7. Yakubu, L. A., & Musa, A. M. (2024). Evaluating the impact of Nigeria's Solar Power Naija initiative on energy access and rural livelihoods. *International Journal of Green Technologies*, 18(2), 134–148. <https://doi.org/10.1016/ijgt.2024.02.008>

8. Adefolu, A. O., & Olanrewaju, T. M. (2021). Energy access and development indicators in sub-Saharan Africa. *African Journal of Sustainable Development*, 9(2), 45–58.
9. Adewole, S. A., Okojie, E., & Hassan, I. (2021). Economic impacts of Nigeria's electricity shortage. *Nigerian Journal of Energy Policy*, 17(1), 28–39.
10. Ajiboye, K. A., Bello, R. T., & Yakubu, U. I. (2024). Environmental implications of photovoltaic waste in sub-Saharan Africa. *Journal of Green Engineering*, 11(2), 88–101.
11. Bamidele, F. J., Osakwe, C. M., & Lawal, A. T. (2024). Solar entrepreneurship and industrial growth in Nigeria. *Energy Development Review*, 14(1), 74–90.
12. Bello, R. A., & Akanbi, M. A. (2024). Power supply deficit and industrialization in Nigeria: A macroeconomic review. *Journal of African Economic Sustainability*, 12(1), 76–88.
13. Chigozie, C. J., Onwuka, M., & Ibe, K. (2024). Climate mitigation and solar adoption in Nigeria: Pathways to sustainability. *Global Clean Energy Research*, 16(2), 133–148.
14. Chukwu, B. C., Amadi, N. E., & Okonkwo, E. M. (2023). Electricity access and poverty alleviation in Nigeria. *Journal of Energy for Development*, 10(3), 112–125.
15. Emeh, A. C., Odo, E. O., & James, A. T. (2025). Unlocking rural Nigeria through solar micro-grids. *African Journal of Clean Energy Innovation*, 11(1), 102–115.
16. Eze, I. C., & Maduekwe, C. P. (2023). Environmental risks of hydroelectric power projects in Africa. *African Environmental Science Journal*, 9(2), 56–69.
17. IRENA. (2023). Renewable capacity statistics: Nigeria country profile. International Renewable Energy Agency. <https://www.irena.org>
18. Ishola, T. S., & Adeyemi, M. O. (2023). Cost-benefit analysis of alternative energy systems in Nigeria. *West African Energy Studies*, 7(3), 112–126.
19. James, K. O., Agwu, N. C., & Onuoha, A. D. (2025). Solar-powered agriculture in Nigeria: A path to sustainable food security. *Journal of Agritech and Sustainability*, 13(1), 50–66.
20. Kalu, U. J., & Okoro, M. A. (2023). Next-gen photovoltaic technologies: A Nigerian roadmap. *Solar Tech Africa*, 5(2), 87–98.
21. Munir, R. H., Bello, I. A., & Smith, P. L. (2023). The global energy dilemma: Transition and crisis management. *International Energy Journal*, 34(4), 201–218.
22. Nnaji, E. C., & Ugochukwu, M. I. (2022). Climate commitments and renewable energy adoption in Nigeria: A policy-path analysis. *African Energy Research Review*, 10(2), 76–91.
23. Nwankwo, A. T., & Ibrahim, S. A. (2022). Governance and inefficiency in Nigeria's electricity sector. *Journal of Public Utilities and Governance*, 8(3), 155–167.
24. Obi, A. K., & Nwachukwu, L. O. (2025). Localizing renewable energy: Manufacturing solar solutions in Nigeria. *Journal of Clean Energy Policy and Practice*, 12(2), 92–106.
25. Ogbonna, F. J., & Uduma, I. A. (2024). Estimating solar energy potential across Nigeria's ecological zones. *Renewable Energy Reports*, 13(2), 145–162.
26. Ogundipe, S. M., Akomolafe, R. K., & Eze, T. D. (2024). Gender, energy access, and rural development in Nigeria. *African Journal of Development Studies*, 8(2), 90–105.
27. Salihu, B. M., Ibrahim, M. S., & Okojie, F. T. (2023). Nigeria's generator economy: Risks and resilience. *Journal of Nigerian Energy Policy Studies*, 6(1), 49–64.
28. Udo, U. A., & Hassan, K. O. (2024). Decentralized energy solutions in Nigeria's informal economy. *Energy Equity and Sustainability*, 11(3), 174–189.
29. Yahaya, M. T., & Osagie, C. O. (2025). Accelerating renewable energy adoption in Nigeria: Policy and market gaps. *Journal of Renewable Energy and Climate Policy*, 14(1), 29–43.