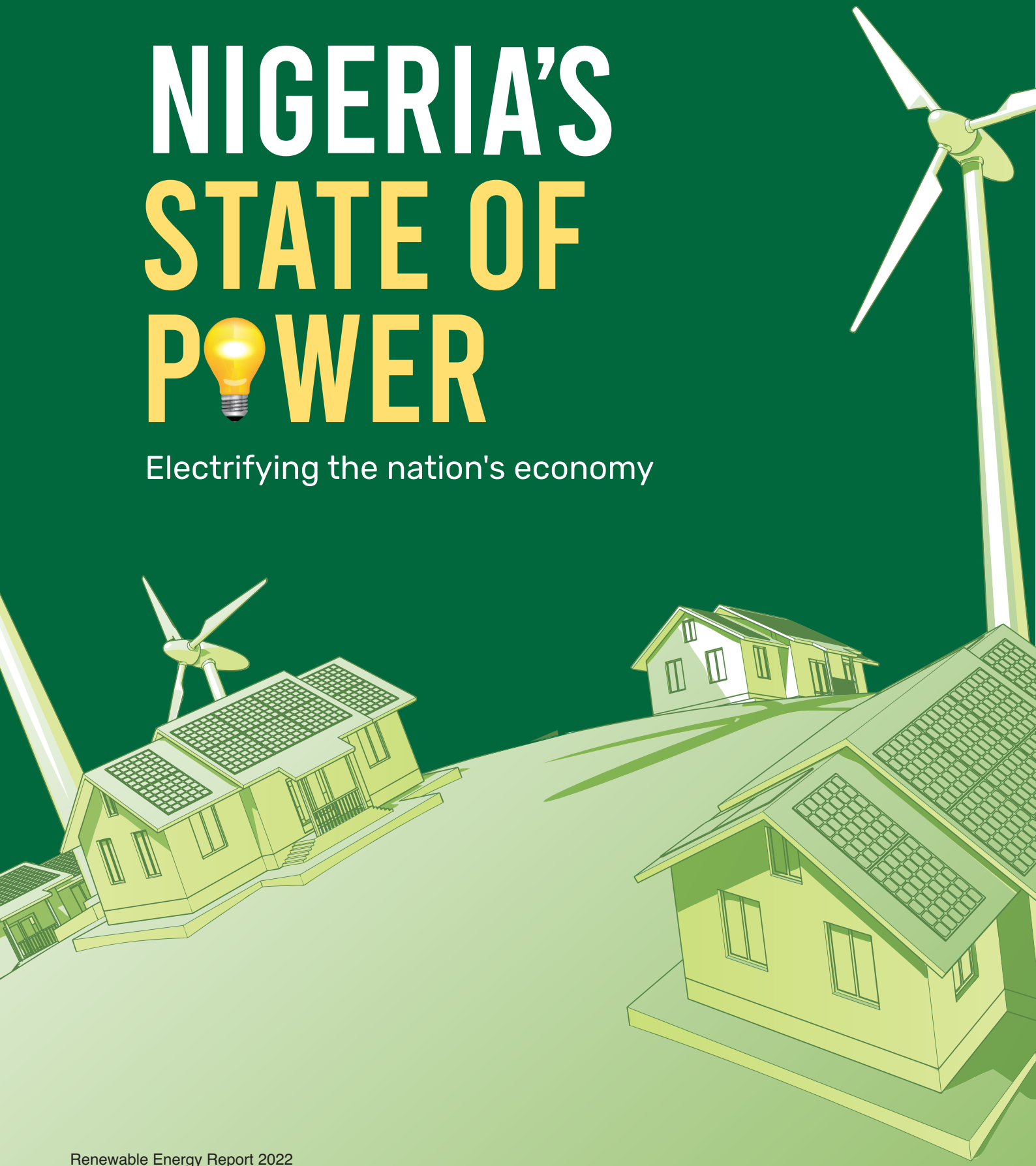
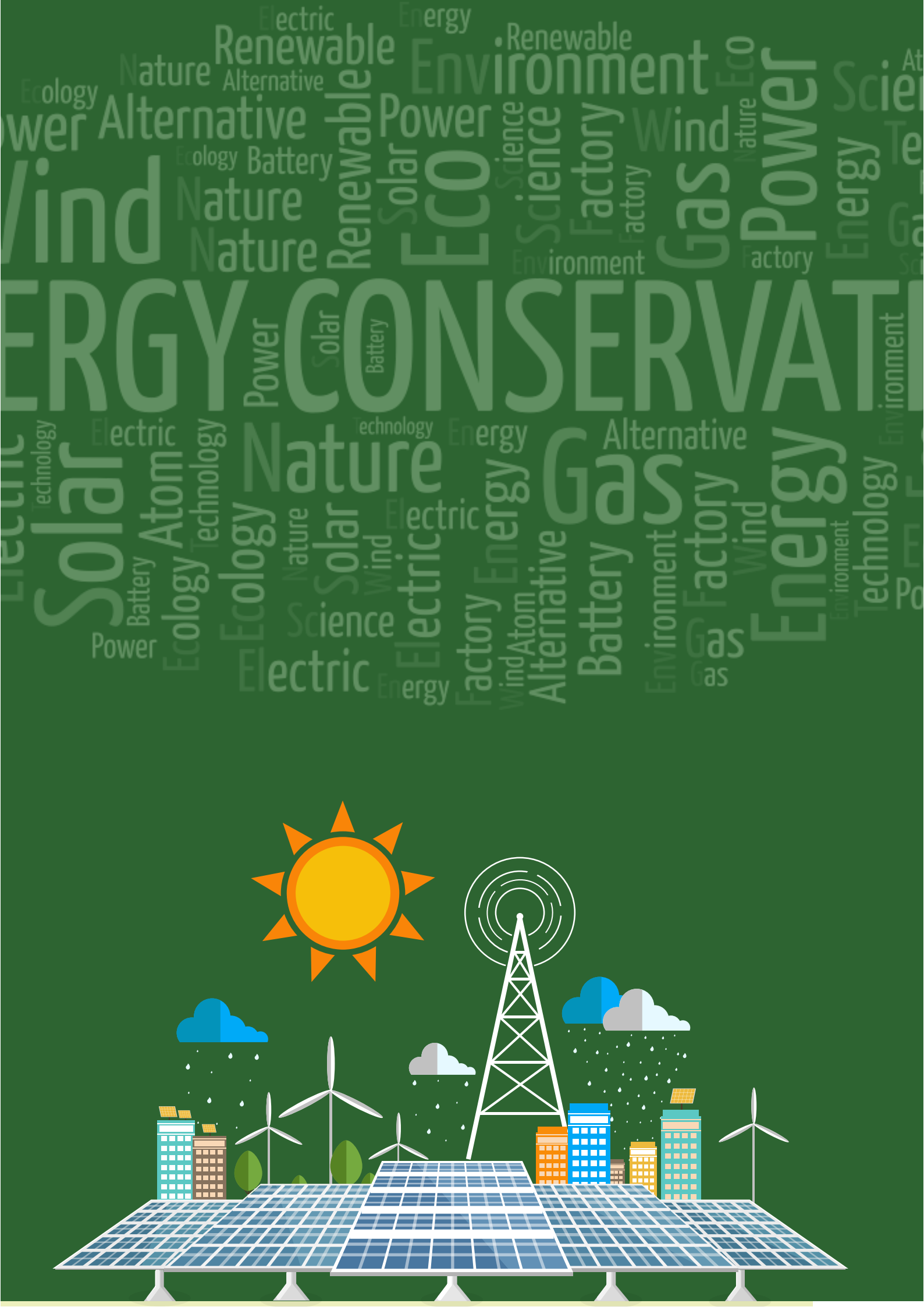
Stears | Sterling

NIGERIA'S STATE OF POWER

Electrifying the nation's economy



Renewable Energy Report 2022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INTRODUCTION

Nigeria has one of the lowest electrification rates in the world. In the most populous country in Africa, 43% of the population have no access to grid electricity[1]. This means that 85 million Nigerians are not connected to—and cannot receive electricity from—the Nigerian transmission grid. While Nigeria's electrification rate is above the Sub-Saharan Africa regional average of 47%, it lags significantly behind its peers across the continent and the global average.

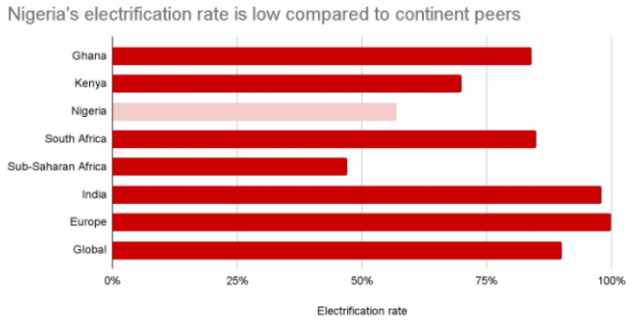


Chart 1: *Comparison of electrification rates*[2]

Nigerians who do have access to power also have to contend with its poor quality, typically exhibited by epileptic supply. Households connected to the grid only receive an average of 7 hours of electricity per day, forcing them to turn to alternative energy sources—most prevalently diesel generators, an expensive and dirty[3] source of energy. The impact of not having reliable energy cannot be overstated. Economic losses associated with Nigeria's energy crisis are estimated at 10 trillion[4] ($26 billion)—the country's 2022 proposed budgetary revenue and roughly 3 times what it actually earned in 2020. Businesses face a double loss—the productivity and output losses and the increased spending involved in maintaining alternative energy sources like diesel and petrol generators. Considering the skyrocketing rise in diesel costs, and the persistent fuel scarcity experienced in the first quarter of 2022, these losses have risen even further.

Renewable energy has emerged in the last few decades as a solution to the energy issues across the world. Developed nations, where most—if not all—of the population have reliable access to electricity, are making concerted plans to reduce their reliance on fossil fuels. Developing countries, with notable success stories from Kenya and India, have turned to renewable energy solutions to meet the growing energy demand of their populations.

Demand for electricity will continue to grow, with population growth and increasingly complex energy uses. For this reason, governments must look to sustainable, reliable and cost-effective solutions for its citizens. Already, many companies and individuals are rising to innovate, build, promote, finance and use these renewable

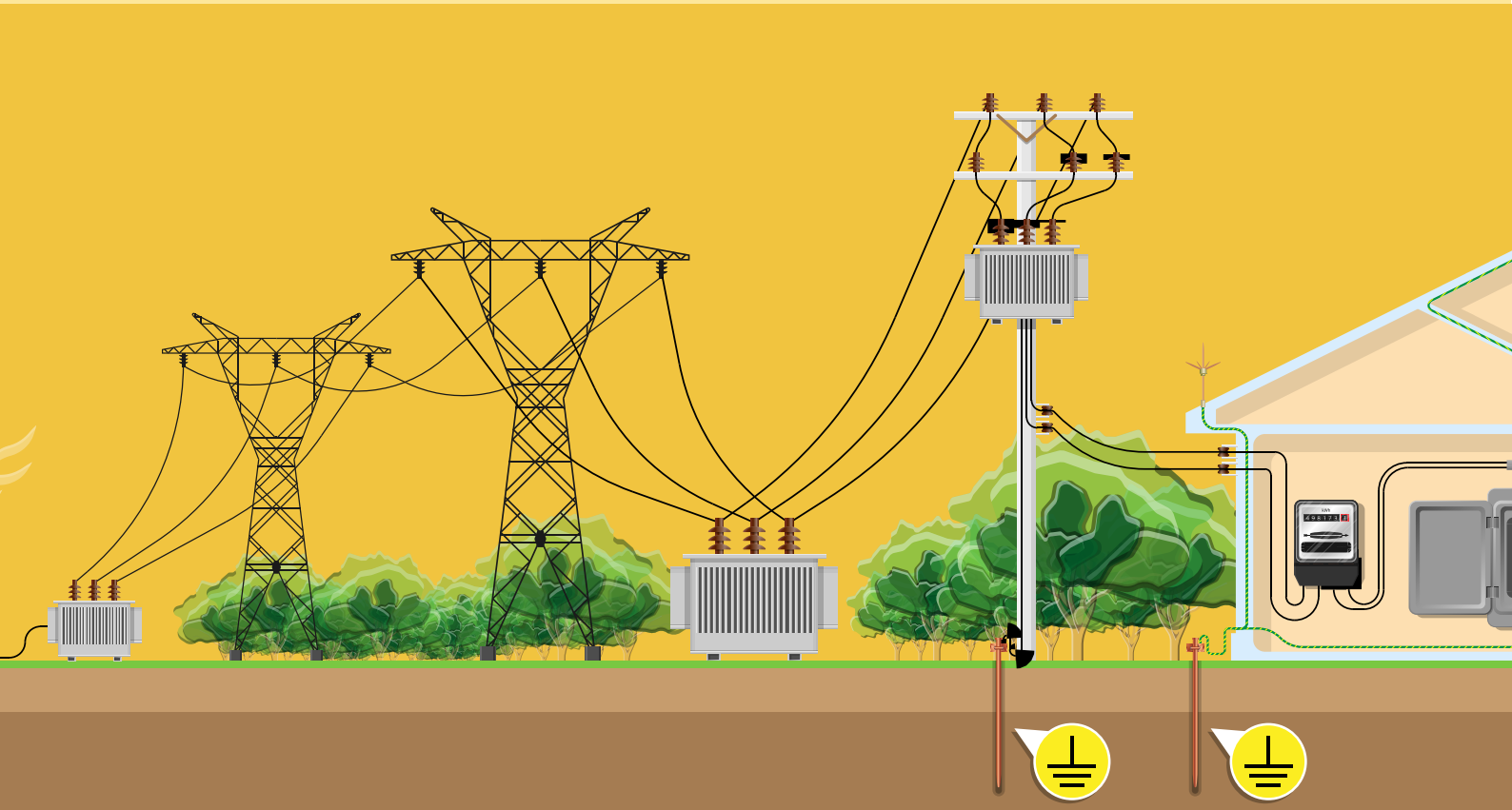
[1] *World Bank, 'Nigeria to Improve Electricity Access and Services to Citizens, https://www.worldbank.org/en/news/press-release/2021/02/05/nigeria-to-improve-electricity-access-and-services-to-citizens*
[2] *Global electrification rates, World Bank: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS*
[3] *Nigeria Living Standards Survey 2020, NBS*
[4] *World Bank, 'Nigeria to Improve Electricity Access and Services to Citizens, https://www.worldbank.org/en/news/press-release/2021/02/05/nigeria-to-improve-electricity-access-and-services-to-citizens*

solutions. It is important that there is an enabling environment for these to operate in.
There are various models of delivering renewable energy at a massive scale available. In 2021,

Nigeria's Generating Companies (GenCos) generated 36GWh, with about 25% of Nigeria's grid supply from hydropower—a form of renewable energy. However, the remainder is still supplied from natural gas, fossil fuels and coal[5,6].

Nigeria's transmission grid significantly constrains the amount of generated energy that gets to the end uses. Outdated and inefficient infrastructure and equipment, as well as inadequate investment in expanding the grid, means that increasing electricity access in the country through the grid would be ineffective in the medium term. Therefore, it's necessary to explore how off-grid solutions can be best placed to augment the gap in electricity supply.

> ***Nigerians who do have access to power also have to contend with its poor quality,***

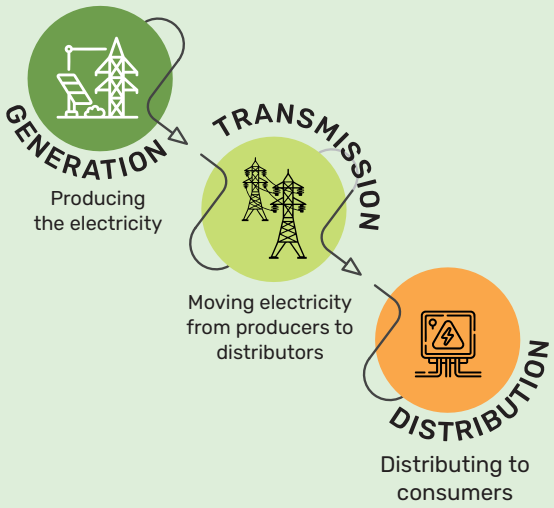


[5] *Power Sector Dat: Energy Generated and Sent Out, 2021, NBS (data provided by NERC)*
[6] *Nigeria Energy Profile, 2020, IRENA*

1 NIGERIA'S ELECTRICITY PROBLEM

1.1. . Electricity Supply

Nigeria's grid-supplied electricity is grossly insufficient—the country has the largest electricity access deficit in the world. The electricity supply value chain can be broken into 3 main components.



Understanding the history of the electricity sector can help shed light on the persisting issues still facing supply today.

Nigeria's power generation, transmission and distribution was wholly controlled by a state-owned facility—National Electric Power Authority (NEPA)—from 1972 till 2005. In 2005, the Power Holding Company Nigeria (PHCN) was formed to transition to unbundling and privatising components of the power supply companies and form successor companies that would handle distinct parts of the value chain—generation, distribution or transmission. The idea behind this was to create smaller, nimbler, more efficient corporations. [7]

However, unbundling NEPA into specialised, privately owned companies left the state company's legacy intact. Deteriorating infrastructure, energy losses, energy theft and non-cost reflective tariffs[8] are still crippling the sector. And while the new structure was intended to address these problems, underlying issues have kept the sector in the same spot—or moved it backwards as some might argue.
The Nigerian electricity sector is stuck in an unproductive cycle.

Nigerians do not want to pay higher tariffs because they are getting low-quality electricity (and often have to spend on self-supplying electricity), leading to collection losses / poor collection rates, resulting poor revenue intake, meaning they're unable to spend on upgrading infrastructure, which results in the same low quality electricity, which again, Nigerians do not want to pay higher tariffs for, and so on.

[7] *Transmission Company of Nigeria, https://www.tcn.org.ng/page_history.php*
[8] *'Why privatising NEPA did not work', 2022, Stears Business, https://www.stearsng.com/premium/article/why-privatising-nepa-did-not-work*

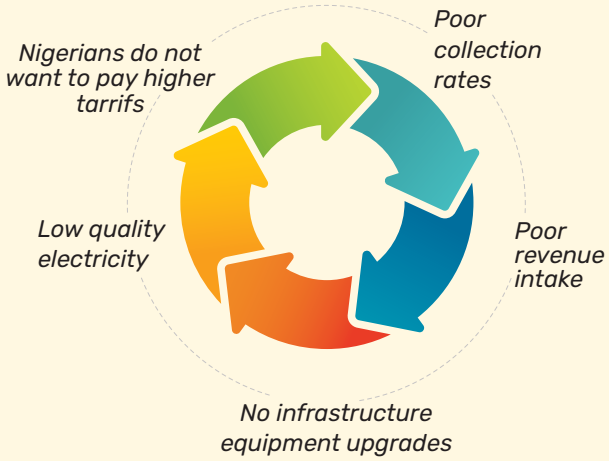


Image 1: *Nigeria's electricity supply cycle*

Generation	Transmission	Distribution
The generation sub-sector includes 23 grid-connected power plants that generate electricity from various sources (hydropower, natural gas, fossil fuels and coal). Generation companies (GenCos) are either privately owned, privately managed, or plans are underway to privatise them (in the case of National Integrated Power Project plants).	The Transmission Company of Nigeria (TCN) is fully owned by the Federal Government of Nigeria. They have the responsibility of developing and maintaining transmission infrastructure, administering the wholesale electricity market and managing the flow of electricity through the power system. The transmission network consists of 159 substations with a transmission capacity of about 19,000 MW.	Distribution companies (DisCos) are privatised. There are are 11 DisCos across the country that are allocated power proportionate to the customer base they serve (i.e. DisCos covering a large population are allocated more power).

With the disbandment of NEPA, the Electric Power Sector Reform Act (EPSR, 2005) was enacted, establishing the Nigerian Electricity Regulatory Commission (NERC) as an independent regulatory body for Nigeria's electricity industry.

They are responsible for setting the tariffs that DisCos have to pay the GenCos based on the power received (not the power delivered to customers). However, liquidity is a key issue as DisCos often struggle to pay. One of the reasons for this is their ability to collect tariffs from customers to pay them back.

NERC also sets the remuneration rates which have been highly subsidised. This creates a cycle that means the DisCos are underfunded, and have issues paying GenCos.

Generation:

Nigeria does not generate enough to meet its energy demand. The current generation potential is around 12,522 MW with average output of 4,000MW. With estimated demand between 8,000MW - 17,000MW, there is a shortfall of at least 4,000MW.

Transmission and Distribution:

Only a small fraction of the generated energy actually gets to the end user. Installed transmission capacity—or the maximum amount of electricity that can be transmitted under ideal conditions—is 8,100MW, and the peak transmission has been 5,459MW.

Further, only a quarter (3,100 MW) of our current generating potential reaches the end user, signs of a highly inefficient value chain. On top of these inefficiencies, the transmission grid's outdated and worn infrastructure makes it highly prone to frequent system collapses.

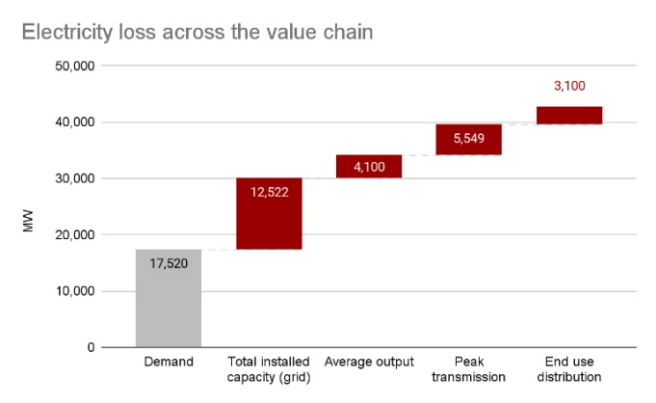


Chart 2: *Nigeria's electricity loss, from demand to end use*

> ***The current generation potential is around 12,522 MW with average output of 4,000MW.***

1.2. . Electricity Demand

Nigeria's daily electricity demand is estimated to range from 8,000MW-17,000MW. One of the several reasons that it is difficult to measure how much electricity Nigerians actually need is latent demand, or the dormant demand caused by not having access to electricity in the first place[9,10].

For instance, a Nigerian factory may only use 4 packaging machines because of how expensive it is to run 7 packaging machines using diesel generators. The factory's actual demand for electricity would be estimated at 4 machines. However, the latent demand would be an additional 3 machines. Because in an ideal world—or simply in another country—the factory would run 7 machines.

In any case, it is evident that the energy generated from Nigeria's national grid is insufficient to meet demand; one only has to listen. Nigerians rely primarily on loud, expensive and environmentally harmful generators to meet their energy needs.

Based on Nigeria's current population size and income levels, the country's energy consumption is an estimated 80% below expectations. This means that the country's actual energy demand could be closer to 20,000MW. Another way to understand what real demand could be is by looking at self-supply. Generators are the most prevalent form of self-supply in Nigeria, with roughly 60 million small scale generators powering households and small businesses across the country.

These generate an estimated total of up to 42,000MW[11]. Either of these estimates still implies

Based on Nigeria's current population size and income levels, the country's energy consumption is an estimated 80% below expectations

a mammoth energy shortfall. Research from GIZ found that nearly half—48%—of the electricity demand is satisfied by generators alone[12].
Over the next few years, the demand for electricity is only expected to rise. As the population grows, there will be more individuals requiring energy. In the next 3 decades, Nigeria is expected to double its population. In addition, as the economy grows, there will be more activities requiring energy and more complex uses for energy. For instance, the growth of the digital economy—an estimated global average of 6% annually—will demand power for all facets of the technology driven economy. Even the Central Bank of Nigeria forecasted electricity demand to grow by 52% between 2010 and 2035[13]. In every scenario, Nigeria needs more energy fast.

Energy consumption—or the total amount of energy used—is typically measured at an individual level. Nigeria has an extremely low per capita consumption compared to other nations, at 152 kWh compared to the Sub-Saharan Africa average of 448 kWh and the global average of 30 kWh[14]. This means that the average Nigerian uses significantly less electricity than the average African or even the average human.
Unfortunately, this is not driven by Nigerians

[9] *Solar Report Nigeria, Netherlands Enterprise Agency: https://www.rvo.nl/sites/default/files/2021/06/Solar-Report-Nigeria.pdf*
[10] *Nigeria energy sector profile, 2020, GET.Invest, https://www.get-invest.eu/market-information/nigeria/energy-sector/*
[11] *A2E and Dalberg, Putting an end to Nigeria's generator crisis: the path forward, 'https://a2ei.org/resources/uploads/2019/06/A2EI_Dalberg_Putting_an_End_to_Nigerias_Generator-Crisis_The_Path_Forward.pdf*
[12] *GIZ, The Nigerian Energy Sector, 2015, https://www.giz.de/en/downloads/giz2015-en-nigerian-energy-sector.pdf*
[13] *CBN, Analysis of Market Conditions in Nigeria, 2015, https://www.cbn.gov.ng/out/2017/rsd/analysis%20of%20energy.pdf*
[14] *IEA, Electricity Statistics, https://www.iea.org/fuels-and-technologies/electricity*

being highly energy conscious, but because Nigerians don't have reliable access to energy in the first place.

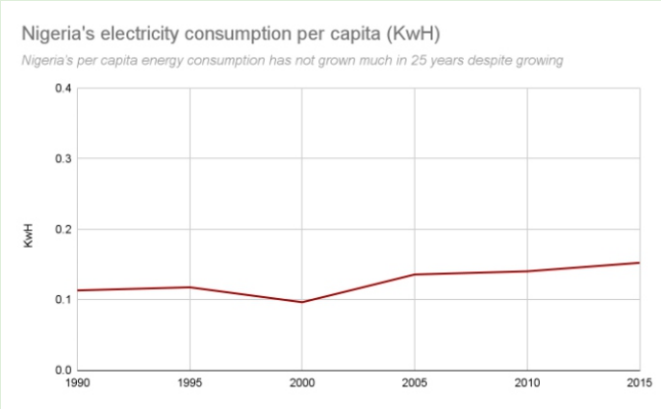


Chart 3: *Electricity consumption per capita Nigeria's per capita energy consumption has not grown much in 25 years despite growing technological advancements and more complex energy usage*

Low electricity consumption can be a function of both demand and supply. This means that there are issues on both the demand and supply side keeping electricity consumption low. Demand can be depressed by factors such as poor access to the grid electricity and how affordable tariffs are.

An individual might rely on a non-electric solution like a kerosene powered lamp instead of electric bulbs to meet lighting needs simply because they cannot rely on electricity from the grid. They learn to consume less electricity in response to unreliable electricity supply and thus demand less electricity.

On the other hand, supply problems restrict the amount of electricity that individuals, businesses and households can get access to even when they do require it. In this way, supply also has an impact on constraining consumption.
The relationship between the demand and supply of energy is not one-directional. Significant latent or dormant demand means that when supply issues are addressed and workable options are provided, the actual demand for energy will also go up.

In other words, when the cost, availability and reliability of electricity is no longer a problem, Nigerians will be able to replace non-electricity solutions—like rewarming food in a pot—with more efficient, electricity driven alternatives—like using a microwave oven. Unblocking demand or supply bottlenecks in the electricity value chain is critical to tackling our low consumption.

In Nigeria, residences are the largest consumers of energy (as of 2019 models[15]), using an estimated 68% of all energy consumed[16]. This is quite high, as consumption is primarily driven by industrial activity globally—42%. Several factors could contribute to this.

One is Nigeria's consumption-driven, service-based economy. This is not helped by the fact that unreliable and poor electricity supply makes industrial activity extremely difficult and prohibitively expensive in the country. In addition, Nigeria's economy is driven by micro, small and medium enterprises (MSMEs) who make up over 90% of all businesses and over 80% of all employment.

[15] *Source: IEA World Energy Balances https://www.iea.org/data-and-statistics/data-product/world-energy-statistics-and-balances*
[16] *Due to the complexity of calculating final consumption, different sources attribute different proportions (i.e. residential can be anywhere from 59%-70%). It's an estimate, but the trend shows that households consume the largest proportion of energy in Nigeria.*

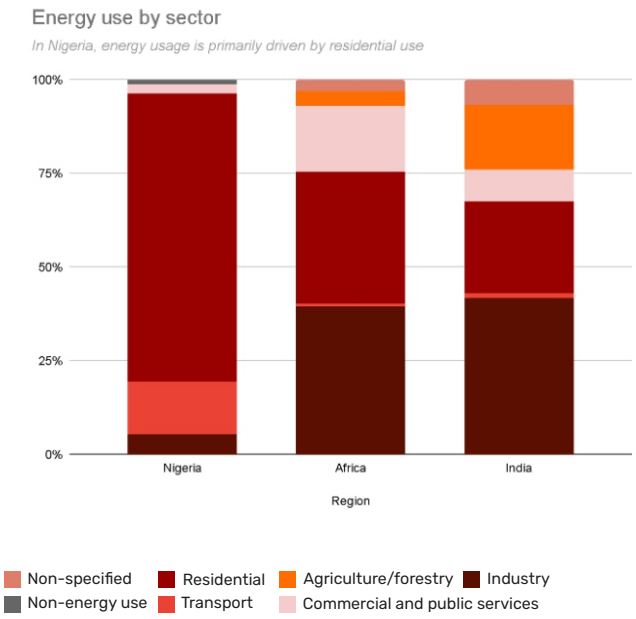


Chart 4: *Energy usage by sector*

2 THE IMPACT OF NIGERIA'S ELECTRICITY PROBLEM

Nigeria's electricity deficit affects the country on multiple levels—at a household, business and even at a macro, economy level.

2.1. The Household Level

According to NOI Polls and the World Economic Forum, households self-reported average monthly electricity tariffs of $17 in 2015. Despite tariffs almost doubling since then[17], households do not enjoy better services. Nigerian households, on average, have electricity in their homes for 15 hours each day[18]. Of that, 44% (or 6.8 hours) is self-supplied by generators. And this differs by geography. In a state like Taraba, only 19% of households report having electricity.

Over 40% of Nigerian households own generators, and bear the associated costs[19]. First, the cost of purchasing generators—an estimated $500 million between 2015 and 2019[20], higher than the proposed capital expenditure in Nigeria's 2022 budget. There is also the cost of powering these generators. Sources and estimates vary widely, but the African Development Bank (AfDB) estimated that Nigerians spend $14 billion fuelling petrol or diesel powered generators.[21]

While PMS or petrol prices have been kept artificially low for the consumers through subsidies, variations in AGO or diesel prices can have severe impact on households and businesses as Nigerians are currently experiencing. Although the National Bureau of Statistics (NBS) diesel price watch for February 2022 shows a less than 10% rise in the price of the fuel from the beginning of the year, diesel is widely sold at prices 200% to 300% up from the end of last year. This has made it incredibly difficult for households or businesses to plan and manage themselves.

While petrol prices appear more stable, prices are kept artificially low by government subsidies which are generally acknowledged to be unsustainable even in the near to medium term. These prices make the small petrol generators more attractive to households and MSMEs. However, perennial issues like product scarcity, makes using these generators unreliable as well as expensive.

> ***diesel is widely sold a prices 200% to 300% up from the end of last year.***

With households consuming the largest proportion of energy in Nigeria, increased spending on self-supplied energy has implications on the wider economy. Increased prices in goods and services are fuelled by relying on these expensive sources of electricity, which contributes to inflation, especially since

[17] *World Economic Forum, How much are Nigerians spending on backup power?, https://www.weforum.org/agenda/2015/08/how-much-are-nigerians-spending-on-backup-power/*
[18] *Nigerian Living Standards Survey (2020)*
[19] *Nigerian Living Standards Survey, 2020, NBS*
[20] *'Putting an End to Nigerias Generator Crisis: The Path Forward. 2019. Dahlberg, Access to Energy Institute*
[21] *Nigeria: African Development Bank approves $210 million financing for Transmission Expansion Project. 2019. AfDB*

almost 70% of the lifetime cost of a generator is spent fueling it.

From an environmental perspective, relying on generators is also a step in the wrong direction. Already, 75% of the power generated on the grid is generated using fossil fuels. To worsen this, the capacity of small gasoline generators owned by Nigerians is 8 times larger than the grid's peak capacity.[22]

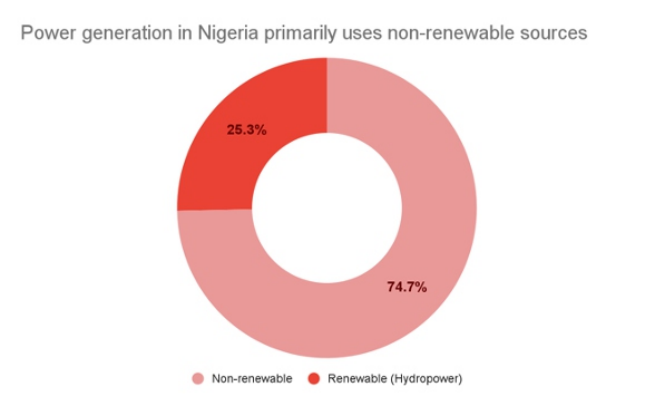


Chart 5: *Source of generated energy (renewable vs non-renewable), Nigeria*

This makes the case for the kind of energy that Nigeria should focus on as it diversifies its energy generation mix. Renewable energy is not only better from a cost perspective for Nigerian households, it is ultimately better for Nigeria in the long run.

On the positive, there is great potential for increasing the share of certain models of renewable energy. Solar power, for instance, currently supplies less than 1% of Nigeria's electricity.

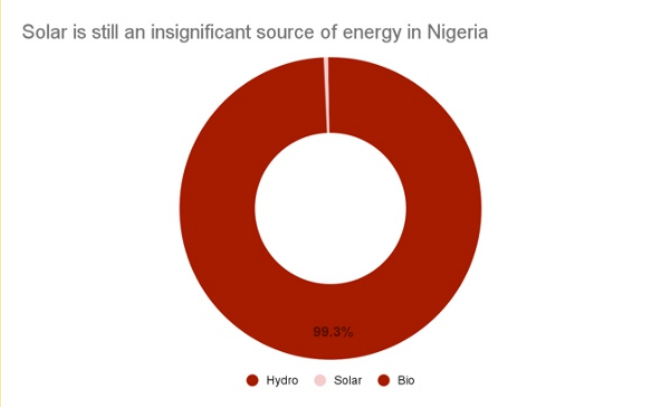


Chart 6: *Sources of Nigeria's renewable energy*[23]

Finally, the fact that other African nations with lower proportions of installed generated capacity coming from renewables, yet Nigeria still has lower electrification rates suggests that adding more sources of energy to be distributed through the grid will not suffice.

This is the primary reason that off-grid renewable solutions should be explored as alternatives for even household users.

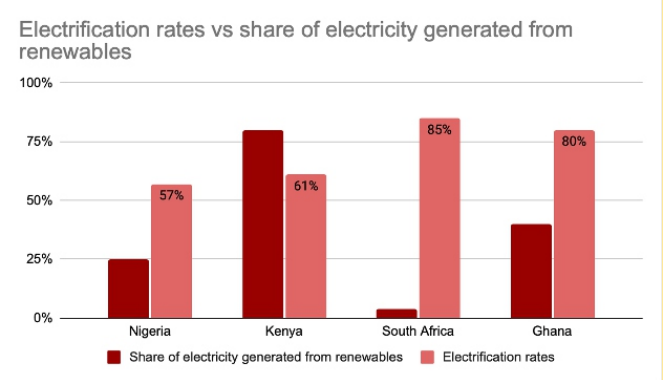


Chart 7: *Electrification rates vs source of energy*[23]

[22] *'Putting an End to Nigerias Generator Crisis: The Path Forward. 2019. Dahlberg, Access to Energy Institute*
[23] *Source: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/Renewable_Energy_Transition_Africa_2021.pdf*

2.2. The Business Level

Nigeria's economy is driven by its MSMEs. They are responsible for 80% of employment and they contribute almost half of the country's GDP (around 49.8%) annually[24]. As the backbone of Nigeria's economy, enabling them without hindrances is key to Nigeria's development. Ensuring businesses have reliable and affordable access to energy can be transformative to the economy.

According to an estimate by the World Bank, Nigerian businesses experience electricity outages 32.8 times per month and in total, 46 days a year. Running a generator to make up for this shortfall comes with significant cost implications. It's been estimated that the average monthly cost of the fuel to run generators to make up the shortfall is triple that of direct grid supply[25]. Consequently, Nigerian households and businesses collectively spend millions of USD per year fuelling their generators annually (between $12-$20 billion per year between 2018 - 2021)[26] [27]
.
In a 2014 World Bank Enterprise Survey, businesses identified that electricity is one of the most significant obstacles to the business environment, second only to access to finance. This has not changed over the years. A 2020 PwC MSME survey found that infrastructure deficit (including electricity) was one of the most pressing problems facing businesses. The availability and cost of electricity can determine whether a business survives or not, especially since 85% of MSMEs had a monthly revenue of less than 100,000 as of 2017[28]. They cannot afford the additional cost outlay of providing their own electricity.
But businesses have little to no choice. Surveyed SMEs received between 1 to 5 hours of electricity each day. It's no wonder that power generation was the biggest cost to businesses in Nigerian companies[29]. An estimated 15% of businesses cease operations due to the pressures of keeping up with these costs.

Apart from the direct cost of self-supply, there are also indirect costs stemming from a loss of productivity. Loss of productive capacity can include the inability to complete or continue work when there is no electricity, or even when the quality and or quantity of work is diminished. produced is hindered.

> ***The availability and cost of electricity can determine whether a business survives or not***

[24] *PwC MSME Survey 2020, https://www.pwc.com/ng/en/assets/pdf/pwc-msme-survey-2020-final.pdf*
[25] *https://qz.com/africa/4745*
[26] */nigerias-electricity-crisis-is-so-bad-people-spend-three-times-more-running-back-up-generators/26 Note: Prices vary annually due to various circumstances such as fuel prices, electricity provided from the grid*
[27] *Sources: A2EI, Dalberg: https://a2ei.org/resources/uploads/2019/06/A2EI_Dalberg_Putting_an_End_to_Nigeria%E2%80%99s_Generator-Crisis_The_Path_Forward.pdf*
[28] *National Survey of Micro, Small, Medium Enterprises (MSMEs) 2017 SMEDAN*
[29] *According to the National Bureau for Statistics (NBS), less than 5% of SMEs are able to access adequate finance for working capital*

2.3. The Economy Level

Nigeria's energy situation is extremely detrimental to its businesses and households. It is no surprise that the wider economy suffers as well. In addition to wide scale productivity losses, there are more direct impacts on the country such as attracting investments and the opportunity cost of funds spent fuel (both at an individual and at a government level)

Attracting investment:

The World Bank's (now discontinued) Ease of Doing Business ranked Nigeria 131st (out of 190 countries) for access to electricity, a measure for how easy it is to run a business in the country. Likewise, on the latest World Economic Forum Global Competitiveness Index (2018), Nigeria is ranked second-to-last out of 137 countries—only ahead of Yemen—for the quality of electricity supply indicator. Generating energy to run a business is inconvenient and expensive, a discouraging prospect for investors looking to build a business in Nigeria. Investors will look to regions with more stability and higher potential profit margins. The high cost of energy must be passed unto the consumers of goods and services. And given that most Nigerians live in extreme poverty—below $2 a day—it is unlikely that many businesses will maximise profits from Nigerian customers.

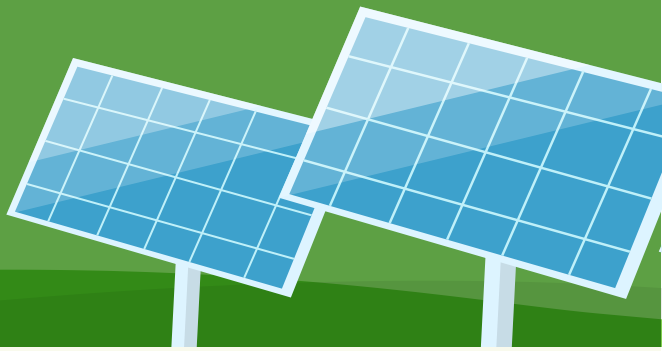
Government spending on fuel:

In the 8 months between February and September 2021, the Nigerian government spent almost 900 billion on petrol subsidies[30], more than the country intends to spend on education, healthcare or social development programs in 2022. Nigerians are highly reliant on cheap fuel for transportation and self-supplying energy, and price shocks will negatively impact most Nigerians. Yet, government spending on subsidies has no doubt diverted spending on more productive areas of the economy, arguably eventually weaning the country of the need for subsidies.

> ***Generating energy to run a business is inconvenient and expensive, a discouraging prospect for investors looking to build a business in Nigeria***

[30] *Leveraging Budget Reforms For Economic Development, 2021, BudgIT*

3 THE CASE FOR SOLAR ENERGY IN NIGERIA



The case has been made. Nigeria cannot afford to generate its electricity using fossil fuel powered generators. Beyond the financial implications, the prevalence of generators causes severe health and environmental damage in Nigeria.

Fossil-fuel generators are associated with significant air and noise pollution, which can cause respiratory illness, death, and more. Data is sparse when it comes to causes of deaths in Nigeria, but the most recent statistics indicate that between 2008 and 2014, 10,000 deaths were caused by generator fumes in Nigeria[31]. A steady stream of news reports on deaths caused by generator fumes suggests that the problem persists even today[32] [33]. Based on the current trajectory, greenhouse gas emissions are expected to rise from 11.9 million tons to 17.1 million by 2030 from generator usage alone, if nothing changes[34].

Renewable energy sources offer a viable alternative that is better for the environment and cheaper in the long run. Under the Paris Agreement, the Federal Government of Nigeria set the ambitious goal to reduce greenhouse gases by 45% by 2030[35]. This provides additional incentive to promote and invest in the spread of clean alternatives, such as solar energy, to help reach these goals.
Although there are a number of renewable energy solutions available, solar energy is the most suitable off-grid solution to explore for Nigeria due to the abundance of the natural resource, the long-term relative affordability, and the modularity of solar energy solutions in providing options for all levels of consumption.

Abundance of the natural resource:
Nigeria's climate is well suited to relying solar energy, receiving an abundance—over 2,600 hours—of sunshine each year, which has the potential to provide between 5.5kWh and 6.7kWh per square metre on a daily basis[36]. The natural resources required for other renewable solutions (hydropower being an exception), are not available in Nigeria's climate for the necessary generation quantities. Other forms of natural resources aren't suited for off-grid usage and require large-scale, expensive projects to work, and are therefore impractical for Nigeria to consider in the short to medium term.

> ***greenhouse gas emissions are expected to rise from 11.9 million tons to 17.1 million by 2030 from generator usage alone***

[31] *Socio-economic case for deepening solar PV deployment in Nigeria, 2021, All-On, BCG*
[32] *https://dailytrust.com/generator-fume-kills-two-in-unizik-private-hostel*
[33] *https://www.premiumtimesng.com/news/more-news/475022-generator-fumes-kill-family-of-four-in-kwara.html*
[34] *Ibid.*
[35] *Ibid.*
[36] *https://www.power-technology.com/features/electrifying-nigeria-could-solar-power-one-million-households/*

Long-term affordability

As the technology used to generate solar advances, the associated costs fall. Solar energy is becoming increasingly cheaper to generate. By some estimates, costs for electricity from utility-scale solar photovoltaics (PV) fell 85% between 2010 and 2020[37]. Between 2011 and 2017, solar PV generation costs for residential and commercial scale had dropped by an average of 72%—from $0.52 to $0.16 and from $0.40 to $0.11 per kWh respectively[38] —these cost reductions were three years ahead of schedule based on targets set by the global solar industry at the start of the decade. Overall, the costs of solar inputs e.g., modules, have fallen by up to 95% since 2009[39].

The flexibility of solar energy solutions also makes it cheaper for consumers. For instance, households can choose to buy solar powered appliances like fans and lamps if they cannot afford to power entire houses.

As the prices of petroleum products rise, solar will also become more affordable relative to fossil fuel powered generators. Energy users that might have been deterred by the perceived high costs of solar solutions, will likely reconsider as diesel prices in Nigeria over double in the span of a few weeks.

Modularity of solar energy solutions

In theory, solar power can power anything, with sufficient modules or components to scale generation. This is one of its biggest benefits. Applications range from single appliances to large-scale industrial uses. This gives the end-users the freedom and flexibility to choose exactly how they can use solar. This means two things—its applications are potentially unlimited, and there is an opportunity to drive solar power generation to a large enough level that companies can achieve economies of scale and make these solutions cheaper and more accessible to the wider population.

The Rural Electrification Agency (REA) estimates the annual market opportunity of $10 billion per year for mini-grids and solar home systems in Nigeria, with the potential to save Nigerians $6 billion a year over current energy costs, including generators[40]. There are opportunities for players of all sizes to contribute to this, as there is a wide spectrum of solutions that can help solve the power crisis.

The flexibility and modularity of solar energy solutions is a huge selling point for solar energy. Solutions lie on a spectrum from individual solar powered items, all the way up to solar farms that can provide energy to the national grid. This means that there are numerous models of solar energy solutions for operators, financiers and users to tap into.

It is important to examine the range of solutions that exist, their functional uses and their suitability for the Nigerian market to assess the models that could be primarily considered to serve Nigeria's needs.

> ***solar will also become more affordable relative to fossil fuel powered generators.***

[37] *Renewable Power Generation Costs in 2020. June 2021. International Renewable Energy Agency*
[38] *New Solar Opportunities for a New Decade. 2017. US Office of Energy Efficiency and Renewable Energy*
[39] *IRENA, Renewable power generation costs in 2020, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf*
[40] *Nigeria Minigrid Investment Brief, 2017, REA*

3.1. Powering individual appliances

Individual solar powered appliances like lamps, fans, refrigerators etc. are typically appliances used in the house that have solar panels mounted on them or separately installed. These are also commonly called “pico-solar” and provide small amounts of electricity to low-use appliances. They are extremely cost efficient, as they power the most critically needed appliances, without having to power the entire home[41]. This provides a low-cost entry point for new users.

Lighting, for instance, can be a huge enabler, especially for rural communities without access to grid electricity. It allows them to remain productive, even at night. These communities would have to rely on ineffective, expensive and potentially dangerous kerosene-powered lamps. Africa Clean Energy Technical Assistance Facility (ACE-TAF) is a programme funded by the UK Foreign,
Commonwealth and Development Office, aiming to catalyse private sector delivery of renewable energy solutions. Research by the organisation found that solar lamps had the highest penetration of usage across urban, peri-urban and rural settings compared to solar panels and home systems[42].

When this data was segmented across customer types, MSMEs were found to have a higher penetration of solar panels in comparison to solar lamps. This is one of the primary disadvantages of these individual appliances. Whilst they're useful when users are only looking to ensure reliable access to key products, they can be limited in their scope. For consumers that prefer or need to have consistent electricity supply for multifunctionality, pico-solar devices do not adequately suit their needs.

Product example

Solar powered appliances like the one below can be found on websites such as Jumia.com and Jiji.com, starting from as low as ₦4,000 (less than $8).

[41] *You can find solar-powered fans on websites such as Jiji.com and Jumia.com starting from around ₦6,000.*
[42] *ACE, Standalone off-grid solar market research, 2021*

3.2. “Small” Solar Home Systems (typically used for off-grid electrification)

Solar home systems (SHS) are a standalone solution that at their most basic level consist of Photovoltaic (PV) modules and a battery system that work together to provide energy to an entire residence or building, and not just individual appliances. This system typically covers low power devices, of less than 100W, meaning that it is most suitable to meet low energy needs. It's typically used for those that aren't connected to the grid and are just getting onto the energy ladder.

Most systems also come with a battery that stores energy for use at nighttime, or in insufficient sunlight. Solar home systems can be modified to meet different consumption levels. Payment models vary. One method is by paying for the home system upfront, after which the purchaser owns the solar system. This can be cost-prohibitive, and so more affordable payment models have emerged in Nigeria. The utility-as-a-service model allows users of the system to pay only for the energy consumed—as tracked by a metre. The user never owns the solar home system. This provides a more affordable option to solar powering entire buildings.

The growth of “**As-A-service**” (AAS) business models for solar home systems in an attempt to tailor the solution to local realities offers a practical way to penetrate Nigeria's low-spending market. Solar applications for MSMEs—the country's economic backbone—holds even greater potential. MSMEs reported a 50% reduced monthly spend on lighting (from N9,406 to N4,738) as well as increased working hours and better yields[43], when they went from having no access to grid supplied electricity to using solar energy solutions. The knock on benefits are also well

Product example

Pawame[44], a Kenyan solar energy startup provides pay-as-you-go solar home systems to underserved customers. They provide a system that includes a number of appliances including, lamp, radio and phone charger. Customers pay a small down payment and installation fee, and subsequently pay on a daily basis via mobile money for continued access. They are paying for the device, so once the repayment period ends, they own the solar home system and after this can enjoy free solar power.

[43] *ACE, Standalone off-grid solar market research, 2021*
[44] *Pawame website, https://pawame.com*

Business models

Increasingly, solar home system providers are providing instalmental payment plans like the pay-as-you-go (PAYG) and AAS models. The PAYG can take various forms however, such as a lease-to-own model, where they are spreading the cost of the devices over months or years to increase affordability and accessibility. In the AAS business model, the solar company owns the devices and the customers pay for the units of electricity that they wish to use.

The main enabler in these business models is the fact that providers offer a form of customer financing where users can begin to benefit from solar solutions with a down payment, significantly lower than the upfront cost, and affordable periodic payments.

This suits the income pattern for the demographics that these solar home systems are now able to target (low income individuals). From a business perspective, this financing solution helps these users avoid the upfront costs which is often a barrier to adoption for this group.

Costs to the consumer

Associated costs[45] may include

- Installation / setup cost, which is a one-time payment cost of around $20.
- Ongoing micro payments, which can cost $0.4 to $0.6 per day.
- Periodic maintenance costs

Penetration in Nigeria

The uptake of solar home systems in Nigeria has risen in recent years. This is in part driven by government efforts to increase energy access

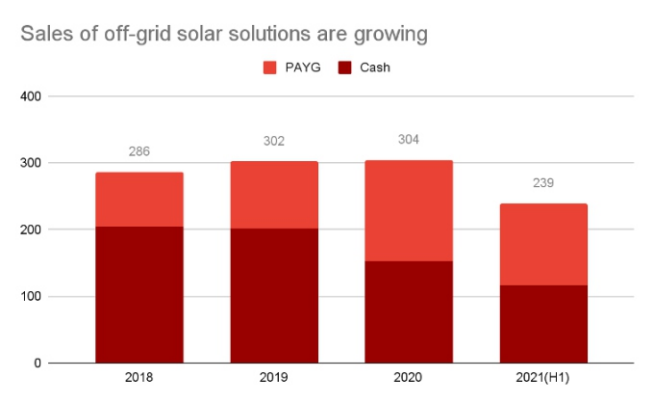


Chart 8: *Sales of off-grid solar products ($), Nigeria (2018-2021)*[46]

through easily distributable, low-cost solutions and also by growing accessibility of the solutions themselves.

The pace of solar off-grid adoption is outpacing the pace of grid extension, which might explain why Nigeria's electrification strategy has moved from grid extension to off-grid enablement.

The Nigerian Sovereign Investment Authority (NSIA)—managers of the country's sovereign wealth fund—created a revolving fund of 10 billion for the off-grid renewable space, in partnership with the REA for developers to manufacture and distribute SHSs and increase energy access to 5 million households across Nigeria.[47]

[45] *Benchmarked across various providers in African markets, e.g. Pawame, BBoxx, M-Kopa solar*
[46] *Global off-grid solar market report, 2021, GOGLA, https://www.gogla.org/global-off-grid-solar-market-report*
[47] *'NSIA & REA Partner On N10bn Fund For Solar Power Naija Programme', Https://Rea.Gov.Ng/Nsia-Rea-Partner-On-N10bn-Fund-For-Solar-Power-Naija-Programme/*

3.3. “Large” solar home systems (typically used as an alternative for homes connected to the grid)

Solar solutions can deliver larger capacities and meet more complex energy needs, powering devices from 500w (including many small household appliances like laptops, small fridges and televisions) to 10kW which powers most heavy duty household items such as air conditioners. It is unlikely to be suitable for industrial or heavy commercial use.

These systems are able to directly compete with generators as generators can power upwards of 1kW with virtually no-upper limit depending on the generating set you buy. However, they also tend to be more expensive, making it unattainable to many Nigerians

Business models

These SHS usually serve businesses and households that would otherwise use generators. This means they target a demographic that is able to afford the cost of generators and the ongoing cost of fuel.

Because of this, many of these providers will follow a retail or over-the-counter business model where customers pay upfront for the inputs needed. This might limit the accessibility of these solutions to the average Nigerian where the cost cannot be spread out to more manageable instalments.

Given the cost of these systems, consumer financing is often not an option. This is based partially on the perception that purchasers of this model can likely afford the upfront cost, as well as the unwillingness of service providers or financiers to bear the default risk.

Costs to the consumer
Associated costs may include

- The installation costs
- The costs of the units (batteries, solar panels, inverter)
- Maintenance costs

Product example

From Sterling Bank's Imperium's platform, a 500w solar generator is listed for ₦357,000, inclusive of installation, the battery and the solar panels.[48]

A solution such as this bundles all of these together and provides the end customer with an affordable alternative to diesel generators. This allows customers access to a solar product that can power the devices they use the most in their households or businesses when they need it.

On the other end of the spectrum in this category, Sterling Bank also lists larger bundles, for instance a 10kVa (roughly 10,000W or 10kW) that can provide power to a household. This is listed for ₦3.3 million including installation.[49]

This illustrates how solar solutions can deliver on a wide range of needs.

[48] *https://shop.imperiumng.com/product/500w-solar-gen-0002?category=bundle*
[49] *https://shop.imperiumng.com/product/tendon-10kva-0001?category=bundle*

3.4. Powering commercial structures / ventures

Nigeria's commercial and industrial (C&I) sector makes up about 8% of Nigeria's electricity consumption, markedly lower than other countries. Although the sector's electricity consumption is comparatively low, “per user” demand is much higher than for households or small businesses.

Green Energy Investment Nigeria—the Nigerian Investment Promotion Commission (NIPC) built investment platform—provides investment information on renewable energy in Nigeria. Data on the platform found that larger commercial sectors such as hotels and shopping malls consumed between 61 kWh and 106,000 kWh monthly. Industrial sectors consumed between 7,900 kWh and 6 GWh on a monthly basis. Energy consumption at this level needs large industrial solutions.[50]

Hybrid solar solutions emerged as the most cost effective way to meet the needs of these segments. These typically consist of a solar PV system (solar panels, inverter), battery storage and a diesel generator for emergency power generation as a back-up to the solar solution.

These solutions are estimated to cost over double the price of grid-generated energy (N21.33 vs. N46.23 per kWh)[51]. However, many businesses find the cost an agreeable trade-off for the ease and reliability of the solution

Business models

There are two primary models used by C&I solar developers in Nigeria, ownership and service models.

I. The ownership model

In the ownership model, the customer purchases the asset from the provider. As is typical in a B2B (business-to-business) sales cycle, this may be done through a procurement service or third party.

The service provider will often work with the business's internal system engineer to tailor-build the solution to the customer's needs. Here, the customer may pay for the entire system up front, through a lease-to-own or a financing model. In contrast with retail customers, it's much easier for large businesses to obtain financing from financial institutions, because there's a lower degree of risk involved with lending to this segment.

ii. Solar-As-A-Service

Under service models, project developers may offer either solar-as-a-service model and power as a service model. Solar-as-a-service involves the project developer delivering solar power on an ongoing basis, with the customer making ongoing payments as they would to distribution companies providing electricity from the grid. Unlike grid supplied energy, the service provider ends up delivering all of the customer's energy needs at a discount compared to a mix of grid and diesel generators.

[50] *Green Energy Investment, Commercial and Industrial Systems Report, https://www.greenenergyinvestment.com.ng/sites/default/files/documents/greenenergyinvestment_ee-commercial-and-industrial_systems.pdf*
[51] *Ibid.*

3.5. Powering a community (through Mini-grids)

According to the REA, there are at least 10 mini-grid operators in Nigeria providing connections to 2,000 households and 250 commercial projects. Together the combined capacity provides 364kW.

However, GIZ estimates that there are as many as 30 solar mini grids with a total installed capacity of 1 MW, serving 6,000 customers. Regardless, there is a low penetration of mini grids in the country. According to the Nigerian Living Standards Survey, only 1.5% of households with electricity is supplied by a mini grid . It's also important to note that mini grids are not always powered by solar, so the actual penetration rate of solar powered mini grids is likely to be lower than 1.5%.

However, there is a concerted effort by mini-grid developers to rapidly expand the number of mini grids across the country. The REA instituted the Nigeria Electrification Project (NEP) with the target of electrifying 300,000 households and 30,000 local enterprises through mini grids[52]. With government support and available funding and apparent demand, it has been reported that 8 developers have expressed intentions to develop over 200 mini grids across the country[53]

What are mini-grids?

Mini-grids are systems powered by energy that involve small-scale electricity generation—of up to 10MW—to serve a limited number of consumers through a distribution grid, operating independently from the national grid. Consumers may also be connected to the transmission grid.

One of the main advantages of mini grids is that they allow customers to increase their electricity consumption without having to invest in the additional capacity themselves. Customers enjoy the advantages of sharing the infrastructure cost with a large group, often within a small area.

Mini-grids resemble the electricity supply value chain (from generation to distribution), while being self contained. Like the national electricity value chain, power can be generated from various sources, including solar.

Business models

Mini-grids can be developed and operated by the state, private companies, communities, or a mix of different stakeholders. The key difference with previous models is that the cost and adoption of power from mini-grids is generally for a group of residences or businesses, not individual ones.

Many commercial mini grids use owner-operator business models that are funded through a mix of debt, equity and grant funding. Consumers access electricity the same way they would from the grid, usually paying usage tariffs to the operator. These tariffs could be a fixed fee and / or a consumption based fee (utility-as-a-

However, there is a concerted effort by mini-grid developers to rapidly expand the number of mini grids across the country.

[52] *Nigerian Living Standards Survey 2020*
[53] *ASALAW LP, https://asalawpractice.org/fg-signs-e9-3m-agreement-with-eight-indigenous-solar-developers-for-23-mini-grids/?utm_source=rss&utm_medium=rss&utm_campaign=fg-signs-e9-3m-agreement-with-eight-indigenous-solar-developers-for-23-mini-grids*

service). Because this solution is not government driven, tariffs are cost-reflective so that owners and operators can recover capital and operational costs.

Costs

For the developers of these mini grids, project financing is typically from governments, private financiers or non-governmental organisations (NGOs). These costs will include the initial build of the grid, switching costs and operational and maintenance costs. Capital expenditure estimated by the Rocky Mountain Institute ranged from 30 million to 300,000 to 100 million (~ $90,000 to $300,000), with annual operating expenditure ranging from 2.4 million (~ $900 to $6,900).[54]

For the consumer or end user, the primary cost will be the cost of the energy units that they use. Cost-reflective mini grid tariffs were close to 200 per kWh in 2018[55], over 4 times current electricity tariffs. However, cost reductions were forecast as operating, capital and financing costs also fell, resulting in a 60% decrease to 70/kWh[56].

Running a generator however, could cost over N300/kWh, meaning that there could be a significant cost savings for end consumer at most price points

> ***One of the main advantages of mini grids is that they allow customers to increase their electricity consumption without having to invest in the additional capacity themselves.***

[54] *Rocky Mountain Institute (RMI), Nigeria Minigrid Investment Report: https://rmi.org/wp-content/uploads/2018/08/RMI_Nigeria_Minigrid_Investment_Report_2018.pdf*
[55] *Rocky Mountain Institute (RMI), Nigeria Minigrid Investment Report: https://rmi.org/wp-content/uploads/2018/08/RMI_Nigeria_Minigrid_Investment_Report_2018.pdf*
[56] *Ibid.*

3.6. Powering a nation

This model of solar power involves photovoltaic power stations or solar farms being used to generate electricity on a large scale and integrated into the grid supply, to provide energy to the nation. This model is used in more advanced nations with stable grid capacity, such as Japan, using abandoned golf courses as solar farms. This has led to them adding 7GW of installed capacity from solar in 2019.

Recently, they're going even further to create floating solar islands on water to further create additional capacity and utilise space.
Because this is a solution aimed at increasing generated electricity to the grid, it requires significant grid development in order to transmit generated energy across the country, this is not a model that's feasible for Nigeria to adopt in the near-term.

Takeaways

One of the key benefits of solar, outside of the cost benefits, when compared to the primary alternative in Nigeria; generators, is its flexibility and modularity - giving a multitude of options for adoption. The flexibility of solar also means that it can cater to a number of different markets and solve a number of different electrification issues.

Our findings suggest that the models most suited for household and small business use are larger solar home systems and the development of mini-grids for communities.

A blended approach is most likely in the near-medium term as consumer acceptance and tested performance of solar products increase (i.e. some consumers may feel comfortable retaining a generator for emergency use). One ACE-TAF survey found that a third of solar product users also used a generator. Consumers may also opt to incorporate a number of the different solar models, i.e. an SHS and individual solar appliances.

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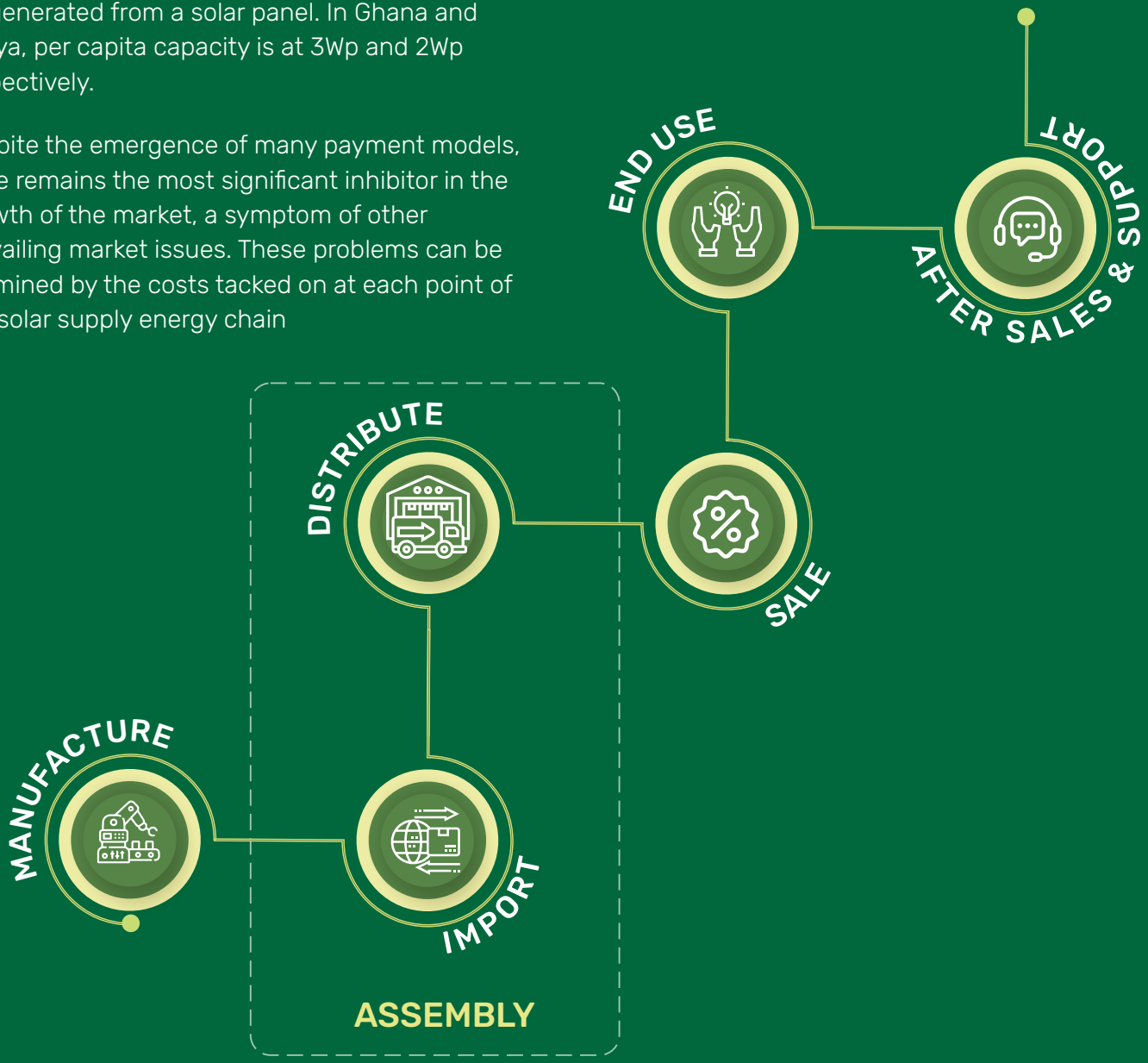
4 LIMITATIONS TO SOLAR ADOPTION IN NIGERIA

Although innovations, falling prices, and increasingly unattractive electricity alternatives have driven the adoption of solar in Nigeria, the country still has a long way to go. Per capita, solar capacity remains at 1Wp (watts peak)—the maximum power that can be generated from a solar panel. In Ghana and Kenya, per capita capacity is at 3Wp and 2Wp respectively.

Despite the emergence of many payment models, price remains the most significant inhibitor in the growth of the market, a symptom of other prevailing market issues. These problems can be examined by the costs tacked on at each point of the solar supply energy chain



4.1. Manufacturing and Assembly

The vast majority of solar products sold in Nigeria are manufactured and assembled abroad, with very little local value-add. Only a few players participate in this part of the value chain locally. Auxano Solar and Blue Camel are the two major players that assemble in Nigeria.

The solar off-grid market is highly dependent on imports, with much of the inputs for the solar components coming from China[57]. This means the products are subject to several issues such as import tariffs, foreign currency restrictions and quality control issues. Not only does this translate to higher prices—about 40% of the retail price is from the cost to import—it also makes it difficult for service providers to guarantee a consistently high quality product offering at competitive prices. Nigerians, who could need these low-cost solar solutions, are missing out on cost benefits due to advances in solar technologies across the world.

One alternative to importing solar products would be to buy locally. This means that these products would need to be produced locally. Apart from the financing required to build manufacturing facilities, there's a technical and skills gap that exists in Nigeria that makes this difficult to achieve. For example, ACE found that only 21% of solar technicians have any sort of formal training and are often self taught leading to reports of challenges with installation and repair.

There have been recent efforts to increase local training and production capacity. For instance, Blue Camel has a training academy and solar assembly plant based in Kaduna that trains technical personnel, entrepreneurs, and developers. This training academy is necessary to increase the pool of skilled professionals at all points across the value chain.

In 2020, AllOn, the impact investment arm of Shell, invested $1.5 million in Auxano Solar to scale its operations over the next 5 years[58]. The investment will increase Auxano's assembly capacity by over 50% and increase the amount of locally produced inputs in the Nigerian solar market, ultimately reducing the cost to the consumer.

Despite these efforts, there is little hope for manufacturing solar system components locally at the scale needed, in the medium term. There is however an opportunity to localise assembly where possible. This has the dual impact of reducing importation costs and create up to 250,000 jobs in the energy sector[59].

The impact of import tariffs

Research on the impact on import tariffs shows that instating high tariffs has adverse impacts to the industry. For example, in 2018, the US imposed import tariffs on solar panels in a bid to boost domestic manufacturing. Instead, this led to an increase in the cost of solar and the loss of over 20,000 jobs in the industry, slowing the trajectory of adoption down by over 10%.

Maintaining import tariffs—even if just in practice—is contradictory to policies aimed at stimulating the renewable energy sector e.g. the 2015 National Renewable Energy and Energy Efficiency Policy and the 2017 National Renewable Energy Action Plans. Currently, the CET Tariff list taxes most solar inputs (except for batteries) at

[57] *'How China's Solar Industry Is Set Up To Be The New Green OPEC', 2021, Forbes, https://www.forbes.com/sites/kenrapoza/2021/03/14/how-chinas-solar-industry-is-set-up-to-be-the-new-green-opec/?sh=66dfa9061446*
[58] *AllOn,https://www.all-on.com/media/media-releases/all-on-and-auxano-solar-nigeria-sign-dollar-1-point-5m-investment-deal-for-solar-panel-assembly-plant-expansion.html*
[59] *'Achieving Economies of Scale in the Nigerian Solar Value Chain', 2021, SEForAll*

the lowest applicable rate or at a zero rate[60]. However, there are reports of customs relying on technicalities to collect import duties on certain types of panels[61]. This directly contradicts the intention and objective of providing fiscal incentives to these inputs. In addition, batteries used for energy storage, which most consider a critical component of the solar systems, are still subject to import duties of between 20 and 25 percent and VAT.

Further to this, there are informal taxes and levies that importers often have to pay to 'settle' the authorities and clear the goods quickly, with some developers reporting they often have to pay an extra 1-2% of the cost of the goods.[62]

Addressing legally and illegally collected taxes and levies at the port will be helpful progress in reducing the prices of these products, especially since the country will realistically still rely on importing solar inputs in the near to medium term. Even investors have noted that sales and penetration have declined since the imposition of these tariffs. [63]

4.2. Distribution and Marketing

Nigeria's legacy logistics and transportation challenges makes distribution—to the rural and geographically dispersed areas that really need solar solutions—difficult and expensive. The associated costs of inefficient distribution are passed onto the final consumer, making the solar solutions even more expensive and unaffordable to many Nigerians.

For this reason, providers have reported a preference for selling within cities and urban regions. The impact is that the areas of the country that could benefit the most from off-grid solar solutions might be excluded.

4.3. Sale and End Use

At this stage, providers of solar solutions face two distinct problems that directly impact adoption of solar solutions: convincing Nigerian customers that these solutions are ultimately, and easy to manage.

With a monthly minimum wage of $72, and an average 60% of income spent on food[64], the vast majority of Nigerians cannot afford the upfront costs of a solar home system to provide energy to their homes. This is why the PAYG and AAS models have been so revolutionary to the sector. However, when faced with investing in an alternative energy solution, most individuals will perceive the 200,000 petrol generator as much cheaper than a solar solution providing similar levels of energy for an initial price of 1.5 million, despite the generator ultimately costing more in the long run.[65]

The upfront cost of a generator is only 16% of its lifetime costs to the user, meaning that a 200,000 generator will actually cost close to 1.3 million during its lifetime. Running a generator also leaves the customer vulnerable to fuel price hikes and unreliable availability. Finally, solar systems are more durable in the long run, with most components lasting over 5 to 10 years.

Because solar usage is not widespread in Nigeria, customers must be educated on the financial benefits of switching to increase adoption.

[60] *Nigerian CET Tariff List. Accessed and downloaded March 2022*
[61] *Solar energy is about to get even more expensive in Nigeria. 2018. Techpoint Africa*
[62] *Bloomberg NEF, ResponsAbility report*
[63] *Policy research on the imposition of 10% tariff duties on solar components making a way for solar in Nigeria, https://ng.boell.org/sites/default/files/uploads/2019/07/final_35_page_-_policy_research_on_the_10_duties_on_solar.pdf.pdf*
[64] *Nigerian Expenditure and Consumption Patterns 2019, NBS*
[65] *A2E(Access to energy), Dalberg , Solving Nigeria's Generator Crisis*

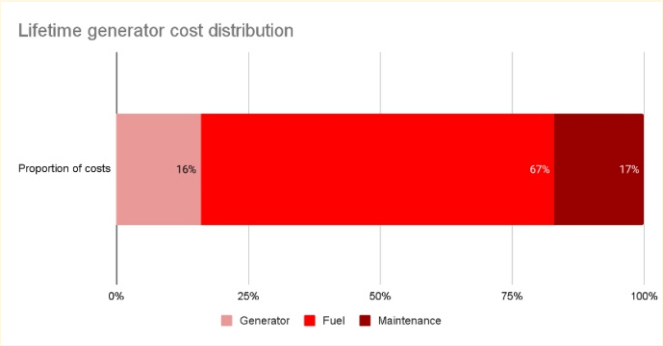


Chart 9: *Lifetime generator cost distribution*

Sterling Bank's Imperium Platform

One way to tackle this problem is to ensure that there are a range of purchase options available for consumers. Solar energy solutions are not one-size-fits-all, so purchasing options needn't be either. Sterling Bank employs a number of various purchase models to provide renewable energy solutions for their customers.

This ensures that customers with different needs and purchase abilities are able to access solar energy solutions. The options are as follows:

- Outright purchase: Energy consumers can purchase products directly from vendors via a dedicated e-commerce platform hosted by the Bank, known as Imperium.
- Lease to own: Imperium provides financing at competitive interest rates for consumers (with good credit scores and/or clean credit checks) who are keen to own the assets.
- Power-as-a-service: Imperium offers fixed monthly energy-charge options to consumers. The underlying assets are owned by Imperium.
- Imperium purchases and owns the assets, saving its clients the huge capital outlay and maintenance worries.
- The monthly energy charge is based on the capacity of the solution deployed.

Customers also need to be adequately educated so that they know how exactly their solar systems should work. For instance, one stakeholder noted that part of the problem with maintained adoption is that people don't understand how their systems work.

For example, thinking they have a power as a service model (i.e. paying for energy credit with usage) when the system they have is closer to a hire-purchase (i.e. payments are made regardless of use). This creates friction in the exchange and can be the tipping point that pushes customers back to familiar energy alternatives.

4.4. After Sales Support

Nigeria does not have a large pool of skilled technicians to provide maintenance or repair services after solar systems have been installed. This gap in the market introduces a level of uncertainty for potential customers, and may act as a disincentive for switching to solar. High quality after sales care can be expensive, when only a small group is able to provide these services. This adds another layer of costs that Nigerians are very sensitive to.

4.5. Financing

Energy is a capital-intensive industry that requires investment into equipment, manufacturing, distribution and financing; depending on the business model. This makes the ability to access sufficient and adequate funding a make-or-break factor for providers of solar solutions in Nigeria.

There is a gap in the amount of funding needed in the solar PV market. The ACE-TAF estimates that between 2015-2020, $227 million of capital has flown into the sector in Nigeria. However, there's an estimated investment need of $1.5 billion. With roughly 20% of the needed capital is available, many companies are struggling to access the much-needed financing to support scaling.

Multiple operators and other stakeholders in the rural off-grid solar space highlighted available funding up to $1.4 billion from government bodies, DFIs, and commercial banks in the country. However, if available funding cannot be accessed by those who need it, there is still a significant issue.

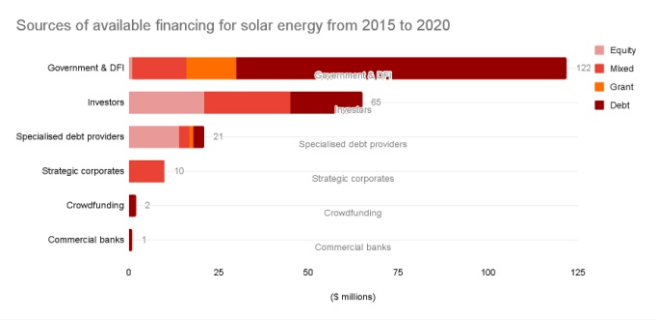


Chart 10: *Sources of available financing for solar energy (2015-2020)*[66]

> ***The ACE-TAF estimates that between 2015-2020, $227 million of capital has flown into the sector in Nigeria.***

In Nigeria, funding appears to be skewed to international solar providers, with research by ACE-TAF finding that 93% of the funding disbursed goes to international companies. This further reduces the chances for local providers, who already face severe competition on the manufacturing front.

The type of funding also matters. Solar solutions providers need patient capital, with long-term investment horizons, so that these companies can innovate, scale and invest in making the solutions affordable to a wider market.

This suggests that DFI, impact or even government financing is most appropriate for these companies, as they are better set up for long term, impact driven investments. For larger scale projects, manufacturing, commercial funding might also be suitable because this is more familiar to commercial lenders. However, the expected returns timeframe is still an issue.

One of the main things that prevents the cost of solar from being more cost competitive is the way that solar companies can access financing. The major issue with financing is the absence of favourable local financing. This means that companies need to seek external financing raised in foreign currency, mainly via debt financing.

[66] *Socio-economic case for deepening solar PV deployment in Nigeria, 2021, All-On, BCG*

For local companies with loans denominated in USD ($), for instance, but price their services in Naira ( ), this represents a foreign exchange risk, especially given recent currency exchange volatility. Currency devaluation has meant that they will often have to mitigate this by charging higher and higher prices.

The role of local financiers

All On estimates that only $1 million of the estimated $227 million of financing to the solar PV market was through commercial banks[67]. Although it's not necessarily abnormal for commercial banks to find these ventures risky, even in more developed markets like Kenya[68], there is a role for local banks to play to help develop the market.

Local banks have historically been largely absent from financing in the solar market, and where they do participate, this form of financing is often too expensive (i.e. offering over 25% interest for two-year loan tenors)[69]. Additionally, much of the local financing available requires operators to provide physical assets like land and real estate as a collateral. There are a few reasons for this.

First, there is no adequate credit-rating and reporting system in Nigeria, meaning that creditors often must navigate a lot of information asymmetry, and because of this, they are left in the position where they must hedge this risk to the best of their ability. Therefore, loan terms are so harsh. Secondly, the solar market is fragmented, with many small players, which means that many of these companies don't have enough scale to attract / command favourable terms.

Secondly, renewable energy is still a relatively new and growing industry worldwide. This introduces an information gap that needs to be bridged, especially amongst financiers. Financiers are not aware of what to expect from these business models, amplifying the perceived risk. The information gap amongst consumers also means that wide scale adoption can take many years and could indicate to investors that returns will be slower than even a mature or proven market. This also heightens the hesitation to invest.

Solar providers then have to find investors who combine a higher risk appetite, general understanding of the market, patient capital and/or goals that are beyond purely commercial or profit-making. In the solar PV market, this typically points to DFIs or governmental agencies.
Some local commercial banks are beginning to change this.

Sterling Bank renewable energy investments

Sterling Bank is a local financier dedicated to advancing renewable energy in Nigeria. They contribute as a local financier in a number of ways. So far, they have invested 10 billion into the sector.

One of these is through partnering with government agencies, such as the REA on the Energising Economies Initiative. This aims to support the rapid deployment of off-grid electricity solutions to MSME's in economic clusters (e.g. markets, industrial/agricultural clusters). The impact of this will be to connect

[67] *Ibid.*
[68] *Strathmore University Energy Research Center, Local value capture from the energy transition: insights from the Solar PV industry in Kenya. See: https://unepdtu.org/wp-content/uploads/2021/06/local-value-capture-from-the-energy-transition-insights-from-the-solar-pv-industry-in-kenya.pdf*
[69] *Bloomberg NEF, ResponsAbility Report*
[70] *Sunref Financial Criteria, https://www.sunrefnigeria.org/financial-criteria*

over 100,000 of these establishments to electricity, create 2,500 jobs and reduce carbon emissions by 25,000 metric tonnes annually.

Another is through direct investments into innovative solar companies, such as Zola Electric and OneWatt Solar. These companies are providing affordable, flexible solutions to allow consumers of all energy needs to benefit. Investing in these types of solutions helps to ensure the accessibility of viable solutions across the Nigerian market.

Other banks are also beginning to provide funding to developers in another way—through on-lending via facilities provided by development partners. Sunref (Sustainable Use of Natural Resources and Energy Finance) provides the funding to some Nigerian banks.

Sunref is a $70 million fund seeded by the French Development Agency (AFD) to back renewable energy projects. The AFD works with local banks to disburse this funding, which can be denominated in the local currency with a capped interest rate[70]. Although this initiative is relatively new (announced in October 2021), it is progress in providing local operators more financing options.

We can anticipate the type of impact this will have on Nigeria's renewable energy sector by looking at how Sunref's financing model has supported this sector in other regions. Sunref has been an active venture involved in the East African solar markets since 2011. They have disbursed over €120 million (~ $135 million) to successfully finance 11 projects across East Africa, with the result of reducing dependence on external suppliers, reducing the cost of financing, and increasing the energy mix of renewables. In Kenya, 23 MW of renewable energy capacity has been installed.[71]

The role of DFIs and Government financiers

Financing plays a role in enabling operators to reduce the costs of the products they offer to customers while remaining viable. The vast majority of Nigeria's solar PV investment originates from DFIs and governments, such as the CBN, World Bank, Africa Development Bank and Sunref. As highlighted earlier, industry stakeholders affirmed the availability of funding worth over $1 billion from these sources—and these also tend to have longer loan tenures and lower interest rates than commercial sources, making them a more ideal source of financing for operators. However, there are barriers that have prevented solar providers and operators from accessing funds.

For example, the Nigeria Electrification Fund has only disbursed $2 million of the $500 million earmarked for this purpose, most of which has gone to international beneficiaries. The government financiers might not be all to blame. Local providers, which tend to be smaller, may not understand how to apply and may not meet certain eligibility criteria, such as a minimum sales number.[72] Financiers themselves must tailor eligibility criteria to reflect realities of local companies so that they can access financing.

[71] *Sunref East Africa, https://www.sunref.org/en/projet/promoting-investments-in-renewable-energy-and-energy-efficiency-in-east-africa/*
[72] *NEP Fund Eligibility Criteria, https://nep.rea.gov.ng/how-to-apply-to-nep-programmes/#shs*

5 ENABLING NIGERIA'S SOLAR ENERGY MARKET

Interventions to this sector can directly address the barriers preventing wide scale adoption of solar in Nigeria. There are also broader regulatory changes that would contribute to a more enabling environment for these businesses.

Intervention	Impact	Examples of Interventions
Localisation of the value chain	Reduced cost Local capacity building	Make in India Blue Camel Auxano Solar
Consistency of policy and implementation	Better business environment Access to investors	Kenya solar duties
Ecosystem engagement (operators and regulators)	Better business environment	India country case study
Consumer education	Increased visibility	Blue Camel Sterling Bank
Access to affordable financing	Reduced cost	Sterling Bank Bank of Industry

5.1. Localisation of the value chain

Localising key components of the solar value chain, specifically at manufacturing and assembly stage is a high impact activity that will have far reaching effects across the industry. It benefits both operators and consumers as it reduces the reliance on imports and cuts out a significant amount of the costs.

SEForAll modelled a number of scenarios where key components are manufactured and/ or assembled in Nigeria to assess the impact on the local market and identified a combination of factors with significant impact on the price and households' abilities to afford these systems.[73]

Import tariff waiver	Product subsidy	Cost of debt reduction	Increase local plant capacity
Remove the import waiver on all solar components	20% product cost subsidy	Reduce the cost of debt to 5%	Increase capacity from 20MW to 100MW
Product price of SHS decreases by 9%implementation	Product price of SHS decreases by 17%	Product price of SHS decreases by 1%	Product price of SHS decreases by 9%
A combination of all four of these interventions compound to reduce to price of SHS by 34%			

Apart from the cost, localising the value chain also has the impact of building a capable, productive workforce and creating jobs. SEForAll research also found that increasing the local capacity for upstream assembly and manufacturing could have the impact of creating 250,000 jobs in the energy sector.

Locally, Blue Camel's training academy is looking to train and upskill thousands of young people in all aspects of the solar value chain as well as supporting industries, such as marketing and distribution, plumbing, painting, recycling and so on to completely restructure Nigeria's alternative energy industry.[74] To incentivise this, some countries with growing renewable energy markets have attached local-content of requirements to renewable energy subsidies.

Case study: Make In India, increasing local production[75]

India's 'Make in India' campaign targeted incentives towards the development of local players and increasing domestic manufacturing capacity. The campaign required 70% domestic

[73]
[74] *https://techpoint.africa/2018/06/11/blue-camel-renewable-energy-plant-academy-kaduna/*
[75] *https://www.sciencedirect.com/science/article/pii/S2211467X2030122X*

content for off-grid PV inputs. The Indian National Solar Mission initiative aims to secure 20GW of grid-connected solar power in India by the end of 2022.

This is a bid to increase domestic capacity as part of government reforms to increase reliance on renewable energy, specifically wind and solar PV. These reforms have now led to India being reported as the most cost-efficient market for solar globally, at $60 to $65 per MWh on average.[76]

Case Study: Auxano Solar

In Nigeria, there is an attempt to build local assembly and manufacturing capacity, by 2 local companies—Auxano Solar and Blue Camel. In 2020, Auxano Solar received a $1.5 million investment from AllOn, to expand the assembly capacity by over 50%. This provides security for the operator for inputs and managing operations.

Importers of solar inputs can wait 3-6 months to receive their products after ordering, and purchase in foreign currency, making the products vulnerable to sudden price hikes and long delays. By producing locally, Auxano is solving both of these problems by offering the same equality of solar panels available to purchase in Naira ( ).

Furthermore, a wide scale project as this acts as proof of concept that manufacturing solar products in Nigeria can become viable, profitable and impactful. This also has the wider impact of increasing the pool of knowledgeable professionals in Nigeria's solar energy sector and impact job creation in the long-run.

One of the constraints in Nigeria's renewable energy industry is a disconnect between government intentions and implementations of these plans. There have been clear intentions to develop the renewable energy industry in policy. This often does not match the experiences of solar providers in reality. A key example is that of the import tariffs. Another is the inaccessibility of government loans (like the REA's $550 million facility) already earmarked for this sector, over 3 years since the fund was established.

Whilst there has been commentary from the government that this move is to encourage local manufacturing, the reality is that the renewable energy industry in Nigeria is in its infant stages. Before Nigeria can create a robust, self-supported energy industry, it needs more investment. Without this, businesses cannot prove their models or attract further investors.

Case study: Kenyan solar energy duties removal

East African—and Kenya, in particular—has seen impressive levels of solar adoption. One key intervention was the provision of tax incentives on renewable technologies. For example, the East African Community has import duty and VAT exemptions on solar products. This contributes to driving down the cost to the end user and ensuring that investments in solar technologies and companies are used as efficiently and as productively as possible, i.e. investments are spent on technology and not taxes and duties in the developing area.

These exemptions have led to increased adoption and affordability of pic-solar products. These interventions, as well as a thriving mobile money landscape—that makes PAYG business

[76] *https://www.livemint.com/*

models viable—has led to Kenya becoming one of the fastest growing off-grid energy markets in Africa. Kenya has also become an increasingly attractive destination for funding, with M-Kopa Solar raising the $80 million—the largest debt finance raised by a solar company primarily offering a PAYG model.

5.2 Ecosystem engagement and business support

The Nigerian government can do more to eliminate the inconsistencies between stated policy objectives and practical implementation.[77]

There have been various interventions to increase the penetration of solar energy solutions and provide renewable energy access. Because the power sector is quite heavily regulated, much of this has come in the form of government policy.

It's important to note that the existence of policy is one step, and so far Nigeria has made progress on this. On the other hand, implementation and execution is another issue. It's necessary that for these policies to have an impact, that the relevant stakeholders can rely on these policies to access the funds or support that they need.

Intervention	Relevant provisions	Implications
National Energy Efficiency Action Plan	Sets out the implementation strategy for the NREEEP, including development of financing schemes to cover the upfront cost of on-grid and off-grid lighting products, bulk procurement of on-grid and off-grid lighting products (through reduced import duties).	Reducing the barrier to access off-grid products through better financing options and cheaper import costs.
National Renewable Energy Action Plan (NREAP)	This action plan includes provisions for exemptions in renewable energy equipment such as provision of fiscal incentives, subsidies to alleviate upfront costs and tax and duty exemptions for prospective investors. Secondly, the provision of a duty-free incentive to exporters of energy saving equipment and incentives for importers.	Reducing the burden of import levies, making it cheaper for importers, and consequently for their customers.
NEP Solar Hybrid Mini Grids[78]	One of the projects deployed by the REA is the NEP. The REA secures a $350 million loan from the World Bank to support this project. The aim of this is to provide financial incentives to facilitate the growth of the Nigerian off-grid market. This comes in the form of market data, grant funding and technical assistance.	Increased / eased access to finance for developers, meaning increased and potentially faster implementation of mini-grid products.

[77] *https://techpoint.africa/2018/07/18/ceo-blue-camel-energy-on-nigerian-renewable-energy-ecosystem-challenges/*
[78] *REA, Nigeria Electrification Project (NEP) Solar Hybrid Mini Grids Component: https://rea.gov.ng/minigrids/*

Intervention	Relevant provisions	Implications
	Of this $350 million, $150 million has been set aside for grant funding to support the electrification of 300,000 households and 30,000 enterprises by 2023.	
Solar Power Project Naija	This initiative is a part of the Federal Government of Nigeria's Economic Sustainability plan to help the economy rebound from the effects of the covid-19 pandemic. This project aims to achieve the rollout of 5 million new solar-based communities that aren't grid connected.	Increase the adoption of solar products amongst non-connected communities, increasing the pool of addressable consumers for operators.
Bank Of Industry (BOI) Solar Energy Fund[79]	The Bank of Industry has a clean energy fund worth 6 billion. The fund allows developers and end-users (homes and businesses) to secure a loan of up to 350 million per customer to acquire reliable solar solutions. The fund is disbursed through several depositary monetary banks and microfinance banks for individuals (micro-users) to get access to this funding. This fund has an interest rate of 9% per annum, which is significantly lower than the double-digit interest rates that local commercial banks typically offer.	Eased access to low-cost financing for operators.

This challenge is not unique to the solar industry as other nascent industries such as the innovation ecosystem have also called for greater collaboration between the government and industry stakeholders.

This is important for any growing industry, as government engagement to support growth and provide the tools for these industries to thrive seamlessly. When there isn't government collaboration this can lead to mismatch between the type of policies and interventions that are developed and the immediate and long-term needs.

Operators and stakeholders within the industry are best placed to advise the government on what the industry needs and the government is best-placed to protect consumers, support the industry's growth and encourage investments.

Case study: Government intervention has been a major factor in India's renewable energy boom[80]

[79] *Bank of Industry Solar Energy Fund, https://www.boi.ng/solar-energy/*
[80] *https://www.weforum.org/agenda/2020/01/india-new-hotspot-renewable-energy-investors/*

India has seen major growth in their renewable energy segments, specifically wind and solar power in the last decade. This has been in no small-part due the government's visible and intentional efforts to develop these sectors. The country's total share of new power additions grew 80% year-on-year by early 2022, with solar making up 93% of these additions.[81]

In order to support the industry, the government stabilised policy in the industry and offered fiscal incentives to operators. These efforts contributed to improving the viability of the Indian solar industry. Since 2014, the industry has attracted over $42 billion local and foreign investments, with FDI growing by 20% within a 2018 to 2019 period.

5.3. Consumer awareness and education

As many stakeholders have noted, customer awareness is critical to increased adoption of solar solutions, and customer education is critical to longevity. Consumer awareness and education can be tackled in several ways.

Case Study: Sterling Bank - Creating Visibility and Awareness

Sterling Bank is working to expand the narrative around renewable energy by providing accessible financing, developing projects in partnership with government stakeholders and educating Nigerian customers on the benefits of solar adoption. The Bank's Imperium Solar Platform is key to its plans to drive awareness.
Information asymmetry, and market fragmentation means that consumers are unaware of the options available to them and even the quality and standards of the products of the market. On the other hand, it's also difficult for these solar companies to reach their target audience. This is what the Imperium platform is aiming to solve. It is an online platform that connects a highly-vetted selection of solar operators to consumers. On the Imperium platform, customers are able to see a full selection of products available and how they are tailored to their needs.

The platform includes an energy calculator that allows customers to enter their electricity needs and suggests the most appropriate system to them, and the estimated cost savings over time. This takes all of the guesswork and confusion out of trying to find a solution, and can help to increase the conversion rate for partner-operators.

Case Study: Blue Camel - Educating young people about the benefits of solar

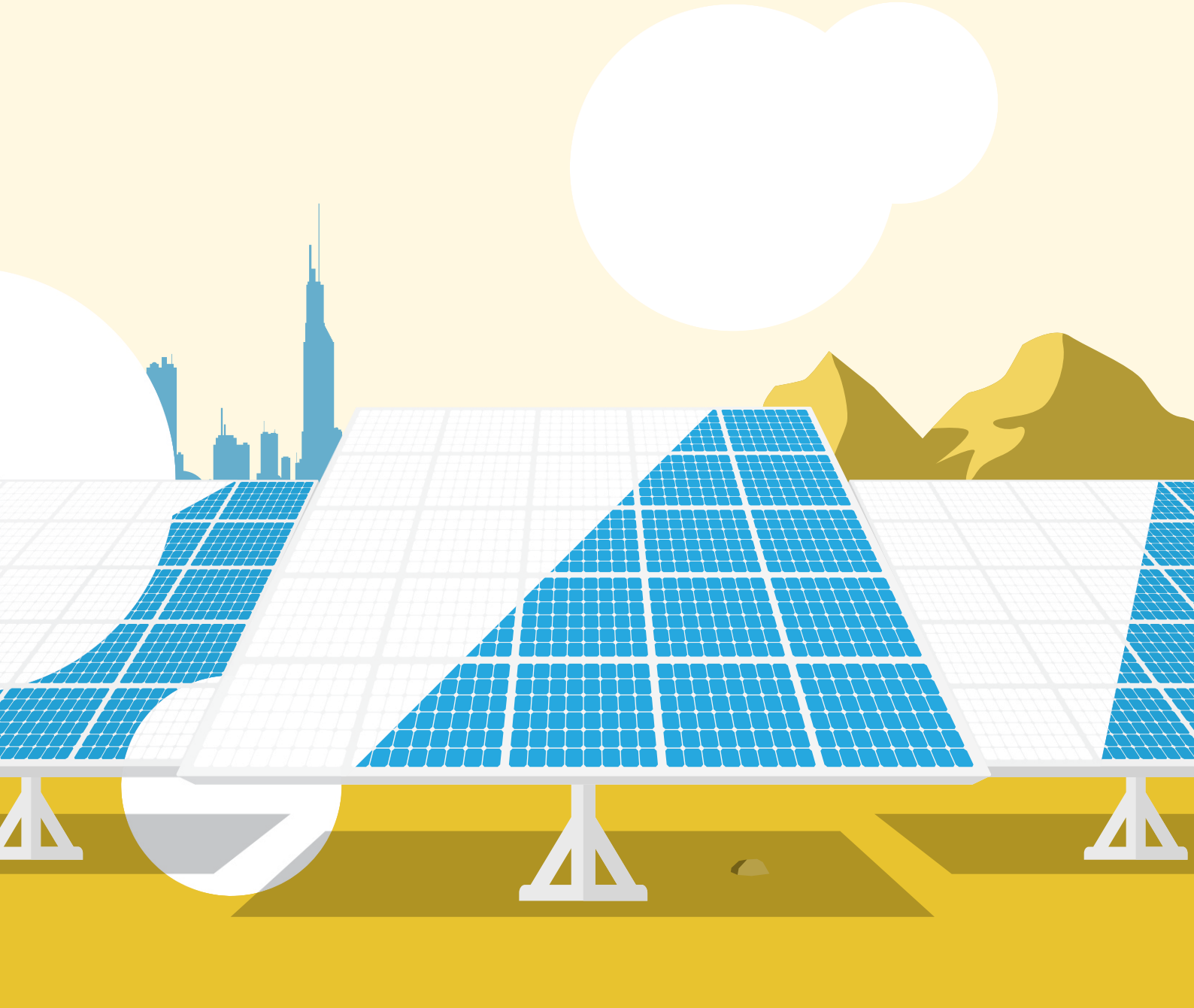
Blue Camel's training academy is also working to sensitise local communities on the benefits of solar energy. The organisation is engaging schools in Kaduna and Abuja, hosting workshops, and collaborating with associations to ensure that people at all levels of the community are more familiar with the concept of solar energy.

This means that when solar energy solutions are deployed, these communities will be more likely to accept and use them correctly, supporting wide-spread penetration. This type of community engagement can be replicated by both public and private stakeholders across the country to gain traction.

[81] *New Renewable Energy Capacity Addition Increased by ~80% During Q3 FY2022: CEEW-CEF (2022) Council On Energy, Environment And Water*

5.4. Low-cost financing

The availability of low-cost financing is crucial for the growth of the renewable energy industry. Whilst there are a number of sources of financing available, it is necessary to ensure that they are actually accessible, and affordable by the time they reach the operator. One example cited by a stakeholder is the Bank of Industry Fund—a source of low-cost capital available, disbursed through a financial services provider. Charges added on by the disburser raises the cost of capital to a level comparable to accessing debt capital directly from a commercial bank.



CONCLUSION

Nigeria's solar energy sector is promising, especially as recent events have forced Nigerians to see the unsustainability of relying on fossil fuel powered generators. However, there are important issues that are constraining the growth of the sector in Nigeria. These issues can contribute to making the end-solutions expensive and inaccessible to the majority of Nigerians.

Much investment and intervention is needed from stakeholders to take advantage of this $10 billion market opportunity, that also has the impact of building a more resilient economy for Nigeria. These interventions range from providing appropriate financing for the business models and target market, policy support and consumer education to ensure individuals are making the most informed choices.

Both the public and private sectors have incredibly important roles to play here, and the public sector needs to provide an adequate business environment for those operating within it to support the industry. This is key, as many private sector stakeholders are working to diminish the barriers, but their impact can be amplified by government support.

All in all, the future of Nigeria's solar energy is looking bright.

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