IJAAR PUBLISHING®

African Journal of Environment and Sustainable Development | ISSN: 3027-2718
Vol. 3, Issue 3 (2025) | www.ijaar.org

DECENTRALIZED ENERGY ACCESS: A CATALYST FOR INCLUSIVE DEVELOPMENT IN NIGERIA

Laoye, Adedipupo David and Osarosee, Ekhator Osagie

E-mail: davpupolaoye@gmail.com, osagierios@gmail.com

Abstract

This study explores the influence of decentralized energy access on inclusive development in Nigeria. The study is guided by three (3) research objectives, questions, and hypotheses. 40.6 million people from urban and rural households, and SME owners from the six (6) geopolitical zones in Nigeria make up the population of the study. Taro Yamane was used to determine the population sample size of 400 people who are the respondents of the study. A structured questionnaire was used to solicit data from the study respondents. Of the 400 questionnaires distributed, 394 were retrieved and used for the study. The Spearman Rank Correlation Coefficient statistical tool was used to test the hypothesis. Findings from the study indicated that a significant positive relationship exists between decentralized energy access and inclusive development in Nigeria. The study concluded that decentralized energy systems such as mini-grids, solar household systems, and other renewable energy solutions address the energy poverty that impedes social and economic development by increasing access to reasonably priced, dependable, and sustainable electricity. This study recommended that the government, communities, and business owners in Nigeria should adopt various forms of decentralized energy systems for inclusive development.

Key Words: Decentralized, Energy, Renewables, energy poverty, development, climate change.

Laoye, A. D and Osarosee, E. O. (2025). Decentralized Energy Access: A Catalyst for Inclusive Development in Nigeria. *African Journal of Environment and Sustainable Development. 3*(3), 1-17. DOI: https://doi.org/10.5281/zenodo.16759659

INTRODUCTION

Today, more than 20% of the global population lacks access to reliable electricity, and nearly 40% are dependent on biomass fuels, such as charcoal or wood, for cooking. Access to energy and a healthy market environment for small, locally-owned businesses are two major drivers of poverty reduction. However, the persistent challenge of energy poverty continues to hinder socio-economic development in many emerging economies, particularly in Sub-Saharan Africa. Nigeria, with its vast population and significant energy deficit, exemplifies this struggle. Traditional centralized energy infrastructure has often proven inadequate in reaching Nigeria's remote communities and addressing the growing energy demands of the nation. Despite abundant fossil fuel resources, a substantial portion of the Nigerian population lacks access to reliable and affordable electricity, impeding economic growth, healthcare, education, and overall quality of life (Akua, Twum & Beecham, 2024). This has led to a critical need for alternative energy solutions that can provide reliable and affordable power to underserved populations, fostering inclusive development.

In this context, decentralized energy systems in Nigeria, ranging from LPG, solar home systems to mini-grids, are gaining traction as viable alternatives to traditional, centralized grid expansion. These systems offer flexibility, scalability, and resilience, making them particularly well-suited for underserved communities. Miller, Carney, Bosma, Abrams, Cox, &Willis (2019) opined that in emerging markets around the world, having access to electricity raises economic value and improves living standards. However, the successful deployment of decentralized energy in Nigeria requires more than technological innovation; it demands an enabling policy environment, sustainable business models, and community-driven approaches that prioritize inclusion and equity.

STATEMENT OF THE PROBLEM

Despite being rich in oil and gas resources, Nigeria continues to grapple with a substantial energy deficit. Access to reliable and affordable energy remains a significant challenge in Nigeria, hindering economic growth and social development in many emerging economies. World Bank. (2021) reported that an estimated 85 million Nigerians lack access to electricity. This energy poverty impairs households, limits industrial productivity, and hampers efforts toward inclusive development.

Also, traditional centralized power generation and grid extension have proven costly, technically challenging, and often inadequate in reaching rural and remote communities (Omole, Olajiga & Olatunde, 2024). As a result, these areas remain marginalized, facing disparities in development outcomes due to limited energy access. Nnadi, Onwuagbu & Chigozie (2025) asserted the reliance on fossil fuels and large-scale infrastructure investments further complicates Nigeria's transition toward sustainable and resilient energy systems.

In this context, decentralized energy solutions such as solar mini-grids, home solar systems, and off-grid renewable technologies offer promising alternatives to expand access. However, there is a lack of scalable models that integrate decentralized energy solutions with inclusive development goals, ensuring social equity, economic empowerment, and environmental sustainability

STUDY GAP

Numerous similar studies in recent years have tried to examine decentralized energy access and inclusive development as a catalyst for emerging economies. Orudukobipi (2022) explained that the centralized and unsustainable nature of Nigeria's energy system is linked to huge wastage of primary energy input, climate change, and persistent insecurity. And these energy challenges can be addressed through the capacity of the Community Choice Aggregation model (CCAM) to decentralize Nigeria's entire energy system and ensure sustainability. Oyedepo, Babalola, Nwanya, Kilanko, Leramo, Aworinde, Adekeye, Oyebanji, Abidakun, & Agberegha (2018) in their study and survey stated that for Nigeria to have access to a reliable and stable supply of electricity, decentralized renewable energy systems should be harnessed for continuous energy supply and the government's efforts to ensure renewable energy's sustainability. Ogbomida, Mustapha, Emeribe, Ezemonye & Ajieh (2024) also found that to address the challenges associated with Nigeria's energy shortages, the national energy research centers have emerged as vital institutions that can contribute to the development of decentralized energy access and sustainable innovations that would catalyze the transition to a low-carbon economy.However, more work is needed in the form of literature gaps where decentralized energy access canserve as a catalyst for inclusive development in Nigeria. Towoju, Ishola, & Elomien (2021) proposed that decentralization of energy generation will provide a window of opportunity for industrialization and the advancement of the national economy by extension. Furthermore, Abba, Balta-Ozkan & Drew (2025) have focused on how private investment can be scaled in the decentralization of renewable energy, which is critical to achieving universal electricity access in sub-Saharan Africa.

In addressing these gaps, this article further examines the work of previous research to explore how emerging economies such as Nigeria can be developed through decentralized energy access. Additionally, this study improves the existing knowledge base by carefully discussing how new scalable models of energy access decentralization can be used to solve the problems associated with energy deficiency and shortages. Thus, this paper proposes a novel way of addressing the uncertainties of these shortages and informing policymakers and other industry stakeholders that these models are indeed feasible by utilizing a range of theories and developments in the decentralized energy access literature.

OBJECTIVES OF THE STUDY

The study aims to determine the relationship between decentralized energy access and inclusive development in Nigeria. Its specific objectives include:

1. To determine how decentralized energy access contributes to energy poverty reduction in Nigeria.
2. To examine how decentralized energy access influences entrepreneurship development in Nigeria.
3. To ascertain how decentralized energy access improve environmental sustainability in Nigeria**.**

RESEARCH QUESTIONS

1. How does decentralized energy access contribute to energy poverty reduction in Nigeria?
2. How does decentralized energy access influence entrepreneurship development in Nigeria?
3. How does decentralized energy access improve environmental sustainabilityin Nigeria?

THE STUDY HYPOTHESIS

H_{01}: There is no relationship between decentralized energy access and energy poverty reduction in Nigeria.

H_{02}: There is no relationship between decentralized energy access and entrepreneurship development in Nigeria.

H_{03}: There is no relationship between decentralized energy access and environmental sustainability in Nigeria.

LITERATURE REVIEW

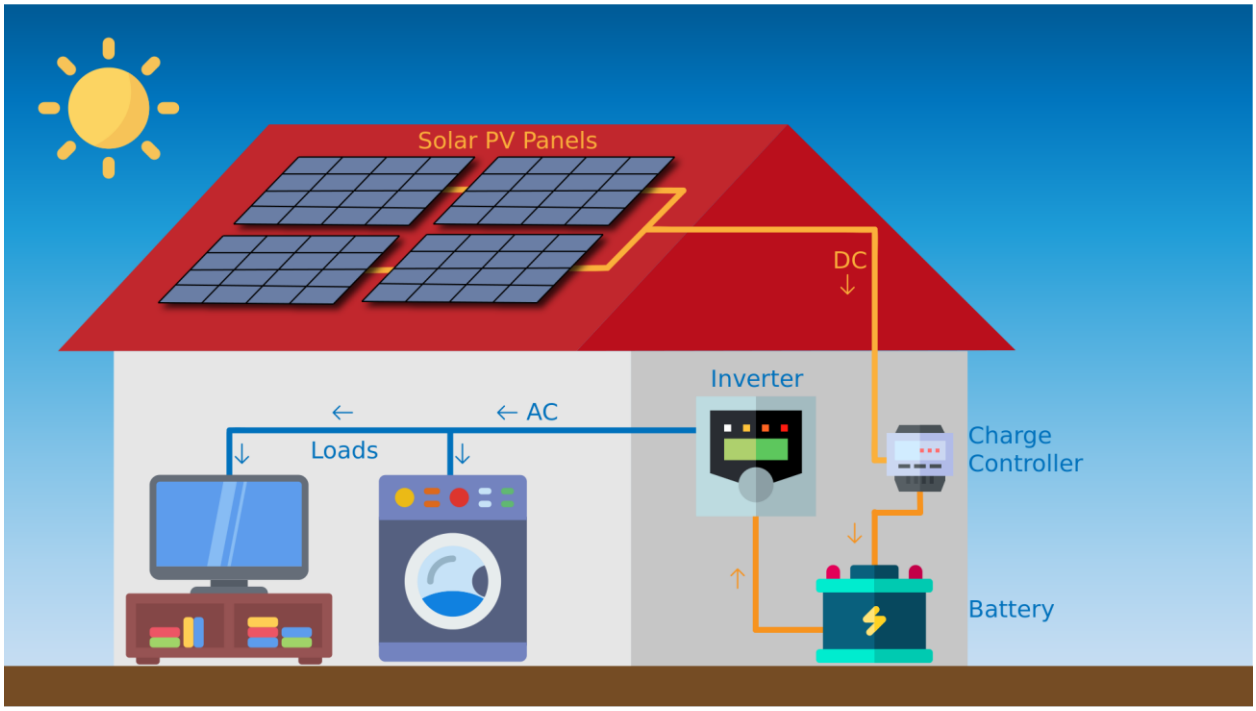
Background Concepts

Decentralized Energy Access (DEA) signifies a pivotal transition from centralized power generation to localized energy production and distribution. This method entails producing electricity in proximity to its point of consumption, frequently within or adjacent to towns, enterprises, or private residences. This differs from conventional systems that depend on substantial, centralized power stations and extensive transmission networks. It is a widely dispersed energy-generating facilities that produce energy from sources at or close to the location where it is used (Asime et al. 2022).

Hossen et al. (2024) explained that Decentralized Energy Access means that electricity is made, sent out, and managed by many small or local sources instead of being centralized at one big plant or grid. This method lets communities, families, or small companies make and use energy in their own areas, generally from renewable sources like solar, wind, or small hydro. Javid, Chauhan, Thappa, Verma, Anand, Sawhney, Tyagi & Anand (2021) asserted that small-scale production units that use locally accessible resources and distribute according to specific needs form the foundation of DEA networks. DEA is especially crucial in rural and isolated places where expanding the traditional grid may be difficult or expensive. In Nigeria, here are the main forms of decentralized energy access.

Solar Home Systems (SHS)

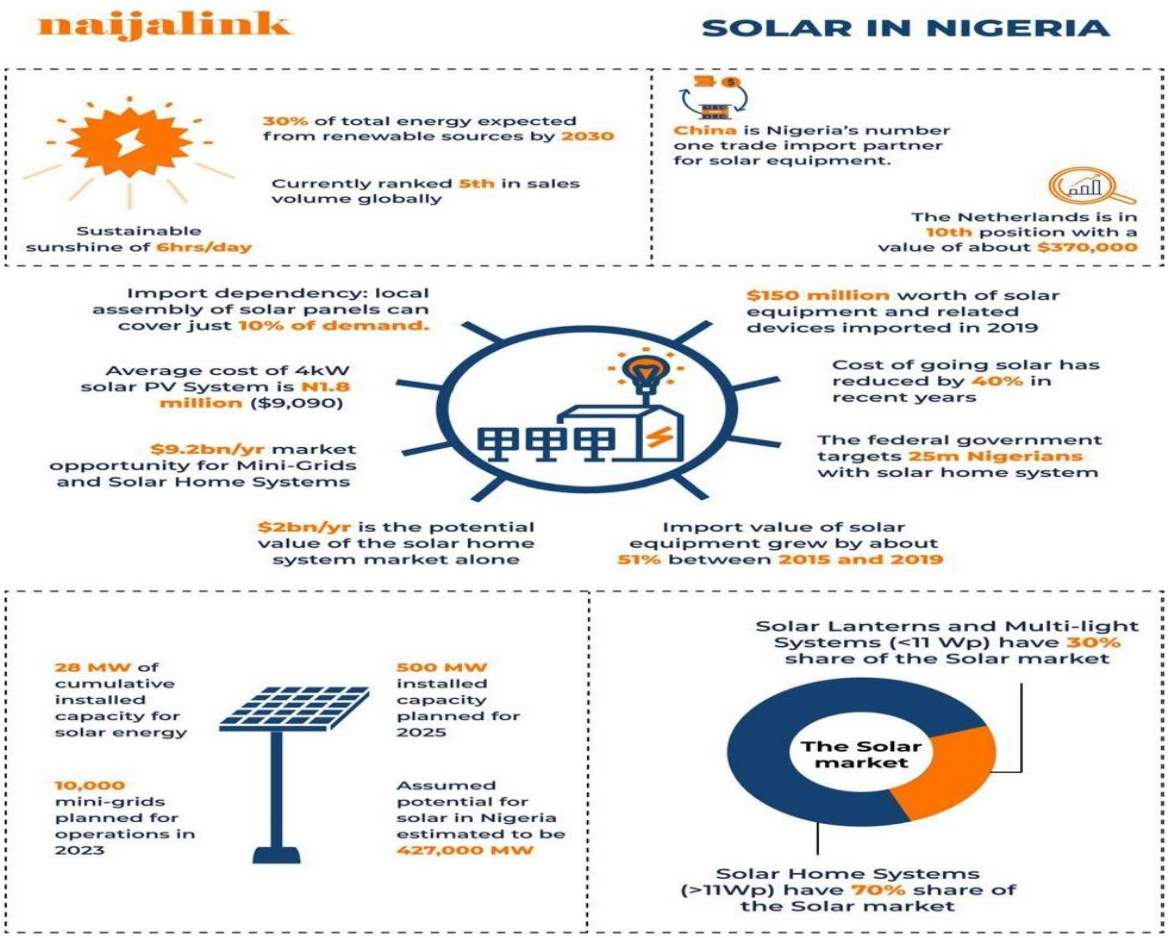
Solar Home Systems (SHS) are standardized off-grid photovoltaic systems that are often self-contained and provide households and small businesses with an affordable means of producing electricity. A typical SHS consists of several key components working together to generate, store, and distribute electricity. These include solar PV panels, a charge controller, a battery, an inverter, wiring, and a balance of system (BOS). Solar Home Systems (SHS) provide an alternative technology of power generation that is environmentally friendly, cost-effective, and does not pose any danger to human health. Additionally, SHS are also installed to generate electricity for health centers to improve the provision of health services, especially in remote areas of Nigeria.



Solar Home Systems (SHS)

About 60% of Nigerians are served by the country's national grid (Ibrahim, 2024), and many areas frequently experience voltage swings and blackouts. The remaining 40%, mostly in underserved and rural areas, either don't have access to electricity at all or use diesel generators. The high cost of generators and the health and environmental risks associated with burning fuel have increased interest in alternative energy sources, particularly solar power.

The average daily solar radiation over Nigeria is roughly 3.5kWh/m2 (12.6MJ/m2 per day) in the coastal latitudes and 7.0kWh/m2 (25.2MJ/m2 per day) in the extreme north (Onuoha, 2025). According to a 2025 report by the Africa Solar Industry Association (AFSIA), Nigeria added 63.5 Megawatt peak (MWp) capacity in 2024, placing it among the top African nations using solar as an alternative energy source. AFSIA Africa Solar Outlook 2025 study further stated that, at the end of 2025, this boost will increase Nigeria's total capacity installed up to 385.7MWp. Also, this report explained that the removal of the subsidy on PMS in Nigeria propelled many Nigerians to seek alternative sources of energy, such as solar, which has led to high demand for solar.Making Nigeria Africa's fifth-largest solar installer in 2024, with 73 megawatts total installed capacity (Esifiho, 2025). Some solar projects in Nigeria include Kano 10 MW Solar Plant, commissioned in 2023, Gwagwalada 143 MW in FCT, Abuja, Ganjuwa 100 MW in Bauchi, Ashama Solar 200 MW Power Station in Delta State, and Middle Band Solar One 157 MW in Kogi State.



Source: 2021 Nigeria Ministry of Foreign Affairs Solar Report.

Mini-Grids

Mini-grids are localized power distribution and generation systems that usually have capacities between a few kilowatts and several megawatts. They create electricity using a variety of energy sources, such as solar, wind, and biomass, and then distribute it to a particular location, such as a small town or hamlet. Due to Nigeria's plentiful sunshine, solar mini-grids are very common here (Uwemedimo, 2025). Mini-grids are rapidly emerging as the most promising route to closing Nigeria's electricity gap, especially in rural and peri-urban zones. The mini-grid system serves as an important building block for various modern decentralized energy access in Nigeria. In line with the SDGs and national inclusive development goals, mini-grids are crucial for advancing rural electrification and impacting local economies and social well-being.

Mini-grids can supply electricity to diverse customers, including commercial buildings, industries, farms, and homes. This form of DEA has lower connectivity bottlenecks,making it easier to control and operate, and is very flexible compared to the main grid. Network and system faults are easily attended to, and energy theft can be spotted and stopped easily. The current era of power generation company deregulation has made it possible for individuals or groups to privately set up and manage mini-grid systems, individuals, private companies, the state, or communities can own them (Bhattacharyya, 2018).

Nigeria's national or main power grid is nevertheless unreliable, frequently providing only a small portion of its 13,500 MW installed capacity, and periodic collapses cost the country's economy over $29 billion a year (Anyaogu, 2024). Decentralized energy solutions, such as

solar hybrid mini-grids, are therefore essential for addressing the lack of energy access, especially in rural and peri-urban areas. Nigeria's first interconnected solar hybrid mini-grid, with a capacity of 352 kWp, was put into service at Toto village, Nasarawa State, in November 2023 (Esiedesa, 2023). It is used by more than 2,800 homes, businesses, and institutions and was created by PowerGen in collaboration with Abuja Electricity Distribution Company (AEDC) and Rural Electrification Agency(REA). Each year, it offsets about 1,920 metric tons of CO_2 emissions (Rural Electrification Agency, 2023).



Nigeria’s first 352.24KWP Interconnected Hybrid Solar Mini-Grid Plant in Toto Community, Nasarawa State



Solar Hybrid Mini-Grid Power Plant, Akpabom Community, Onna LGA, Akwa-Ibom State, Nigeria

Wind Energy Systems

Wind energy is a form of sustainable energy source that employs airflow to create electricity; it is also known as wind power. In order to capture stronger winds, wind turbines are usually 120 meters high, with blades that extend 45 meters (Owoeye, 2017). A generator is attached to a wind turbine, which uses the wind's kinetic energy to generate electricity by turning its blades. Energy is one of the key components of national development as Nigeria seeks to use a variety of hydroelectric and thermal power plants to provide electricity.

Nigeria has a severe energy shortage; its daily electricity consumption is over 31,210 MW, while its average generation capacity from March 2005 to September 2024 was only 7,111 MW (Damare-Abubakar, 2025). This deficiency highlights the necessity of expanding production capacity and broadening the energy mix, which makes wind energy and other renewable options essential. With average wind speeds ranging from 2.1 m/s to 8 m/s, Nigeria has a moderate wind energy potential of about 3,200 MW. Nonetheless, according to some sources, the potential might surpass 4000 MW per day (Damare-Abubakar, 2025). The northern states Katsina, Sokoto, Zamfara, Plateau, Adamawa, Borno, and Mambilla in Taraba state have the fastest wind speeds, which can reach over 7 m/s. Except for coastal and offshore areas like Lagos, Ondo, Delta, Rivers, Bayelsa, and AkwaIbom states, the southern portion of the nation lacks sufficient wind resources.

Existing wind projects in Nigeria include the Lambar Rimi Wind Farm in Katsina State, the Sayya Gidan Gada Small Utility Wind Project which deployed wind turbines in 1996 by the then Sokoto Energy Research Centre. High initial capital expenditure, inadequate

infrastructure, and restricted access to financing are some of the issues facing the wind energy installation industry in Nigeria and Africa. But there are also a ton of potential, like lowering carbon emissions, creating jobs, and generating local income. By 2030, Nigeria wants to generate 30% of its energy from renewable sources, and wind energy is crucial to reaching this target (Edom, 2023)



Lambar Rimi Wind Energy Site, Katsina State, Nigeria

METHODOLOGY

A cross-sectional research design was adopted for the study, due to the nature of the study, which is to determine the relationship between the study variables. The target population of this study is 40.6 million people fromthe six (6) geopolitical zones in Nigeriarepresented by a state (Lagos 12.7M, Rivers 7M, Enugu 4.3M, Nasarawa 2.6M, Kaduna 8.3M, and Bornu 5.6M), data gotten from Nigeria National Bureau of Statistics Report (2020). Taro Yamane was used to determine the study sample size to be 400 people, which consists of urban households-121, rural households-188, and SME owners-91. Out of the 400 questionnaires distributed, 394 questionnaires were returned. The Spearman's Rank Correlation Coefficient was used to test the correlation and strength of relationship.

The decision rule is:

$P<0.05$ significant level = reject the null hypothesis

$P>0.05$ significant level = accept the null hypothesis

TEST OF HYPOTHESIS

Table 1: Ho1 – There is no relationship between decentralized energy access and energy poverty.

	Decentralized Energy Access	Physical Energy Access	Energy Cost
Decentralized Energy Access	1.000	.870**	.668**
Sig. (2-tailed)		.000	.000
N	394	394	394
Physical Energy Access	.870**	1.000	.627**
Sig. (2-tailed)	.000		.000
N	394	394	394
Energy Cost	.668**	.627**	1.000
Sig. (2-tailed)	.000	.000	
N	394	394	394

** Correlation is significant at the 0.01 level (2-tailed)

Source: Research Data Output, 2025

Table 1 on decentralized energy access and energy poverty indicated that at a significant level $p<0.05$ ($0.000 < 0.05$), rho = 0.870**. This means that there exists a significant relationship between decentralized energy access and energy poverty. The null hypothesis, Ho_1, is rejected and the alternate accepted. This reveals that decentralization of access to energy reduces energy poverty through physical energy accessibility and reduction in the cost of energy.

Table 2: Ho2 – There is no relationship between decentralized energy access and entrepreneurship development in Nigeria.

	Decentralized Energy Access	Venture Opportunities	Skills Acquisition
Decentralized Energy Access	1.000	.674**	.610**
Sig. (2-tailed)		.000	.000
N	394	394	394
Venture Opportunities	.674**	1.000	.622**
Sig. (2-tailed)	.000		.000
N	394	394	394
Skills Acquisition	.610**	.622**	1.000
Sig. (2-tailed)	.000	.000	
N	394	394	394

** Correlation is significant at the 0.01 level (2-tailed)

Source: Research Data Output, 2025

Table 2 on decentralized energy access and entrepreneurship development indicated that ata significant level $p<0.05$ ($0.000 < 0.05$), rho = 0.674**. This means that there exists a significant relationship between decentralized energy access and entrepreneurship development. The null hypothesis, Ho_2, is rejected and the alternate accepted. This reveals that decentralization of access to energy improve entrepreneurship development in Nigeria through venture opportunity identification and skills acquisition.

Table 3: Ho3 – There is no relationship between decentralized energy access and environmental sustainability in Nigeria.

	Decentralized Energy Access	Fossil Fuel Reduction	Carbon Emission Reduction
Decentralized Energy Access	1.000	.622**	.666**
Sig. (2-tailed)		.000	.000
N	394	394	394
Fossil Fuel Reduction	.622**	1.000	.627**
Sig. (2-tailed)	.000		.000
N	394	394	394
Carbon Emission Reduction	.666**	.627**	1.000
Sig. (2-tailed)	.000	.000	
N	394	394	394

** Correlation is significant at the 0.01 level (2-tailed)

Source: Research Data Output, 2025

Table 3 on decentralized energy access and environmental sustainability indicated that at a significant level $p<0.05$ ($0.000 < 0.05$), rho = 0.622**. This means that there exists a significant relationship between decentralized energy access and environmental sustainability. The null hypothesis, Ho_3, is rejected and the alternate accepted. This reveals that decentralization of access to energy enhances environmental sustainability through fossil fuel and carbon emission reduction.

DISCUSSION OF FINDINGS

Decentralized Energy Access and Inclusive Development in Nigeria

Decentralized energy is essential for both Nigeria's economic growth and enhancing people's quality of life (Oyedepo, 2014). Because decentralized energy makes necessary services accessible, it can increase socio-economic inclusion. Schools, hospitals, and clinics can be powered by dependable energy, enhancing the standard of healthcare and education, particularly in underprivileged areas (Adetoyi, 2024). Additionally, it can make information and communication technologies accessible, fostering social integration and tying remote communities to the outside world (Africa Oil & Gas Report, 2022). The report also indicates that the DRE sector is providing more opportunities for women in the workforce than the traditional energy sector.

Having access to electricity has the potential to greatly increase Nigeria's economic prospects. Small and medium-sized businesses (SMEs) can boost productivity and function more effectively by using mini-grids to supply dependable electricity. Okewale, Olamijulo & Olaleye (2023) opined that entrepreneurs have been able to extend their working hours and boost their productivity by using solar energy to power their small and medium-sized businesses (SMEs). InNigeria's rural areas, this may result in the creation of jobs and

economic expansion (Africa Oil & Gas Report, 2022). DE systems can also encourage the development of energy-efficient applications, including supplying electricity to agricultural processing machinery, which can raise farmer earnings and enhance food security (Oyedepo, 2014). According to the "Powering Jobs Census 2022: The Energy Access Workforce Nigeria" report, the Decentralized Renewable Energy (DRE) industry is expanding quickly and is starting to provide a significant number of secure employment opportunities that are almost equal to those in the oil and gas industry. To affirm this, Udo, Adetona-Ibrahim, Eshiet, Abubakar & Oduyingbo (2024) posited that the solar industry has generated thousands of jobs in customer support, maintenance, and installation, and many job possibilities are anticipated to be created in the future by renewable energy technologies.

Decentralized energy access provides the freedom to become an entrepreneur or learn a skill in Nigeria.DE projects can boost local economic activity by promoting entrepreneurship, expanding access to basic services like healthcare and education, and generating jobs in installation, maintenance, and operation (Africa Oil & Gas Report, 2022). It promotes gender and socially inclusive entrepreneurship through identifying the vulnerable groups and providing individualized energy solutions for them to enable the growth of their business. DEA enables the operation of technical and vocational training centres in the rural and peri-urban areas where dress making, carpentry, welding, ICT, etc., are taught. There are jobs in the decentralized energy sector as well for installers, technicians, and maintenance workers who require training.

Decentralized energy solutions, including stand-alone systems, mini-grids driven by solar, wind, or biomass, and solar home systems (SHS), present a viable way to improve equitable development in Nigeria. They can be swiftly implemented, particularly in the nation’s isolated locations where grid extension is expensive or impossible (Shaaban & Petinrin, 2014). These systems reduce Nigeria's dependency on fossil fuels, contributing to environmental sustainability and curbing climate change (Emodi & Ebele, 2016).By replacing diesel generators with solar projects ithelps to lower greenhouse gas emissions. This change encourages a cleaner environment and supports Nigeria's commitment to the global climate goals.

CONCLUSION

In Nigeria, decentralized energy access offers a revolutionary means of promoting inclusive development. Decentralized energy systems such as mini-grids, solar household systems, and other renewable energy solutions address the energy poverty that impedes social and economic development by increasing access to reasonably priced, dependable, and sustainable electricity. They help small and medium-sized businesses, increase access to healthcare and education, create job opportunities, and empower marginalized and rural areas that are frequently left out of centralized grid infrastructure. Furthermore, by lowering reliance on fossil fuels, decentralized energy promotes environmental sustainability. However, strong institutional structures, supportive policies, and strategic investments are needed to realize its full potential.

RECOMMENDATION

This study further recommended that:

Strengthen Regulatory and Policy Frameworks: The government should establish and implement transparent, investor-friendly regulations that support community-based renewable energy projects and the involvement of the private sector.

Enhance PPPs (public-private partnerships): To raise money and technical know-how for decentralized energy projects, partnerships between the public and private sectors as well as development partners should be encouraged.

Building Capacity and Creating Local Content: Train local technicians, engineers, and entrepreneurs in renewable energy technologies to ensure sustainability, job creation, and community ownership of energy projects.

Extend Funding Sources: Provide specialized funding programs, low-interest loans, or subsidies to help local company owners, households, and small enterprises adopt renewable energy technologies.

Community Engagement and Awareness: Campaigns to increase public knowledge of the financial and social advantages of decentralized energy solutions should be put in place in order to promote community involvement and ownership.

REFERENCES

Abba, ZYI., Balta-Ozkan, N. & Drew, G. (2025). Catalysing decentralised renewable energy investment in Nigeria: Investor-focused risk evaluation and de-risking strategies. *Journal of Renewable and Sustainable Energy Transition*. Vol. (7), June 2025, Article number 100112

Adetoyi, A. (2024). Illuminating economic sustainability: Harnessing AI for strategic renewable energy deployment in Nigeria. [LinkedIn]

AFSIA Africa Solar Outlook.(2025). Africa Solar Industry Association.

Akua, M., Twum, A., & Beecham, E. O. (2024). Nigerians lack reliable electricity, leaving most discontent with the government's efforts. *Afrobarometer Dispatch.* No. 814

Anyaogu, I. (2024). Why Nigeria's power grid is failing. *Thomson Reuters.* December 11, 2024

Audu, H. & Adamu, A. (2022). Expanding energy access in rural off-grid communities: a study on household adoption and affordability of solar home systems in Kwara state, Nigeria. *Journal of Global Economics and Business.* Vol. 3(11)

Babayomi, O. O., Olubayo, B., Denwigwe, I. H., Somefun, T. E., Adedoja, O. S., Somefun, C. T., Olukayode, K. & Attah, A. (2023). A reviewof renewable off-grid mini-grids in Sub-Saharan Africa. *Front. Energy Res.* 10:1089025

Bernard, T., Greacen, C. & Shrestha, A.(2024). Mini grid solutions for underserved customers: new insights from Nigeria and India. International Development in Focus. *Washington, DC: World Bank Report*.

Bhattacharyya, S. C. (2018). Mini-grids for the base of the pyramid market: *A critical view on Energies.* 11, 813. doi:10.3390/EN11040813

Emodi, N. V. & Ebele, N. E. (2016). Policies promoting renewable energy development and implications for Nigeria. *British Journal of Environment & Climate Change*, 6(1), 1-17.

Esiedesa, O. (2023). REA delivers Nigeria's 1st interconnected mini-grid, targets 2,000 homes, businesses. Vanguard Newspaper November 9, 2023.

Hossen, F., Arafat, M., Islam, R., Rafi, S., Jalil, M. S., Jony, M. M. (2024). Decentralized energy systems and the circular economy: Business models for sustainable energy transitions. *Advanced International Journal of Multidisciplinary Research*. Vol. 2 (6)

Hossen, F., Md-Sheam, A., Islam, R., Rafi, M. S., Jalil, M. S., Md-Anwarul, M. J. (2024). Decentralized energy systems and the circular economy: Business models for sustainable energy transitions. *Advanced International Journal of Multidisciplinary Research*. Vol. 2(6)

Ibrahim, A. (2024). 58% of Nigerian households connected to the national grid – Report. *Business Day Newspaper*. October 23, 2024.

Javid, I., Chauhan, A., Thappa, S., Verma, S. K., Anand, A., Sawhney, V.V., Tyagi, S.&Anand. (2021). Futuristic decentralized clean energy networks in view of inclusive economic growth and a sustainable society. *Journal of Cleaner Production*. Volume 309. ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2021.127304.

Miller, A., Carney, M., Bosma, K., Abrams, E., Cox, C. & Willis, A. (2019). Business models for energy entrepreneurship in emerging markets.

National Bureau of Statistics (2020) Demographic Statistics Bulletin. A Publication of Demographic Statistics Division.

Nnadi, K., Onwuagbu, C. & Chigozie, C. (2025). Potential of integrated energy solution in Nigeria: Opportunities and challenges for sustainable development-multi-facet assessment model. *Journal of Discover Sustainability*. VL 6. DO - 10.1007/s43621-025-00915-5.

Ogbomida, E., Mustapha, A., Emeribe, C., Ezemonye, L., & Ajieh, M. (2024). Perspective chapter: Unlocking energy and natural resources for sustainable development in Nigeria – The role of energy research centers. *Intech Open*. doi: 10.5772/intechopen.1005050

Omole, F. O., Olajiga, O. K. & Olatunde, T. M. (2024). Challenges and successes in rural electrification: A review of global policies and case studies. *Engineering Science & Technology Journal*. Volume 5(3).

Onuoha, D. E. (2025). Unlocking renewable energy materials in Nigeria: Availability, application, and roadmap for sustainability. *RSC Sustainability Journal*. DOI: 10.1039/D5SU00121H

Orudukobipi, A. (2022). Decentralizing the centralized energy system using CCAM model: Key to greener energy mix and sustainability inNigeria. *International Journal of Applied Science and Mathematical Theory.*Vol. 8 No. 1. E- ISSN 2489-009X P-ISSN 2695-1908,

Owoeye, F. (2017). Wind Energy: A choice for energy generation in Nigeria. *Nairametrics Business News*. November 13, 2017.

Oyedepo, S. O. (2014). Towards achieving energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, 34, 255–272.

Oyedepo, S. O., Babalola, O. P., Nwanya, S. C., Kilanko, O., Leramo, R. O., Aworinde, A. K., Adekeye, T., Oyebanji. J. A., Abidakun, A. O. & Agberegha, O. L. (2018). Towards a sustainable electricity supply in Nigeria: The role of decentralized renewable energy system. *European Journal of Sustainable Development Research*. 2(4), 40. https://doi.org/10.20897/ejosdr/390

Power for All and Clean Technology Hub Nigeria. (2022). Powering Jobs Census 2022: The Energy Access Workforce Nigeria report. [Africa Oil & Gas Report]

Shaaban, M. & Petinrin, J. O. (2014). Renewable energy potentials in Nigeria: Meeting rural energy needs. *Renewable and Sustainable Energy Reviews*, 29, 72-84.

Towoju, O. A., Ishola, F. A., Elomien, E. (2021). Decentralized electricity generation can revive Nigeria's dying critical sectors. *IOP Conf. Series: Material Science and Engineering*. Pp. 1-8. DOI: 10.1088/175799X/1107/1/012105

Udo, G. O., Adetona-Ibrahim, T. O., Eshiet, D .J., Abubakar, K. & Oduyingbo, B.J. (2024). Impact of renewable energy projects on job creation and poverty reduction in selected rural communities in Doma LGA Nassarawa State, Nigeria. *International Journal of Management Technology*, Vol.11, No 3, pp.1-16

Uwemedimo, V. (2025). For climate and livelihoods, Africa bets big on solar mini-grids. *Knowable Magazine.* 12th March, 2025.

World Bank. (2021). Nigeria is to improve electricity access and services to citizens. *News release*. 5 February, 2021.