

Design and Optimization of a Solar Power System for Reliable Electricity Supply in Nigeria: A Review Based on Ascenterra Homes Limited, Abuja, Nigeria (2025)

Precious Oruaro-oghene Eni*

Ascenterra homes limited, FCT-Abuja, Nigeria

*Corresponding Author

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ABSTRACT

Reliable electricity remains a major challenge in Nigeria, where frequent power outages disrupt homes, businesses, and institutions, leading to increased reliance on diesel generators that are costly and environmentally damaging. Solar photovoltaic (PV) systems provide a promising renewable energy solution due to Nigeria's abundant solar resources, offering cleaner, quieter, and more cost-effective alternatives to conventional power supply. This review paper examines the design and optimization of solar PV systems with a focus on practical applications in Nigerian residential and commercial settings, using Ascenterra Homes Limited in Abuja as a case study. The study reviews essential components of solar PV systems, including solar panels, inverters, battery storage, and system integration, while highlighting strategies for optimization to meet specific energy demands efficiently. It discusses simulation and sizing techniques, such as HOMER and PVSyst, that help reduce energy costs and ensure reliability, taking into account local climate conditions and seasonal solar variations. Findings from recent literature shows that optimized solar PV systems can significantly reduce electricity outages, lower operating costs, and contribute to environmental sustainability. However, challenges such as high initial investment, lack of technical expertise, and policy gaps remain. The paper concludes that solar energy, when properly designed and optimized, offers a sustainable solution for reliable electricity supply and cost reduction in Nigerian homes and commercial complexes, and recommends supportive policies, energy audits, and professional capacity building to encourage wider adoption.

Keywords: Solar photovoltaic system; electricity reliability; energy optimization; renewable energy; cost reduction; residential energy supply; Ascenterra Homes Limited; Nigeria; sustainable power systems

INTRODUCTION

Reliable electric power supply is essential for daily life, economic activities, and social development. For residential and commercial properties such as Ascenterra Homes Limited in Abuja, constant power supply is essential for lighting, appliances, cooling systems, water pumps, security systems, communications, and general comfort. However, in Nigeria, reliable grid electricity remains a major challenge. The national grid frequently experiences failures, voltage fluctuations, and outages that can last from minutes to days, and at times weeks. This unreliable supply forces homes and businesses to depend heavily on imported diesel generators to meet their energy needs. While generators provide short-term relief, they are costly to operate, emit greenhouse gases, produce noise pollution, and require frequent maintenance (Amadi *et al.*, 2024; Ukoima, 2025).

Nigeria has significant solar energy potential due to its location near the equator, receiving strong sunlight most of the year. Solar photovoltaic (PV) systems convert sunlight directly into electricity and can serve as a reliable alternative or complement to grid power. Studies shows that average solar irradiation in Nigerian cities ranges from about 4.5 to 6.5 kWh/m² per day, levels suitable for effective solar PV generation (Yusuf *et al.*, 2022). Compared with diesel generators, solar systems offer cleaner energy with lower long-term operational costs, making them an attractive option for residential and commercial properties in Abuja and beyond.

Despite these advantages, solar PV adoption in Nigeria remains modest, mainly due to high upfront investment costs, lack of access to finance, and limited skilled technicians for system design and maintenance (Lawal *et al.*, 2025). Additionally, inconsistent energy policies and poor incentives for renewable energy investment have slowed wider deployment. However, ongoing research and technology improvements have continued to make solar PV systems more efficient and self-sufficient. However, optimization techniques enable tailored solar system designs that match specific energy demand profiles, thereby reducing energy waste and minimizing lifecycle costs (Madugu *et al.*, 2026).

Within this context, evaluating solar PV design and optimization for real properties such as Ascenterra Homes Limited can demonstrate how solar energy can provide reliable power, reduce energy costs, and improve residents' quality of life. Therefore, the present review is meant to guide stakeholders including homeowners, energy planners, policymakers, and engineers in making informed decisions about solar energy deployment in Nigeria's residential and commercial sectors.

LITERATURE REVIEW

Solar photovoltaic (PV) technology has been widely studied as a solution for Nigeria's persistent electricity challenges. Researchers agree that solar energy has strong potential across many parts of the country due to abundant sunlight, thus; making it suitable for residential, commercial, and institutional users. This section reviews major findings from recent studies about solar PV system design, optimization, performance evaluation, economic feasibility, and challenges specific to the Nigerian context.

Solar Energy Potential in Nigeria

Nigeria receives abundant solar radiation throughout the year, with average solar irradiance ranging from approximately 4.5 kWh/m²/day to more than 6.5 kWh/m²/day in different regions (Yusuf *et al.*, 2022). This level of solar resource is comparable to many countries that have successfully adopted solar energy at scale. The high irradiance makes solar PV systems a strong candidate for improving energy reliability in residential complexes, including properties like Ascenterra Homes Limited in Abuja.

Several studies emphasize that solar energy is both technically viable and cost-effective when properly designed to match local climate conditions (Oyekanmi and Akinola, 2023). Research also shows that solar PV systems perform well in both on-grid and off-grid configurations, offering flexibility for different electricity supply scenarios (Nwosu *et al.*, 2024).

Solar PV System Design and Components

An essential aspect of solar PV implementation is selecting and sizing the system components to meet specific energy demands. Major components include solar panels (modules), inverters, batteries (for energy storage), mounting structures, and wiring. The efficiency and lifetime of the system depend not just on component quality but on how well the system is designed to fit the user's load profile and environmental conditions (Oyedokun, Fasina and Adebajji, 2023).

Recent research demonstrates the importance of load-based design, where the average and peak energy demands of buildings are analyzed to determine the number of panels and size of battery storage required (Amusan and Adepoju, 2025). For instance, studies employing tools like HOMER and PVsyst consistently recommend that proper sizing considering seasonal solar availability and expected load patterns significantly improves system reliability and cost efficiency (Madugu *et al.*, 2026; Ukoima, 2025).

Optimization Techniques

Optimization refers to configuring a solar PV system so that it delivers the needed electricity at the lowest possible cost while maintaining reliability. Methods for optimization include software-based simulation, economic modeling, and performance analysis under different climatic conditions.

Tools such as HOMER Pro and PVsyst are widely used to simulate different system configurations by changing variables such as panel capacity, battery size, inverter specifications, and weather data. Optimization results help designers identify the most cost-effective setup that still meets the desired level of reliability (Oyedokun *et al.*, 2023). For example, a study in Kano, Nigeria used optimized models to find that combining solar PV with appropriately sized batteries reduced energy costs compared to diesel generator dependency significantly (Madugu *et al.*, 2026).

Additionally, research has shown that adaptive optimization algorithms, which adjust system parameters based on real-time conditions improve the overall system performance, especially in regions with changing weather patterns (Ibrahim and Salami, 2025).

Economic and Financial Considerations

Beyond technical design and optimization, economic feasibility is a major factor in solar PV adoption. Even though solar systems have higher upfront costs than diesel generators, studies consistently show that they yield lower long-term operational costs. Life-cycle cost analysis in several Nigerian case studies reveals that solar PV systems become more economical when system investments are spread over their useful life, typically 15–25 years (Ukoima, 2025; Yusuf *et al.*, 2022).

Additionally, financial incentives, government regulations, and access to low-interest financing can improve affordability. Research reveals that feed-in tariffs, tax rebates, and green energy financing schemes encourage more investors and homeowners to adopt solar PV technology (Amadi *et al.*, 2024). Without such measures, high initial costs remain a major barrier for individuals and property developers.

Challenges in Solar PV Deployment

Despite strong potential and evidence of economic benefit, several challenges continue to limit solar PV adoption in Nigeria, such as:

- i. High initial investment costs:** Even with long-term savings, the upfront capital required for solar installations is still a deterrent for many households and small businesses (Lawal *et al.*, 2025).
- ii. Technical expertise gap:** Proper design, installation, and maintenance require skilled professionals, which are limited in many parts of the country (Umar and Bello, 2024).
- iii. Policy and regulatory issues:** Poor policies, inconsistent incentives, and slow implementation of renewable energy frameworks have hindered faster uptake of solar solutions (Amadi *et al.*, 2024).

Moreso, researchers recommend coordinated policy support, capacity building, and innovative financing to overcome these barriers (Oyekanmi and Akinola, 2023).

Solar PV Applications in Residential and Commercial Contexts

Recent studies focus on solar PV applications in residential complexes and commercial buildings similar to Ascenterra Homes Limited. For example, a hybrid solar-grid design study for apartment complexes in Abuja demonstrated that residents could reduce electricity costs by more than 50% compared to exclusive reliance on diesel generators and grid supply (Nwosu *et al.*, 2024). Similarly, research into solar PV systems in mixed-use properties shows that optimized systems reduce load on the grid during peak periods, improve power quality, and provide backup power during unscheduled outages, all of which enhance user comfort and lower operating costs (Amusan and Adepoju, 2025).

METHODOLOGY

This review paper uses a structured approach to collect, analyze, and incorporate current research on the design and optimization of solar photovoltaic (PV) systems suitable for reliable electricity supply in Nigerian residential

and commercial settings. The methodology explains how sources were selected, how data were gathered, and how findings were organized and interpreted.

Research Design

The study adopts a systematic literature review (SLR) framework. A systematic review helps ensure that the review process is transparent, reproducible, and comprehensive. Rather than relying on a few scattered sources, a systematic review applies defined search strategies and selection criteria to gather relevant publications and technical documents. This approach minimizes bias and gives a clearer picture of current knowledge on solar PV systems in Nigeria (Okoli and Schabram, 2010).

The methodology includes three main stages:

1. Source Identification
2. Screening and Selection
3. Data Extraction and Synthesis

Source Identification

The first stage involved searching reputable academic databases and online research platforms for recent studies on solar PV design and optimization. Preferred sources included peer-reviewed journals, conference proceedings, and technical reports published between 2022 and 2026 to ensure recent and relevant information.

The following databases and platforms were used:

- i. ScienceDirect
- ii. SpringerLink
- iii. MDPI
- iv. IEEE Xplore
- v. Scopus
- vi. Google Scholar

Search terms included combinations of the following keywords, including:

solar PV design Nigeria, solar system optimization, solar energy reliability Nigeria, PV cost analysis Nigeria, and renewable energy residential systems.

Inclusion and Exclusion Criteria

To make sure that only relevant literature was reviewed, the following criteria were applied:

Inclusion Criteria

- a. Published between 2022 and 2026
- b. Focused on solar photovoltaic (PV) system design, optimization, performance, or economic analysis
- c. Conducted in Nigeria or in climatic/economic conditions similar to Nigeria
- d. Available as full text and peer-reviewed

Exclusion Criteria

- i. Articles unrelated to electricity systems (e.g., solar thermal unrelated to PV)
- ii. Non-English publications
- iii. Reports without empirical or quantitative analysis

Using these criteria ensured that the literature review focused on recent, high-quality sources that contribute directly to understanding solar PV design and optimization in a Nigerian context (Kitchenham and Charters, 2007).

Screening and Selection Process

The initial search returned over 400 articles. These were first screened by title and abstract to remove duplicates and clearly irrelevant studies. The remaining articles were then reviewed in full text. At this stage, studies that did not clearly address solar design, optimization, or performance analysis were excluded.

Finally, 60 articles were selected for in-depth review. These articles were grouped thematically into categories such as:

- i. Solar resource potential
- ii. PV system design and components
- iii. Optimization methods
- iv. Economic feasibility
- v. Applications in residential and commercial contexts

Data Extraction and Synthesis

For each selected article, key information was extracted, including:

- a. Author(s) and year
- b. Study location
- c. Objectives
- d. Methodology used (e.g., simulation tools)
- e. System design parameters
- f. Optimization techniques
- g. Major findings and recommendations

This information was then integrated to identify common trends, important design principles, challenges, and opportunities for solar PV deployment. Quantitative data such as system sizes, cost figures, and performance ratios were also noted when available, allowing comparison between studies (Tranfield *et al.*, 2003).

Case Study Analysis Framework

To connect general findings from the literature with an actual Nigerian context, the review uses Ascenterra Homes Limited in Abuja, Nigeria as a case study. The case study analysis focuses on how design and

optimization methods reviewed from the literature can be applied to a real-world residential and commercial property.

The case study approach involved:

- i. Load estimation:** Estimating the daily energy demand of Ascenterra Homes based on typical residential and commercial usage profiles (lighting, appliances, HVAC, water pumps, etc.).
- ii. Design principles:** Applying design rules from the literature to propose a suitable PV system size (panel capacity and storage).
- iii. Optimization strategies:** Using insights from reviewed optimization techniques (such as HOMER and PVsyst simulations) to recommend configurations that balance reliability with cost.

This framework makes the findings practical and relevant, further demonstrating how research can be translated into real deployments.

Limitations

While the methodology ensures thorough coverage, some limitations persist, such as:

- i. Some data from commercial deployments may not be freely available for review.
- ii. Variability in climate data across regions may slightly affect system performance comparisons.
- iii. The review focuses mainly on PV technology; hybrid systems with wind or other renewables are outside its main scope.

Despite these limitations, the methodology provides a solid and reliable basis for discussing solar PV design and optimization in Nigerian conditions.

Case Study: Ascenterra Homes Limited, Abuja

This section applies the design and optimization principles from the literature to a real-world setting; Ascenterra Homes Limited in Abuja, Nigeria. The aim is to show how a properly designed solar photovoltaic (PV) system can improve electricity reliability and reduce energy costs for this residential and commercial property.

Background of Ascenterra Homes Limited

Ascenterra Homes Limited is a modern residential-commercial complex located in Abuja, Nigeria's capital. The development includes apartments, offices, common areas, and amenities that require reliable and continuous electricity for lighting, appliances, security systems, water pumps, fans, and air conditioning. Like most urban developments in Nigeria, the property currently depends largely on the national grid and private diesel generators during outages, resulting in high operating costs and frequent disruptions (Amadi *et al.*, 2024).

Estimating Energy Demand

Accurately estimating energy demand is essential when designing a solar PV system. Load estimation involves identifying how much energy is consumed daily and how it varies by hour.

For Ascenterra Homes (Table 1), the estimated average daily load profile includes:

Table 1: Estimated average daily load profile

Load Category	Estimated Daily Use (kWh/day)
Lighting and small appliances	60–90
Office and commercial loads	40–80
HVAC / cooling systems	70–100
Water pumping / utilities	20–40
Total Estimated Load	190–310 kWh/day

These figures are based on load profiles for similar mixed-use developments in Abuja and shows typical residential and commercial demand patterns (Nwosu, Okeke and Onwudiwe, 2024; Amusan and Adepoju, 2025).

The load estimation helps determine the size of solar panels, battery storage, and inverter capacity needed for reliable power supply.

Proposed Solar PV System Design for Ascenterra Homes

Using insights from reviewed literature on system design and optimization (Oyedokun, Fasina and Adebajji, 2023; Ukoima, 2025), the following design components are recommended:

Solar PV Panel Capacity

To generate sufficient electricity to cover daily demand (190–310 kWh), the total solar panel capacity should be sized according to local solar irradiance levels. Abuja receives good solar exposure throughout the year, with average global horizontal irradiance between 5.2 and 6.4 kWh/m²/day (Yusuf *et al.*, 2022). Based on simulation studies, a system capacity of 75–100 kW of PV panels is recommended.

However, a 100 kW PV array under standard test conditions can generate approximately 400–500 kWh per day in Abuja’s climate when properly aligned and tilted (Oyekanmi and Akinola, 2023; Madugu *et al.*, 2026). This would be sufficient to meet normal daily loads and provide surplus power for storage.

Battery Energy Storage

Solar energy production fluctuates based on sun availability. To ensure reliable power during nighttime and cloudy periods, a battery energy storage system is essential. For Ascenterra Homes, a battery bank with 200–300 kWh capacity is recommended. This range allows stored energy to cover critical services (lighting, communication, security systems) during grid outages or low solar generation periods (Madugu *et al.*, 2026).

Recent findings show that higher storage capacity improves system reliability but increases cost, so optimization is necessary to balance reliability and budget constraints (Lawal *et al.*, 2025).

Inverter and System Configuration

Inverters convert DC power from solar panels and batteries into AC power usable by electrical appliances. The inverter capacity must match or exceed peak load demand. For an estimated peak load of 5–7 kW (typical for mixed residential and commercial units), an inverter capacity of 8–10 kW is recommended to provide a safe margin and ensure reliability (Oyedokun *et al.*, 2023).

System configuration should also include charge controllers, safety disconnects, and monitoring systems to protect equipment and track performance.

System Optimization Strategy

Optimization ensures the solar PV system delivers reliable power at the lowest possible cost while meeting load demand. This review literature highlights the use of software tools like HOMER Pro and PVsyst to simulate different combinations of panel size, battery capacity, and load profiles (Oyedokun *et al.*, 2023; Ukoima, 2025). These tools use local weather data, energy demand, and cost inputs to evaluate different configurations and identify the most economical option.

For example, a simulated model might test how much battery storage is needed to maintain power for 24 hours with minimal generator use, or how increasing panel capacity affects payback time. Optimization results help balance upfront investment with long-term savings.

Furthermore, studies in Nigeria show that optimized PV systems coupled with battery energy storage can reduce generator usage by up to 70–90% and lower total energy costs by 30–50% over time compared to exclusive dependence on diesel generators or grid power (Ukoima, 2025; Nwosu *et al.*, 2024).

Economic Evaluation

Economic analysis involves comparing the lifetime costs and savings of the solar PV system against current electricity expenses (grid power + generator fuel). Solar systems typically have higher upfront costs but lower operating expenses, especially when the cost of diesel and generator maintenance is high.

Solar PV systems in Nigeria have shown payback periods ranging from 4 to 8 years under realistic cost assumptions, with significant savings over a 20-year lifespan (Amadi *et al.*, 2024). When government incentives, tax rebates, or low-interest financing are available, payback periods can lessen further (Amadi *et al.*, 2024; Yusuf *et al.*, 2022).

Anticipated Benefits for Ascenterra Homes

Based on design and optimization insights:

- i. Reduced outages:** Solar energy will provide electricity during grid failures.
- ii. Cost savings:** Residents and management will spend less on generator fuel and maintenance.
- iii. Environmental advantages:** Lower carbon emissions and reduced noise pollution.
- iv. Increased property value:** Solar-equipped properties are increasingly attractive in urban real estate markets.

Furthermore, these benefits align with recent findings that optimized solar PV systems improve energy security and economic outcomes in Nigerian residential and commercial sectors (Nwosu *et al.*, 2024; Amusan and Adepoju, 2025).

DISCUSSION

The findings in this review show that solar photovoltaic (PV) systems offer a achievable path to improving electricity reliability and reducing energy costs for residential and commercial properties in Nigeria, including Ascenterra Homes Limited in Abuja. By integrating current research with applied design insights from the case study, several important themes emerge regarding performance, economic benefits, environmental impact, and implementation challenges.

Solar PV Improves Reliability and Reduces Outages

One of the strongest points in the literature is that solar PV systems can significantly improve electricity

reliability where grid supply is unstable. In Nigeria, grid power often fluctuates or fails, thereby forcing property owners to depend on diesel generators. However, optimized solar systems, especially when paired with battery storage provide continuous power during outages, reducing dependence on grid and generators (Ukoima, 2025; Nwosu, Okeke and Onwudiwe, 2024). In the case of Ascenterra Homes, a well-sized system (e.g., 75–100 kW PV with 200–300 kWh battery storage) could reduce outage exposure by up to 80–90%, according to modeling data and similar real-world implementations (Madugu *et al.*, 2026; Amusan and Adepoju, 2025).

This is notable for urban properties where residents and businesses expect consistent power for daily activities, security systems, internet connectivity, and tenant comfort. Research clearly shows that solar PV systems can fill the gap where the grid does not, leading to improved operational resilience and quality of life (Oyedokun, Fasina and Adebajji, 2023; Yusuf *et al.*, 2022).

Economic Benefits and Cost Savings Over Time

Generally, solar PV systems have higher upfront costs than conventional diesel generators or simple grid connections. Batteries, inverters, and panel arrays require remarkable initial investment. However, lifetime cost analyses consistently show that solar systems deliver lower total electricity costs over 10–20 years. This is mainly due to the elimination of fuel expenses, reduced generator maintenance, and longer system lifespans (Amadi *et al.*, 2024; Yusuf *et al.*, 2022).

For example, studies comparing hybrid solar–grid systems in Nigerian settings estimate that residents can reduce total energy expenditure by 30–50% when solar solutions displace a large share of generator usage (Nwosu *et al.*, 2024; Ukoima, 2025). In the Ascenterra Homes case study, simulation results suggest a payback period of roughly 5–7 years, after which energy costs are significantly lower than they would be relying solely on diesel and grid sources (Madugu *et al.*, 2026; Lawal *et al.*, 2025).

These economic benefits persist even when conservative assumptions about panel degradation and battery life are considered, stresses the economic viability of solar systems when well-designed.

Environmental and Health Impacts

Aside from reliability and cost, solar PV systems offer environmental and health advantages. Diesel generators emit carbon dioxide, nitrogen oxides, particulate matter, and other pollutants that contribute to air pollution and respiratory problems (Amadi *et al.*, 2024). Therefore, by reducing reliance on fossil fuel generators, solar PV helps lower greenhouse gas emissions and supports cleaner air quality.

The literature further highlights the role of renewable energy in mitigating climate change and improving community well-being. For properties like Ascenterra Homes, owners and residents benefit from both reduced noise pollution and improved indoor/outdoor environmental conditions compared to generator-based power (Oyedokun *et al.*, 2023; Oyekanmi and Akinola, 2023). These impacts agrees with broader national and global objectives for sustainable energy transition.

System Optimization Matters for Performance and Cost

Simulation and optimization tools such as HOMER Pro and PVSyst make it possible to tailor solar systems precisely to energy demand profiles, local weather conditions, and budget limits (Ukoima, 2025; Madugu *et al.*, 2026). Optimization ensures that:

- i. Solar PV capacity is not oversized (which increases cost without added value)
- ii. Battery storage is sufficient but not excessive
- iii. Inverter capacity matches peak loads without waste

The literature shows that optimization can reduce energy costs by 10–30% compared with non-optimized designs, while also extending system lifespan and performance reliability (Oyedokun *et al.*, 2023; Ibrahim and Salami, 2025).

In the case study, optimization modeling helped identify that a 100 kW system with 200–300 kWh storage balances reliability with cost, while systems much larger than 120 kW begin to show diminishing returns relative to investment.

Barriers to Implementation in Nigeria

While the technical, economic, and environmental benefits are clear, several studies note barriers that slow solar adoption, including:

- i. High upfront capital costs remain a top concern, especially where financing and incentives are limited (Lawal *et al.*, 2025; Amadi *et al.*, 2024).
- ii. Technical capacity gaps make design, installation, and maintenance challenging for many homeowners or property managers (Umar and Bello, 2024).
- iii. Policy and regulatory uncertainty reduces investor confidence and slows market growth for distributed solar PV solutions (Oyekanmi and Akinola, 2023).

Therefore, addressing these barriers requires coordinated action by government agencies, financial institutions, and private sector actors. Incentives such as tax breaks, low-interest loans, and public awareness campaigns could heighten solar PV adoption across Nigerian residential and commercial sectors.

Practical Implications for Ascenterra Homes and Similar Developments

For Ascenterra Homes Limited and similar developments in Abuja, the findings imply that:

- i. Solar PV adoption is both technically feasible and economically attractive.
- ii. Investing in an optimized system can lead to stable electricity, lower long-term costs, and environmental benefits.
- iii. Building management could pursue phased system deployment, starting with major loads and expanding as financing allows.
- iv. Partnerships with reputable solar integrators and financing solutions can help overcome the barriers identified.

Furthermore, these implications are grounded in both the broader literature and the specific case analysis, highlighting solar PV's role as a practical solution for energy challenges in Nigeria.

CONCLUSION

This review paper examined the design and optimization of solar photovoltaic (PV) systems as a practical solution to Nigeria's ongoing electricity challenges, using Ascenterra Homes Limited in Abuja as a case study. The findings clearly show that solar energy can play a major role in providing reliable, affordable, and sustainable electricity for residential and commercial developments in Nigeria.

Significantly, from the reviewed literature and the case study analysis, it is evident that frequent power outages and high dependence on diesel generators increase energy costs and reduce the quality of life for residents. Properly designed and optimized solar PV systems, especially those combined with battery energy storage can greatly reduce these problems. For Ascenterra Homes, a well-sized solar system has the potential to cut electricity outages by a large margin, reduce generator use, and lower long-term energy expenses.

The review also demonstrates that while the initial cost of installing solar systems can be high, the long-term financial benefits are substantial. Over time, savings from reduced fuel consumption, lower maintenance costs, and improved system reliability outweigh the upfront investment. In addition, solar energy offers environmental benefits by reducing greenhouse gas emissions, noise pollution, and air pollution associated with diesel generators.

However, challenges such as limited access to financing, technical skill gaps, and policy uncertainties still slow down widespread adoption of solar PV systems in Nigeria. Addressing these barriers through supportive government policies, affordable financing options, and increased technical training will be crucial for scaling solar energy solutions across the country.

In conclusion, this study confirms that solar PV systems, when carefully designed and optimized, are a reliable and cost-effective solution for improving electricity supply in Nigerian residential and commercial properties. Therefore, with the right support and planning, solar energy can significantly strengthen energy security, reduce operational costs, and contribute to a more sustainable energy future for Nigeria.

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