

# The Benefits of Solar Energy on the Provision of Sustainable Affordable Housing in Nigeria

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## Abstract

Solar energy is the most abundant form of energy on Earth. Solar energy brings impactful benefits and products that are expected to make homes more reliable, sustainable, and affordable. Thanks to technological advancements like the solar cell, we can gather this energy and turn it into electricity. The construction industry has an exceptional chance of benefiting from this sustainable energy. Many recognised benefits have been spelled forth in the construction industry, such as providing homes with clean energy with no trace of ozone depleting material emission. There are many people in Nigeria who are not linked to the public electric grid, and the energy sector produces and generates less than 58% of the entire amount of energy required. As stated in the Nigeria's National Energy General Plan, the Sustainable Energy programme aims to enhance the country's use of solar electricity. This paper focuses on the role of solar energy in the provision of sustainable affordable housing in Nigeria. It considers the description, method, and utilisation of solar energy with a focus on residential and commercial buildings.

## Keywords

Sustainable Affordable Housing, Solar Irradiation, Solar Energy System, Solar Electricity, Sustainable Development

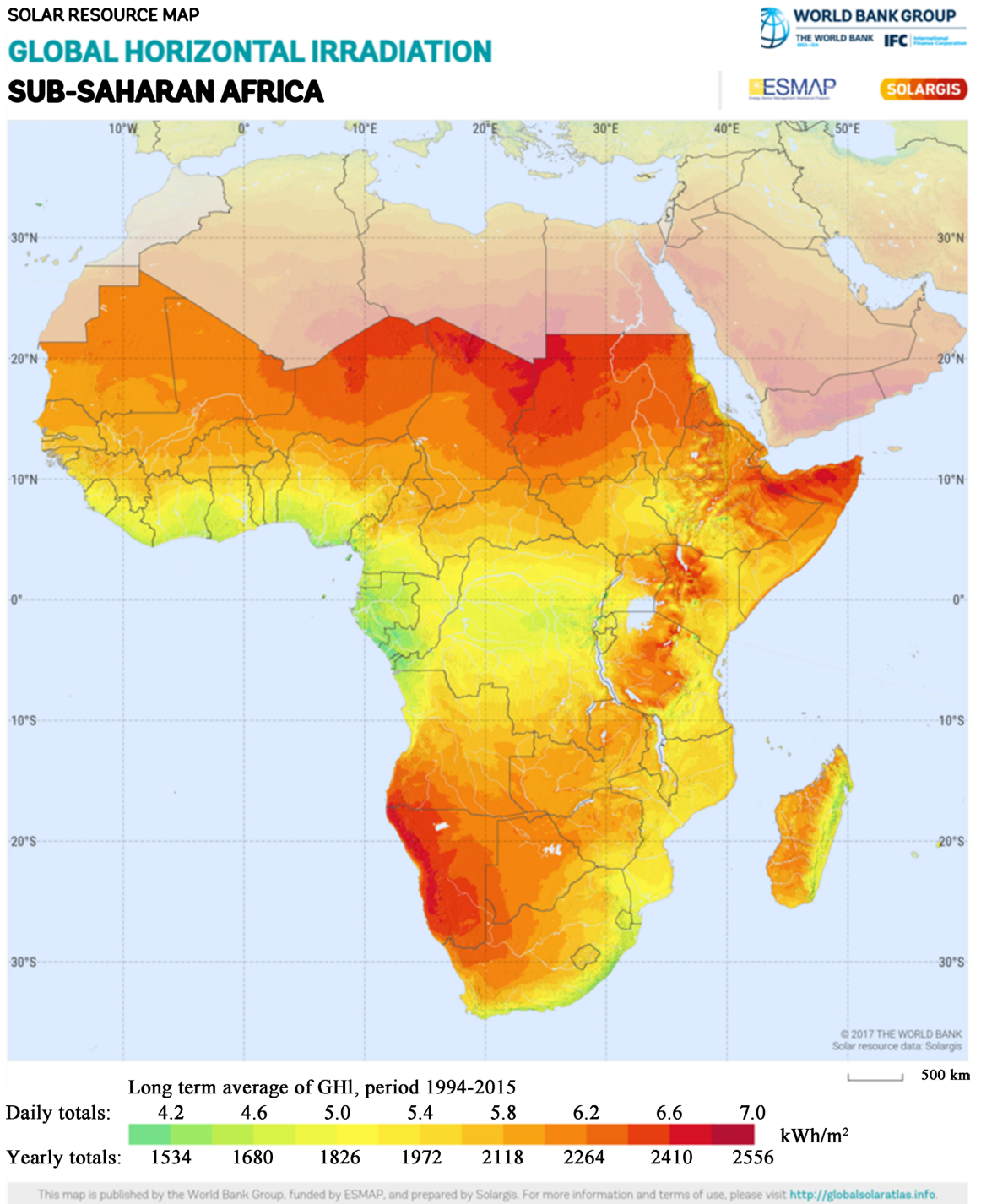
## 1. Introduction

According to a recent analysis of the Nigerian housing market, there are 23 dwellings for every 1000 persons. The republic's predicted housing deficit as of November 2022 was a startling 25 million units, up more than 15% from January 2019 statistics [1]. This has resulted in major housing challenges and several informal settlements. According to several studies, informal settlements are those

where residents lack tenure security over the land on which they live. Also defined as housing in geographically and environmentally vulnerable locations that do not follow planning and building rules [2]. Housing deficiencies have serious consequences ranging from financial to health challenges. Sustainable affordable housing may relieve those challenges such as poverty and a lack of housing by creating work opportunities and inexpensive housing options for the public. By establishing affordable housing in Nigeria, sustainability can be realised across several dimensions, including social, cultural, economic, and environmental. According to the worldwide Sustainable Development Goals report for 2019 (UNSDG, 2019), there was a 23.5% growth in slum residents in 2018, and the number of slum inhabitants surpassed one billion people. The majority of whom live in three regions: Sub-Saharan Africa (238 million), Central and Southern Asia (227 million), and Eastern and South-Eastern Asia (370 million) [3]. By 2030, a global population of 8.5 billion is expected to necessitate sustainable and affordable housing. Rapid urbanisation and population expansion have occupied space for the development of new affordable homes, resulting in a rise in slum inhabitants.

This study focuses on Nigeria. According to the Ministry of Housing, slums and informal settlements house more than 40% of the urban population. The nation wants cities devoid of slums without evicting slum people. Nigeria's strategy for achieving this goal is to plan a public slum remodelling strategy. The approach attempts to prevent new slums from growing and to enhance Nigeria's current living conditions. In Nigeria, solar energy has a lot of potential in the construction of sustainable, affordable homes. According to multiple literature evaluations, solar insolation in Nigeria ranges from 5 to 6 kWh/m<sup>2</sup> per day and estimated that concentrated sunlight-based nuclear energy would generate more than 427,000 MW in Nigeria [4]. **Figure 1** below illustrates Africa's yearly and daily solar irradiation and **Figure 2** illustrates Nigeria's solar irradiation distribution.

Many Nigerian homes presently are not connected to the national electric grid, and those that are connected do not receive an adequate supply from the national system. Also, many households utilise their labour and revenue to provide electricity using traditional generators, which are unsustainable in the long run. These issues have rendered housing development and ownership in Nigeria prohibitively expensive for low-income earners, with the use of solar energy as an alternative energy source. Electricity can become more economical and sustainable, assisting in the development of more affordable housing [6]. As a result, the government can subsidise the incorporation of solar energy into housing. Numerous studies on sustainable affordable housing have mostly focused on energy-saving technologies such as efficient heating systems and glazed windows. Because renewable energy development has not yet achieved its full potential, this article focuses on the benefits of installing solar energy in affordable homes in Nigeria. Solar energy will provide significant benefits to households. Families can also profit financially by feeding excess energy into the grid through net energy metering.

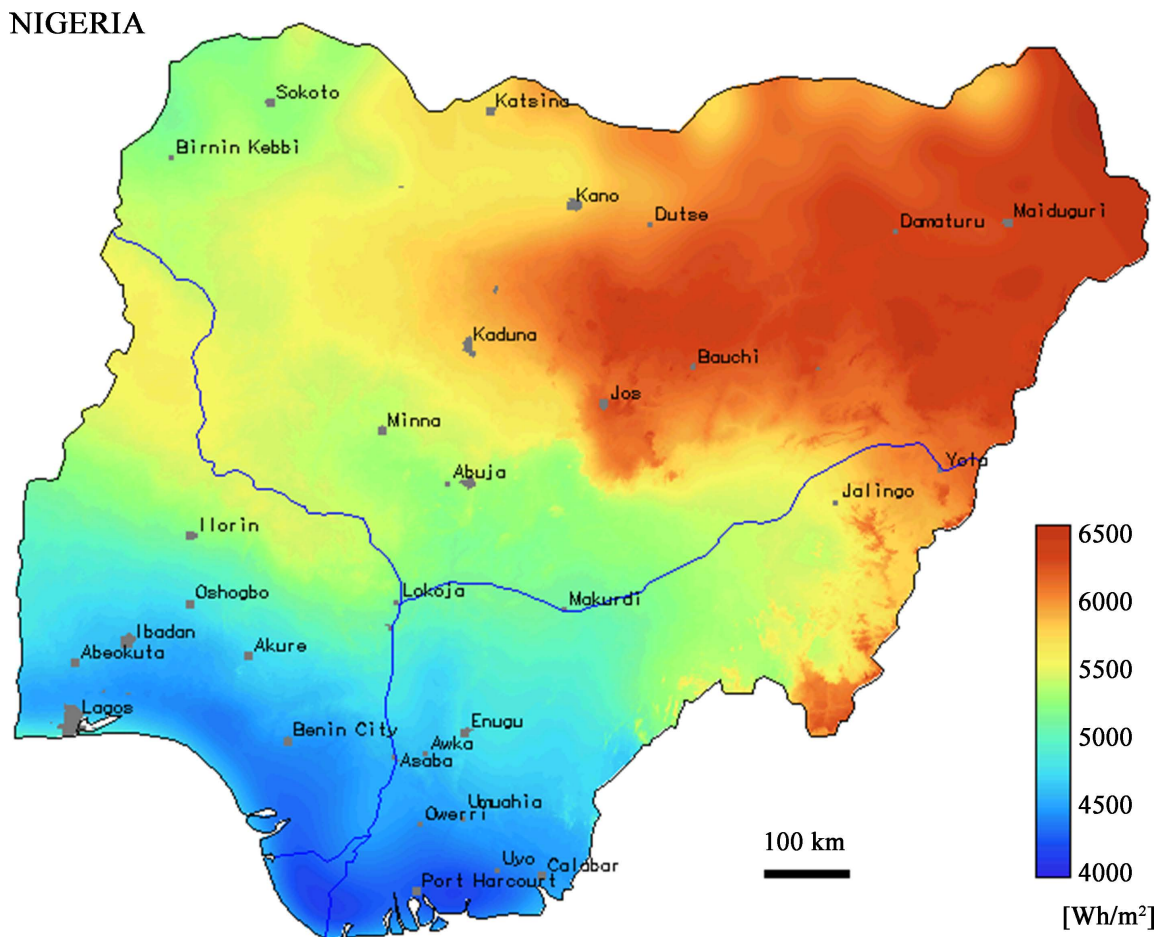


**Figure 1.** Africa’s yearly and daily solar irradiation [5].

## 2. Literature Review

### 2.1. Electricity in Nigeria

According to several studies, Nigeria’s electricity generation is much below demand. Around 90 million Nigerians do not have access to power, and the rest receive only the bare minimum from the grid. Despite billions of dollars spent to



**Figure 2.** Nigeria solar irradiation distribution [5].

“fix” the industry and privatize electrical assets to boost efficiency, Nigerians continue to rely on diesel and gasoline generators [7]. In addition to fuelling pollution, this has a substantial detrimental impact on the economy: Because Nigeria lacks a functional grid, production (and operational) costs are substantially higher than in comparable nations.

## 2.2. Electricity Demand

Nigeria has the largest economy and the most inhabitants in Africa. As a result, it stands to reason that there is a large need for electricity. While the highest generation capability is 5300 MW, daily electricity consumption is projected to be 17,520 MW at the moment. According to the World Bank, Nigeria’s per-capita energy consumption is 144.52 kWh (compared to almost 5500 kWh in Europe), however some sources put the amount as low as 123 kWh. The need for electricity will rise dramatically in the next years. According to some European sources, Nigeria’s power demand will increase by a factor of 16.8 by 2030, whereas other sources predict that demand will be 77,450 MW in 2025 and 119,200 MW in 2030. According to the Central Bank of Nigeria, the country’s energy demand is predicted to rise by 52% between 2010 and 2035, an amazing estimate.

### 2.3. Electricity Generation

Only 60% of the population presently has access to electricity, the goal is to reach 80% by 2030, but even if they do, it is unclear how people would have constant access to energy, given that Nigeria does not produce enough even today. In Nigeria, oil and coal are used to generate energy which would otherwise come from renewable sources. In countryside, most people cook with charcoal, and sometimes the sun is the only source of light. According to the Nigerian Energy Commission, people all around the nation rely heavily on oil to power their generators, spending an amazing \$22 billion per year (or nearly 5% of GDP) to do so [8]. Large diesel generators can be found in houses, stores, and office buildings, while inexpensive petrol generators, which can be shut off when not in use or when money is tight, allow the average Nigerian to live and conduct business.

### 2.4. The Nigerian Solar

With an average of 6 hours of sunshine each day, Nigeria obtains 19.8 MJm<sup>2</sup>/day of equally distributed solar energy [9]. Whereas the southern part of the nation has a tropical climate, the northern part has a savanna environment (with semi-arid or desert geography in the extreme north). Many people are targeting Nigeria for solar energy because of the country's abundant sunshine and ongoing electricity need [10].

In Nigeria, solar energy is being used more and more for a variety of purposes, including typical electrification, communications, lighting, and irrigation. The falling cost of solar is primarily responsible for the rising adoption: Solar panel costs dropped from \$5 per watt in 2000 to \$0.37 in 2017, a 93% decrease in cost. Due to lowering production costs and market competitiveness, the price of going solar has been decreased by more than 40%. However, the average price of constructing a 4-kW solar PV system in Nigeria is N1.8 million (\$9090), which includes the price of an energy storing battery bank. Many Nigerians cannot afford this, as a result, pay as you go (PAYG) types have gained popularity.

In addition to determinedly pushing solar energy, the federal government, as part of the Economic Sustainability Plan (ESP), has offered 25 million Nigerians the opportunity to purchase 5 million solar systems at a monthly cost of N4000 through Solar Home Systems. Also with government support, the private business Lumos has deployed over 100,000 of its systems in homes across Nigeria and intends to tenfold its reach. **Figure 3** below depicts the current update of solar energy in Nigeria.

### 2.5. Solar Energy Brief History

Solar energy, or light from the sun, is the most plentiful source of energy on Earth. The solar cell gathers this energy and transforms it into electricity, every day, the sun emits massive quantities of energy into outer space. The photovoltaic phenomenon, which allows sunlight to be converted into energy, was

## NIGERIA SOLAR UPDATE



By 2030, renewable energy sources are anticipated to provide 30% of all energy.

dependable six hours of daily sunshine.



In recent years, solar energy has become 40% less expensive.

The potential value of solar household systems alone is \$2 billion per year.



Nigeria's solar energy potential is predicted to reach 427000 mw.

For 2025, 500 mw of installed capacity is anticipated.

**Figure 3.** Solar energy data for Nigeria.

discovered in 1839 [11].

This energy form was extremely futile until the solar cell was invented more than a century later. Because of advancements in design innovation, nowadays solar chargers are becoming increasingly effective. During mid-1950s, solar panels were mostly employed on space spacecraft. When solar calculators first became popular in the 1970s, most individuals had probably never heard of solar electricity. Currently, solar energy is used to power numerous houses and towering constructions. Because of its numerous benefits, such as providing a solution that is cost-effective, link-free, beneficial, and harmless to the ecology. **Figure 4** below displays a solar hybrid power plant at Bayero University, Kano state, Nigeria [8].

### 2.6. How Does Solar Panel Work?

Using the photoelectric effect, solar cell (a photovoltaic) can convert sunlight wholly into electricity. The photoelectric effect is the flow of electricity caused by light shining on a substance. The light gives energy to the electrons in the molecules of the substance empowering them to move around to make a current. The solar panel are made up of three layers of silicone, phosphorus, and boron. Silicon of the “positive type” which generates a positive charge contributes to the construction of the lower layer [12]. “Negative type” silicon, releasing negatively



**Figure 4.** A solar hybrid power plant.

charged particles known as electrons, makes up the uppermost layer.

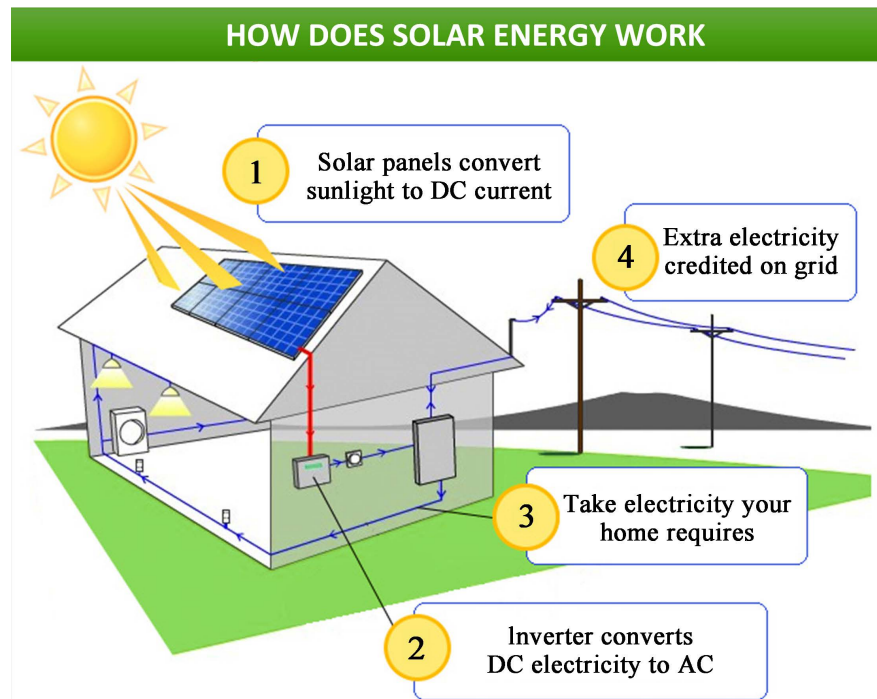
Between the negative type and positive type silicon layers is an intermediate part, or link layer, called an insulator. Photons also known as energy particles that comprise sunlight strike the top layer of a solar cell, they are absorbed and cause a current to flow. When photons collide with negative type silicon atoms, electrically charged electrons are extracted from their “parent” particles, causing this current to flow. The positively charged protons in the solar cell’s p-type silicon layer attract electrons, which flow down wires that link to a battery, where they are stored and returned to the solar cells, ready to be used. While a single solar cell can only provide a little quantity of electricity, a panel of solar cells can produce enough power for an entire building. **Figure 5** depicts how solar energy work.

## 2.7. Solar Energy in Sustainable Affordable Housing

Sustainable, affordable housing is linked to affordability, energy efficiency, and a green lifestyle. According to several studies, there are four potential green technology interventions for sustainable, affordable home development [14]:

- 1) Water and wastewater technologies that improve water quality and conservation.
- 2) Miniature technologies and designs that support increased energy efficiency.
- 3) Waste management systems that encourage resource recycling and reuse.
- 4) Renewable energy technologies that make alternative energy more accessible.

This study will concentrate on aim 4, renewable energy technologies that make alternative energy more accessible, hence saving depleted traditional energies. Solar energy is one type of energy that can be referred to in this situation. Integrated solar energy systems are increasingly being developed as technology advances [15]. Solar energy systems offer a lot of potential for application in Nigerian cities, but this technology has not been completely explored yet. Throughout the year the nation receives a substantial quantity of solar irradiation, and individuals



**Figure 5.** How does solar energy work [13].

have expressed a high interest in using solar energy. To broaden interest in solar energy reconciliation into the nation, several studies proposed that proper solar energy policy schemes, customer interest, and module pricing be reviewed. It enables household to generate electricity independently and cheaper rather than rely on the grid, therefore incorporating solar energy into housing development can make housing easily affordable and sustainable. Furthermore, Nigeria, according to many studies, has solar irradiances of at least 4 kWh/m<sup>2</sup> per day. A favourable response can be expected because the sun irradiation is sufficient. Consolidating solar energy in the development of affordable housing is a viable method of producing electricity.

### 3. What Are the Different Types of Solar Panels?

There are numerous types of solar panels as Solar panel technology has improved greatly in recent years because of increase demand for more renewable energies that lessen dependency on fossil fuels and other activities that emit less carbon.

#### 3.1. Standard Solar Panels

Standard solar Panels are the most well-known product accessible, and they are generally the greatest solution for many households. They are easy to mount on roof and can be properly positioned to receive the maximum sunlight with brackets, which are commonly made of aluminium [16]. Because they can be set with better precision, they usually deliver a substantially larger return on investment. Standard solar panels are depicted in **Figure 6**.

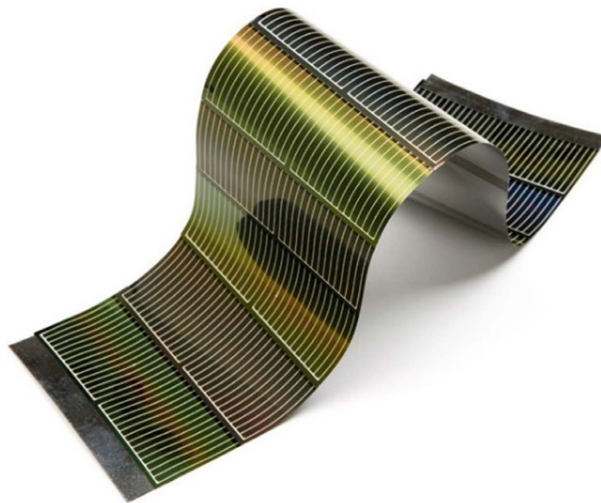


### 3.2. Thin Film Solar Panels

They are lighter in weight, account for approximately 10% - 15% of the market, and require more space than standard solar panels due to their lower productivity [17]. Another difficulty is that thin-film solar panels frequently contain hazardous cadmium telluride, which must be disposed of correctly when they reach the end of their useful life. The fundamental advantage of thin film solar panels is that they are more adjustable and can be created in a variety of configurations, including rollable and foldable. It makes them useful for a variety of purposes, like providing power to a train or tent. Thin Film Solar Panels are depicted in **Figure 7**.



**Figure 6.** Standard solar panels.



**Figure 7.** Thin film solar panels.

### 3.3. Solar Tiles

Installing solar tiles provide a more visually appealing appearance than a traditional panel cluster. Tiles can be linked together to replace the standard panel tiles. Because of their flexibility to be incorporated into an existing roof or utilised to construct a new one, they are one of the more adaptable solutions for both commercial and residential properties. They are inefficient in terms of energy and generally cost twice as much as regular solar panel systems. Some of this can be compensated for if the roof is already at the optimal angle for gathering sunlight and converting it into electricity. Solar Tiles are depicted in **Figure 8**.

## 4. Methodology

This quantitative study will look at the various benefits of adopting solar energy as an alternative energy source into Nigeria's sustainable affordable homes development. The goal of descriptive quantitative research is to characterise and combine different community circumstances, scenarios, or elements. For this investigation, the descriptive format was used [18]. The descriptive technique is a strategy for comprehending and analysing facts by examining barriers in a certain community's circumstance or era, such as interactions, attitudes, and processes. The goal of descriptive study is to create an organised, precise, and definitive record of the peculiarities being investigated.

## 5. Findings: The Benefits of Solar Energy for the Provision of Sustainable Affordable Housing in Nigeria

### 5.1. Household Energy Spend Is Reduced

In Nigeria, most people are aware of solar energy, but few are aware of the significant financial savings that can be realised by putting solar panels in their houses [19]. Solar panels turn the energy of the sun into electricity, which may then be utilised to power lights, appliances, and other essentials.

This not only reduces energy expenditures but also reduces reliance on fossil-fuel energy. The money saved on monthly energy costs will usually more than cover the initial investment in solar energy thereby making homes more affordable



**Figure 8.** Solar tiles.

to live in. Furthermore, because of technology improvements, solar electricity is becoming more cost-effective and efficient.

### **5.2. Provides Energy Reliability, Energy Independence and Energy Security**

Solar energy systems installed in homes provide homeowners with control over their electricity supply and the freedom to utilise it without relying on traditional sources, which can fail at any time. During the day, the electricity generated by the solar panels is sent straight to the homes' appliances. At night, the energy stored in the solar energy system's batteries is used to generate electricity for the home, assisting it in achieving energy independence [20]. This increases the quality of life, making homes more sustainable to live in. Furthermore, Solar power is also energy reliable since the energy generated by solar panels is stored in batteries that can be utilised to power the house at any time or when the sun is not as intense.

### **5.3. Safeguard Houses from Increasing Energy Expenses**

There are several reasons why solar energy homes will defend against growing energy expenses. To begin with, it reduces reliance on the public power grid, and it also provides a sustainable power source. When installed solar panels, can be equated to essentially constructing houses mini-power plant. As a result, houses create their own electricity and are less reliant on the public grid thus making houses sustainable, affordable to live in [21]. This is critical because energy costs will continue to rise as demand rises and assets become more difficult to obtain.

Furthermore, solar energy is a renewable energy source. As a result, it will continue to serve for as long as there is sunlight after installation. As a result, it will protect in the future from rising energy prices. The power generated by solar energy is for the product life expectancy, which can be up to 12 years. This electricity is free and does not fluctuate like regular electricity because it is generated by the sun. When properly maintained, solar panels are sturdy, resilient, and incredibly trustworthy, with a long lifespan. They simply need to be maintained clean to function properly. They do not require much upkeep.

### **5.4. It Is Eco-Friendly**

The primary source of air pollution is the combustion of fossil fuels such as coal, oil, and natural gas. This type of energy extracted from the ground, it is difficult to replace and will take millions of years to change, hence why it is known as non-renewable energy. Solar system generates power using the sun's energy rather than the world's usual resources. Natural processes quickly replace this renewable energy, which is clean and pollutant-free and has an almost limitless supply.

One of the most effective ways to minimise carbon footprint is to install solar panels in housing projects [22]. Solar panels provide a green, clean energy source that is neither harmful to the environment or alters the climate. Solar panels

catch and transform the sun's rays into power. Furthermore, sunlight-based energy is an endless resource that can never deplete.

Solar power is a clean, long-lasting energy source that does not emit hazardous particles into the atmosphere. As a result, it reduces air pollution and makes homes and cities more liveable. Solar panels are typically installed on rooftops or other locations where the sun may shine all day. They can thus generate power every day for up to 30 years without polluting the air and requiring little repairs.

### **5.5. Recyclable**

As solar panels are made from a variety of materials, including silicon and silver, these materials can be reused until the end of their useful life, which is around 30 years. Solar panel reuse companies collect used sun-powered cells made up of semiconductors and other components. They are then recycled into fresh sun-powered cells for usage in new things such as electronic gadgets or building security. This means that solar panels can also benefit from the recycling.

### **5.6. Energy Storage**

Most solar energy systems include rechargeable batteries that store excess energy and can be used anytime electricity is required. These batteries are always ready to discharge and recharge on a regular basis, are mostly of excellent quality and help buildings control their day/night lighting. The solar energy that powers the battery must be managed to prevent overcharging. A regulator safeguards the battery against electrical damage and regulates the quantity of energy delivered by the solar energy. Even though sunlight comes and goes, there is a wealth of data available that may be utilised to accurately anticipate how much sunlight a location will receive.

### **5.7. Minimal Maintenance Expenses**

Solar energy systems normally do not require much upkeep and only need to be kept relatively clean, so cleaning them once or twice a year should suffice. Specialized cleaning businesses that provide this service might also be used for a more effective end.

Many reputable solar panel manufacturers offer warranties ranging from 20 to 25 years [23]. There is also no wear and tear because there are no moving parts. The inverter is often the only component that needs to be replaced every five to ten years because it is always working to convert solar energy into electricity and heat. For the solar power system to function properly continuously, the wires, as well as the inverter, must be maintained. After covering the initial cost of the solar energy system installation, very little spending on maintenance and repair work is required.

## **6. Conclusions**

The study determined that solar energy would be beneficial to Nigeria in terms

of providing sustainable affordable homes. According to this article, the high cost of public electricity and the limited supply of public energy are important barriers to the development of sustainable affordable housing in Nigeria. This study argues that by incorporating solar energy into Nigerian homes, these homes can become more energy reliable, independent, and secure, making them more sustainable and economical for the people [24].

Furthermore, solar energy requires less maintenance and lasts longer, making it suitable for affordable home construction. According to this study, Nigeria has a lot of annual solar irradiation that is required to generate solar energy. When used in the construction of housing, an eco-friendly energy source such as solar energy can considerably improve Nigeria's housing sustainability and affordability. As a result, the research proposes that all levels of government encourage and support solar energy usage, particularly for affordable housing projects.

To enable the success of solar energy, substantial housing reform and strong political support at all levels of government are also required. It is expected that these measures will make housing in Nigeria more sustainable and affordable, as well as motivate many Nigerians to build their own homes.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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