INTEGRATE TO ZERO

Market Research into Nigeria's Manufacturing Value chain for Solar PV Technologies

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pwc

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Executive Summary

Executive Summary

Nigeria, Africa's most populous country with over 200 million people as at 2020, struggles with electricity supply. Even after increasing its capacity to 22,000MW in 2022, it remains one of the world's most underpowered nations, with an 80% shortfall in expected consumption. This is largely due to the Transmission and Distribution infrastructure.

Only 57% of Nigerians had electricity access in 2020, with rural areas especially disadvantaged. Consequently, there's a high reliance on generators, with a backup power capacity of 42GW. Off-grid solar installations are growing in popularity, and the government is promoting renewable energy, especially in hard-to-reach areas.

Nigeria's off-grid solar market, growing at 22% annually over five years, is the largest in West Africa with a 113% sales increase in 2022 from the previous year, amounting to 1.465 million units. This growth is propelled by government initiatives, support from the World Bank and African Development Bank, and an underexploited market.
High electricity demand, combined with rising diesel costs and unreliable grid supply coupled with high solar radiation, make solar attractive. The market potential for off-grid solutions, including mini-grids and solar home systems, is estimated at $9.2 billion yearly, which could save Nigerians approximately $4.4 billion annually, highlighting the economic significance of these technologies.

Since 2019, Nigeria has become a major driver in Africa's solar industry, especially in Solar Home Systems, with over half of all sales coming from GOGLA affiliates. About 500,000 Nigerian households use solar PV systems as alternatives to gasoline generators. The growth in the off-grid solar sector is supported by several policies, initiatives and interventions such as the Nigeria Electrification Project (NEP), financed by a $550 million World Bank loan, aiming to improve energy access.

In 2022, Nigeria’s installed solar capacity reached 200 megawatts, a 506.1% increase from the prior year. The government aims for 30 gigawatts by 2030, with renewables forming 30% and solar contributing 19% of the energy mix. However recent forecasts estimates that solar energy may only constitute up to 15% of electricity generation in 2030 if Nigeria continues to maintain Business-as-usual practices.

With a yearn to draw more attention to the budding Solar PV technologies manufacturing industry, this market study was carried out to gain additional insight into the Nigerian solar PV manufacturing value chain and determine the domestic competitive advantages globally. This research also highlights the current market structure and size of Solar PV technologies manufacturing and the supporting processes needed to advance the manufacturing of clean energy technologies in Nigeria.

Executive Summary

With technological advancements and improved economies of scale, the levelised cost of electricity (LCOE) has reduced substantially, dropping from $400/MWh in 2011 to just $41/MWh in 2022. This, in addition to several encouraging global trends, has further propelled both the government and private investors to actively promote solar energy advancements and local production. The Nigerian government is prioritising sustainable energy, with a focus on renewable energy, leading to the establishment of several Renewable Energy Policies. These policies signify the government's commitment to clean energy and national empowerment. Other advantages such as increased access to finance, availability of required resources, enhanced stakeholder partnerships amongst others highlights the potential of the local market. However, there are still gaps in these strategies that need addressing for Nigeria to fully realise a sustainable energy future.

Nigeria has ample raw materials for solar PV and battery production but imports 85% of vital solar components. From 2018-2021, solar imports cost $518 million, with panels being 48.6% of this. Such imports are typically sourced from regions such as Asia and Europe, with China having a significant share of the global market, exceeding 80%. Locally, existing manufacturing companies do not yet have the capacity to manufacture solar panels and batteries from scratch but conduct limited assembly, specializing more in the assembly of solar panels and systems with a few focusing on battery assembly.

To promote local manufacturing, Nigeria requires investment and policy reforms. Despite solar's LCOE fluctuating in 2022, it remains cheaper than fossil fuels, with prices expected to stabilize soon. Solar PV distribution occurs mainly through business relationships, with local companies often offering complete solar services.

As solar PV usage grows, there's potential for solar e-waste challenges from aging components.

The removal of subsidies and possible electricity tariff increases are expected to make solar installations in Nigeria more affordable, shifting from previous cost dynamics based on installed capacity. Solar PV proves to be more efficient than grid alternatives, and the use of backup generators highlights its importance.

Prominent companies like Phoenix, Auxano, and OneWattSolar export solar products across West and Central Africa through a strong distribution network, promoting regional solar energy adoption, with some of these companies benefitting from incentives and funding from institutions and government alike. The solar energy market in Nigeria is gradually transitioning towards greater competition, increased availability of products, and partnerships between local distributors and international manufacturers. Nigeria is rich in essential solar PV manufacturing raw materials, with silica, abundant in its sands, being a key source of silicon for solar cells.

Executive Summary

The country also has a lot of battery production materials, potentially reducing costs. The Nigerian government supports the renewable sector with policies like import waivers, benefiting companies and attracting investments. Nigeria's abundant solar radiation and access to prime industrial land further support its solar energy sector, offering ideal conditions for solar energy generation and industry expansion.

In the Nigerian context, the subdued local manufacturing capacity for PV modules can be attributed to pivotal challenges. These encompass limited awareness and an underdeveloped infrastructure, both of which are currently constraining the widespread manufacturing of PV systems.

Challenges	Recommendations
Underdeveloped local raw materials solar pv market with limited mining activities in Nigeria despite known abundance of mineral deposits.	• Urgent Comprehensive Mineral Resource Survey. • Infrastructure Development • Collaboration & Partnership • Environmental Safeguards
Ineffective implementation of enabling policies and incentives in Nigeria which discourages investment.	• Urgent Policy Audit and Review • Enhancement Inter-Agency Coordination • Establishment of Policy Monitoring Units • One-stop Investor Support Services
A lack of clear and easily enforceable quality standards.	• Development of National Solar PV Standards • Certification and Labeling • Penalties and Incentives • Foster R&D Initiative
Economic fluctuations and Low Upstream activities.	• Investment in Upstream Exploration • Establishment of Strategic Reserves • Incentives for Upstream Activities

Challenges	Recommendations
Insurgence and insecurity in certain regions of the country has made manufacturing and assembly difficult.	• Regional Diversification • Risk Mitigation and Insurance • Development of a Supply Chain Resilience framework
High initial set-up costs for solar PV production and a lack of access to affordable financing.	• Localized Financing Solutions • Access to tailored International Grants and Funds • Tax Incentives and Subsidies • Establishment of Special Economic Zones
Lack of Awareness of domestic Solar PV products.	• Country-wide Industry Roundtable. i.e. investment summits, campaign, roadshows, etc. • Production of solar PV systems that are suitable for domestic climate in Nigeria.
Insufficient power supply and limited grid development.	• Incentivise Energy Efficiency

To solidify its leadership in Africa's renewable energy landscape, Nigeria must strategically refine its policy implementation, address security and infrastructure challenges, and prioritize the solar PV sector's development, ultimately driving socio-economic growth and ensuring a sustainable future.

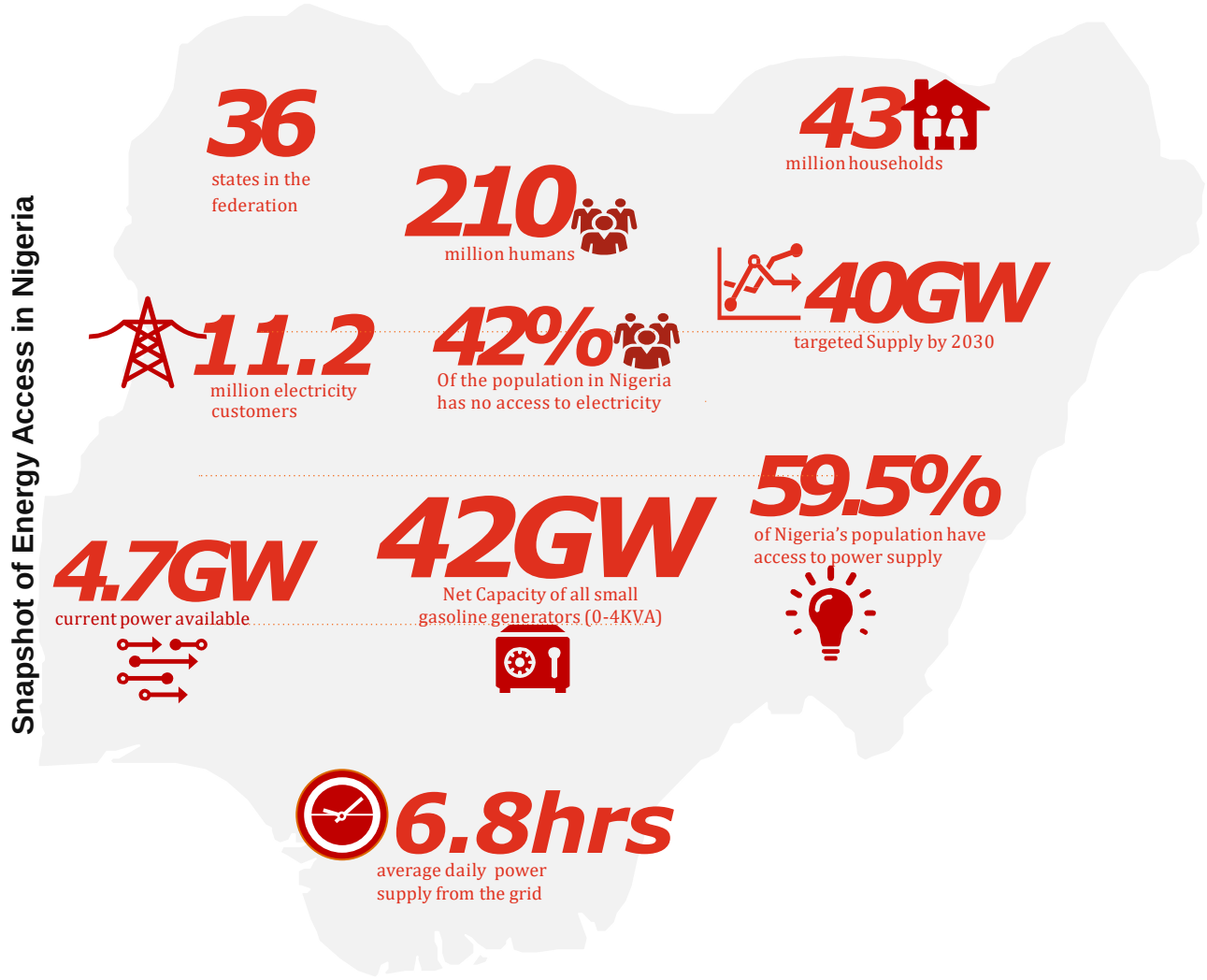
02

Introduction

Background| Overview of the Nigerian Power sector

Overview

- Nigeria holds the title of the most populous country in Africa. By 2020, the population had climbed just above 200 million. Despite increasing its electricity generating capacity to 22,000MW in December 2022 to meet the demand, Nigeria still ranks as one of the most underpowered countries globally. It falls 80% short of the expected consumption based on its current population and income levels. This shortfall primarily stems from the failure of transmission and distribution infrastructure to deliver all the generated power to Nigerian homes.
- As it stands, the available power for on-grid distribution is 4.7GW, predominantly sourced from thermal (80%) and hydro (20%) power generators. However, not all Nigerians can access electricity.
- In 2020, slightly more than 57% of the population could access electricity with the average daily power supply peaking at 6.8 hours. In 2019, rural communities experienced the most significant lack of electricity, with only 30 percent having access to electricity. In contrast, about 90% of the urban population had access to electricity. Households in the northeast and northwest zones were the most deprived of electricity in the same year.
- This unreliable grid energy has fostered a flourishing market for generators in Nigeria, boasting a backup power capacity of 42GW from small gasoline generators. The adoption of off-grid solar power installations is also on the rise across the country as they present a cheaper alternative to generators for residential, commercial and industrial uses. Moreover, the Nigerian government is endorsing the use of renewable energy sources such as biomass and solar for electricity production, especially in rural and semi-urban areas that are out of the distribution companies' reach.

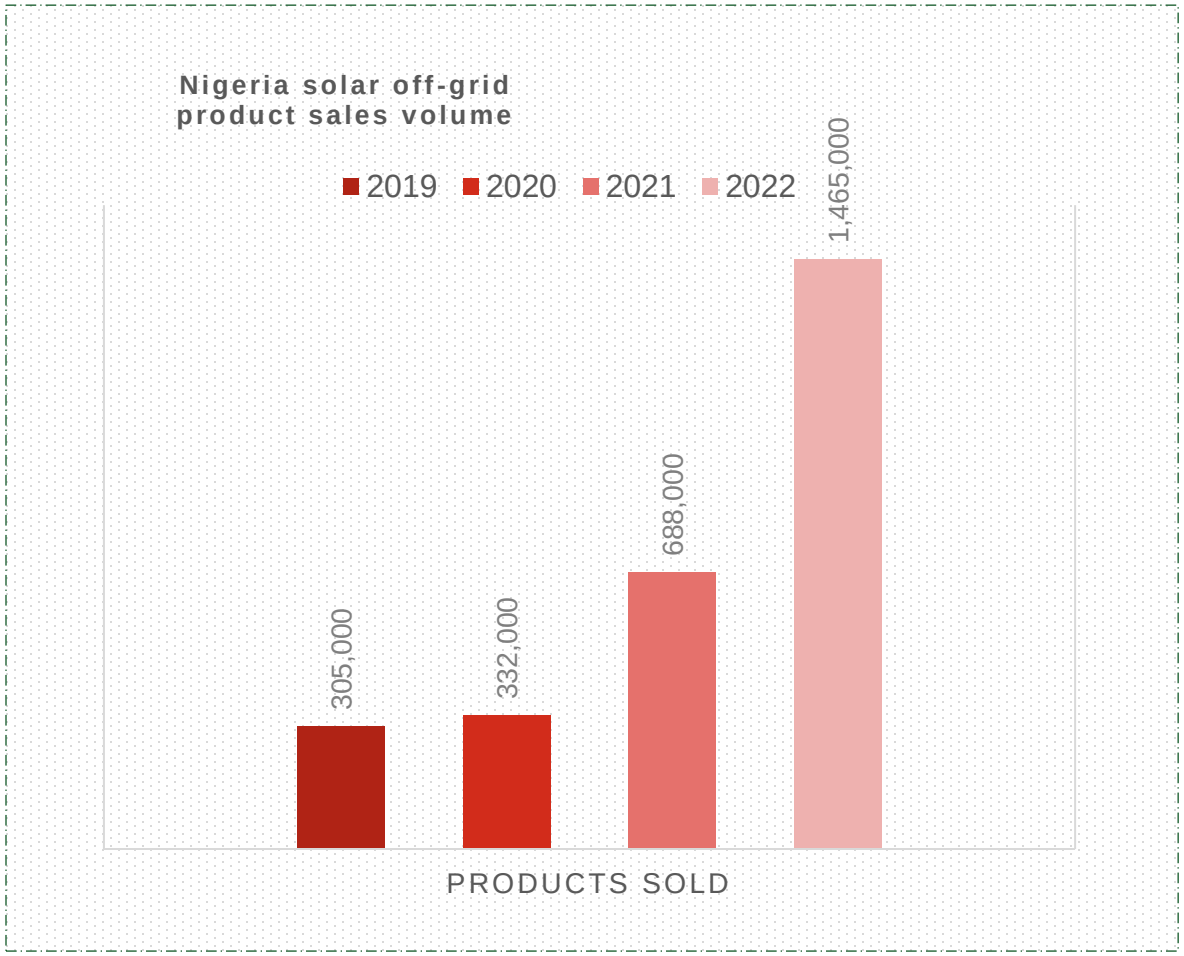


Sources: Statistica, Vanguard, Trade.gov , A2EI and Dalberg (2019)

Background| With an estimated 42% of Nigerians lacking access to electricity, Nigeria has become a rapidly expanding solar PV market in Africa. Since 2019, the sales of solar products have surged, fostering a flourishing and competitive environment within the solar industry.

Nigeria's Solar PV market: Fast growth and Huge potential

- Nigeria's off-grid solar market- one of Africa's fastest-growing- has exhibited an impressive annual growth rate of 22% over the past five years. Presently, it dominates as the largest market in the West African region. In 2022, Nigeria attained an outstanding achievement by establishing a new sales record, with nearly 1,465,000 units sold, reflecting a tremendous 113% increase compared to the previous years.
- The surge in solar technology adoption in Nigeria stems from various factors. Key among these are government initiatives like the Nigerian electrification program, backed financially by entities such as the World Bank and the African Development Bank. Furthermore, the market in Nigeria remains largely underexploited, revealing significant potential for expansion.
- Elevated electricity demand, in tandem with high diesel prices, chronic petroleum product shortages, and the recent subsidy removal, are boosting the reliance on solar technology as a fallback to the unreliable grid. Consequently, the Nigerian market is drawing an array of companies eager to cater to the countless households currently lacking electricity access, fortified by growing government and donor support.
- Off-grid alternatives like mini-grids and solar home systems are an enormous market opportunity in Nigeria, estimated at $9.2 billion per year (₦3.2 trillion per year). These options can enhance the conventional power grid, delivering reliable electricity access to households and businesses. Embracing these off-grid solutions could potentially yield savings of about $4.4 billion per year (₦1.5 trillion per year) for Nigerian households and businesses. This underlines the cost-saving benefits and economic potential of off-grid technologies in meeting the country's energy demands.

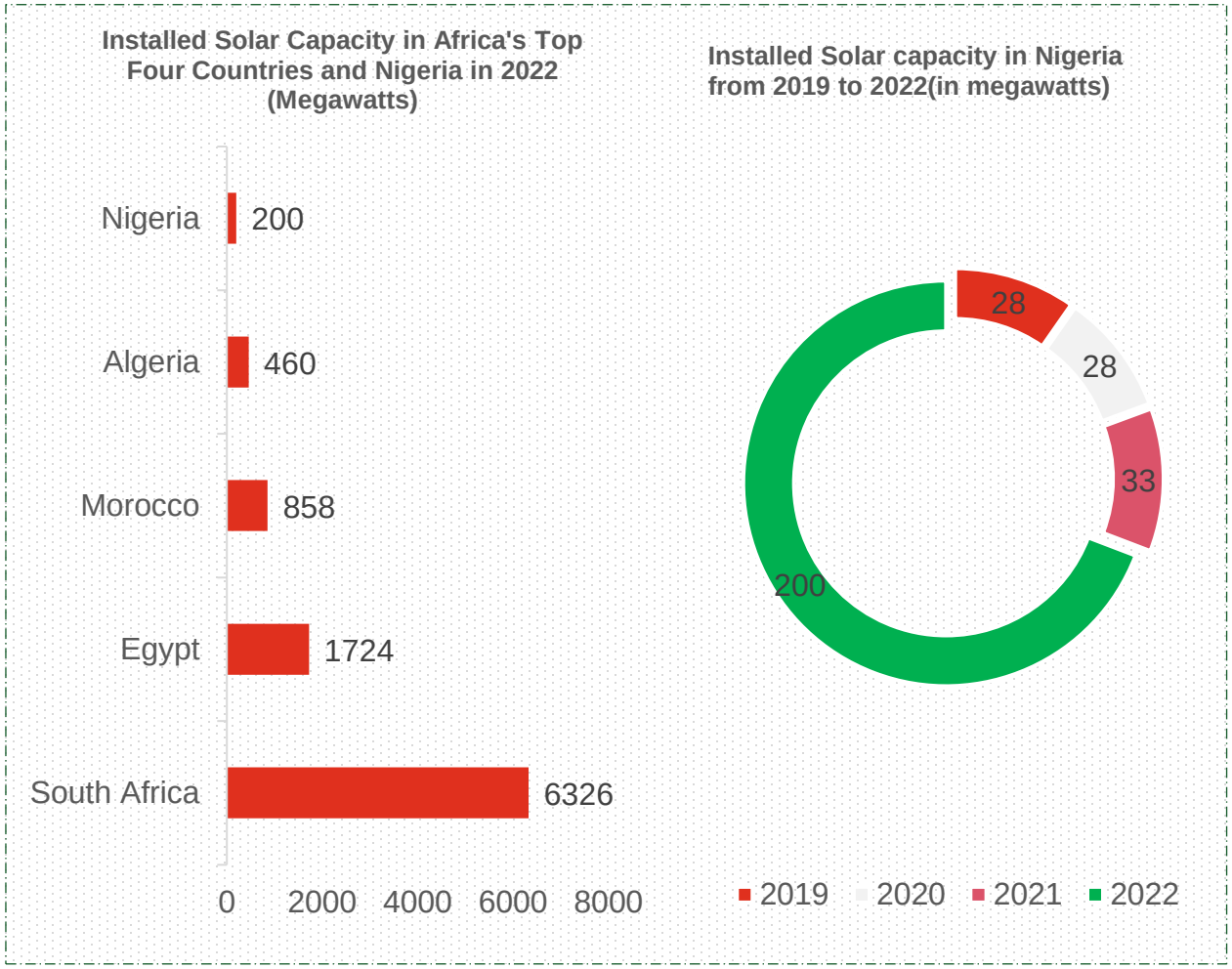


*source GOGLA, PwC Analysis

Background| Nigeria's installed capacity in recent times has emerged to become one of the fastest-growing off-grid solar markets in Africa.

Nigeria's Growing role in Africa Solar energy Industry

- Nigeria has emerged as a dynamic growth catalyst for the solar energy industry in Africa since 2019, particularly in the realm of Solar Home Systems, which constitute more than half of all sales made by GOGLA affiliates. A study by AllOn revealed that around 500,000 Nigerian Household now use solar PV system has a backup alternative to gasoline generators.
- The expansion of Nigeria's off-grid solar sector enjoys the support of the Nigeria Electrification Project (NEP), which is funded by the World Bank. NEP endeavors to provide dependable and clean off-grid electricity through Results Based Financing (RBF), a mechanism made possible by a $550 million loan. This initiative plays a pivotal role in closing the energy access divide across Nigerian communities.
- The AllOn report indicates that Nigeria's solar installed capacity in 2022 amounted to an estimated 200 megawatts, marking a substantial 506.1% rise compared to the previous year, and an exponential increase from the mere 15 megawatts registered in 2012
- In a commitment to promoting cleaner power generation sources, the government has set ambitious targets to meet the energy requirements of both urban and rural regions. Nigeria aims to achieve 30 gigawatts by 2030, with renewables accounting for 30% of the energy mix. Moreover, solar energy is projected to supply 19% of the country's electricity by 2030.
- Nigeria is diligently striving to broaden its installed solar energy capacity and strengthen its foothold in Africa's renewable energy landscape. In their drive to bolster solar energy development and close the gap with other African nations, both the Nigerian government and private investors are taking proactive steps to upscale production and assembly of solar PV system in the country through policies and other interventions.



*source Statista, GOGLA, PwC Analysis

Background| The Nigerian Government has shown commitment in driving sustainable energy solutions by empowering the Nation's future through the establishment of some Renewable Energy Policies (1/3).

- The Nigerian government is actively demonstrating its commitment to fostering sustainable energy solutions. A key part of this initiative is a dedication to shaping the nation's future through renewable energy, a vision which has resulted in concrete actions.
- In an effort to materialise this commitment, the government has established a series of Renewable Energy Policies. These policies not only reflect the government's dedication to clean energy but also illustrate its active role in empowering the nation's future.
- While these strategies and guidelines are essential to Nigeria's sustainable future and place the country as a proactive contributor to the global shift towards renewable energy, certain gaps still exist. These shortcomings need to be addressed to ensure the Nigerian government can effectively propel the nation's advancement towards a more sustainable energy environment.

Policies	Objectives	Targets	Constraints
National Renewable Energy Efficiency Policy Objectives (NREEEP) ***Enacted in April 2015***	• Diversifying Nigeria's energy mix through the development of Nigeria's energy resources to provide energy security • Providing sustainable, affordable, and reliable supply of renewable energy that is cost-effective and environmentally friendly • Boosting investments toward renewable energy in the country	• To achieve 5,300 MW of on-grid RE capacity by 2020 and 13,800 MW of on-grid RE capacity by 2030 (including large hydropower) • To Increase on-grid supply from 26% in 2016 to 48% by 2020 and to 70% by 2030 • To implement energy efficient building designs and methods in 40% of new public buildings and 30% of new large private buildings by 2030	• Access to finance • Limited institutional capacity of renewable energy.
National Energy Policy ***Enacted in August, 2005***	• The National Energy Policy addresses diverse issues such as research and development, energy pricing and financing, legislation, energy efficiency, environment etc to ensure optimal utilization of the nation's energy resources for sustainable development	• To have geothermal energy consist of more than 5% of the energy mix • To have other renewable energy, particularly biomass, nuclear, hydropower, solar power, and wind power consisting of more than 5%	• Insecurity and frequent act of vandalism are a deterrent to successful business operations and management in Nigeria

Background| The Nigerian Government has shown commitment in driving sustainable energy solutions by empowering the Nation's future through the establishment of some Renewable Energy Policies (2/3).

Policies	Objectives	Targets	Constraints
Rural Electrification Strategy & Implementation Plan Objectives ***Enacted in 2005***	• To enhance the standard of living • To boost adoption of clean energy technology • To boost social and economic activities in the economy	• To increase access to electricity to 75% by 2020 and 90% by 2030 • To achieve 10% of Nigeria's energy mix as renewable energy by 2025	• Vandalization and theft of renewable energy technology.
Renewable Energy Master Plan ***Enacted in 2015***	• The Renewable Energy Master Plan (REMP) seeks to increase the share of renewable electricity in Nigeria, from 13% of electricity generation (mainly hydropower) in 2015, to 23% by 2025 and subsequently 36% by 2030. A main driver to achieve these goals is increased diversity of the national electricity mix.	• To achieve 2000, 400, and 40 MW of Hydropower, Solar and Biomass respectively by 2025	• Extreme corruption, a quasi non-existent manufacturing industry and a low knowledge level in the craft sector are hindering factors.
Nigeria Energy Transition Plan **Vision 30: 30: 30** ***Enacted in August 2022***	• Nigeria's Electricity Vision 30:30:30 is to achieve a technology-driven renewable energy sector that harnesses the nation's resources to complement its fossil fuel consumption and guarantees energy security.	• By 2030, renewable energy is expected to contribute about 30% share in the available electricity mix; • To achieve a 20% and 19% contribution of solar energy (PV and Solar thermal) to the nation's electricity generation mix by 2020 and 2030 respectively;	• A shortage in investment capital leading to high interest rates for renewable electricity. • High initial deployment costs of renewable energy projects.
Renewable Energy Policy Guidelines ***Enacted in December 2006***	• Expand electricity generating capacity to meet national economic and social development goals • Stimulate growth in employment generation through an expanded renewable electricity industry	• Expand the market for renewable electricity to at least 5% of total electricity generating capacity and a minimum of 5TWh of electric power production, excluding large.	• Market distortions: price distortions, poor regulatory environment and inadequate infrastructure describe the current energy market situation in the country.

Background| The Nigerian Government has shown commitment in driving sustainable energy solutions by empowering the Nation's future through the establishment of some Renewable Energy Policies (3/3).

Policies	Objectives	Targets	Constraints
The Climate Change Act 2021 ***Enacted in November 2021***	• The CCA primary aim is to develop and implement mechanisms that will foster low carbon emission and develop a sustainable environment in the country by 2050-2070	• Enhancing energy conservation, efficiency and use of renewable energy in industrial, commercial, transport, domestic and other uses • Incentivizing private and public entities for their efforts towards transiting to clean energy and sustaining a reduction in GHG emissions;	• Fragmentation, lack of resources, awareness and communication are the commonly identified barriers to national adaptation policy
Electricity Act 2023 (the "EA 2023'') ***Enacted in June 2023***	• The new Act consolidates the laws relating to the Nigerian Electricity Supply Industry. It provides a comprehensive legal and institutional framework for the power sector in Nigeria in the areas of electricity generation, transmission, system operation, distribution, supply, trading, consumer protection. • The Act encourages the integration of renewable energy technologies into the existing grid system. Under the Act, electricity generation licensees are obligated to meet renewable energy generation obligations as may be prescribed by the Nigerian Electricity Regulatory Commission	• The Act provides a holistic, integrated resource plan that compels the utilization of renewable and non-renewable energy sources for power supply in the country and attracts investments into the sector • The Act further enables States to close the supply deficit gap by exploring innovative energy mix solutions. States can diversify the generation mix by using the abundant renewable energy.	• Electricity policy enforcement, regulatory uncertainty, gas supply, constraint of transmission system, and major power sector planning shortfalls that have kept the sector from reaching commercial viability.

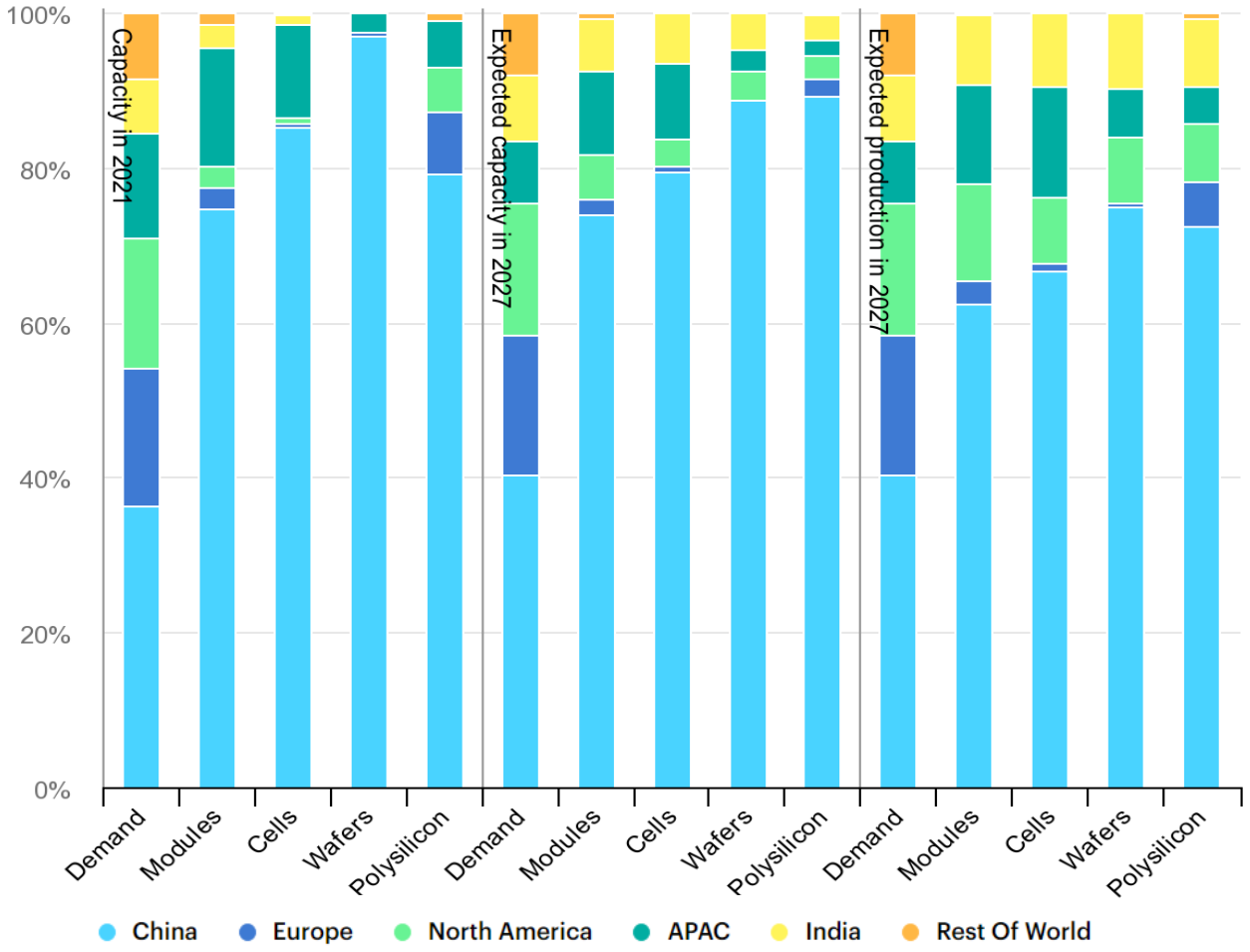
Key Insights

- Nigeria is the most populous country in Africa and to meet the energy need of individuals, a high volume of energy production is expected.
- Backup gasoline generators have contributed 42GW of Net Capacity to the energy. However, the removal of subsidy and the new price of PMS will likely lead to a possible downward turn of generator usage, with a rise in the quick adoption of solar PV module.
- Renewable energy, specifically solar PV, has seen a dramatic reduction in costs, becoming significantly more affordable. The levelised cost of electricity (LCOE) for unsubsidized solar PV has plummeted approximately 90%, dropping from $400/MWh in 2011 to just $41/MWh in 2022.
- Some factors- including policies (e.g. local content requirements, fiscal incentives), technical assistance, transaction facilitation, and financing- are been redirected to scale-up solar PV Module manufacturing in Nigeria.
- Nigeria's solar installed capacity in 2022 amounted to an estimated 200 megawatts, marking a substantial 506.1% rise compared to the previous year
- Perceived investment attractiveness are beginning to favor the upscale of solar PV module manufacturing across its value chain in Nigeria.
- Rising power demand is fueling the push for industrialisation of solar PV modules. Given economic and environmental factors, renewables are projected to take the lead as the primary power source in Africa.
- While policies designed to stimulate the production of solar PV components in Nigeria have been implemented, they haven't yet comprehensively met the business needs necessary for fostering a "best in class" business environment.

03

Value Chain Analysis

Value Chain for Solar PV Module| Currently, solar PV manufacturing is largely confined to specific regions, yet signs indicate that other markets are expanding their capacities and investing in production, driven by favorable policies and an increasing demand for clean energy.



Note: Manufacturing capacity and production in 2027 is an expected value based in announced policies and projects
APAC = Asia-Pacific region excluding India and China

Source: International Energy Agency (IEA)

Internationally, the solar PV system manufacturing industry is comprised of well-developed systems and processes across the value chain however a few segments are highly technical, with expertise mainly focused in regions like China, USA and Europe. Today, majority of the manufacturing of solar panels is carried out in China, exceeding about 80% share of the global value chain[1].

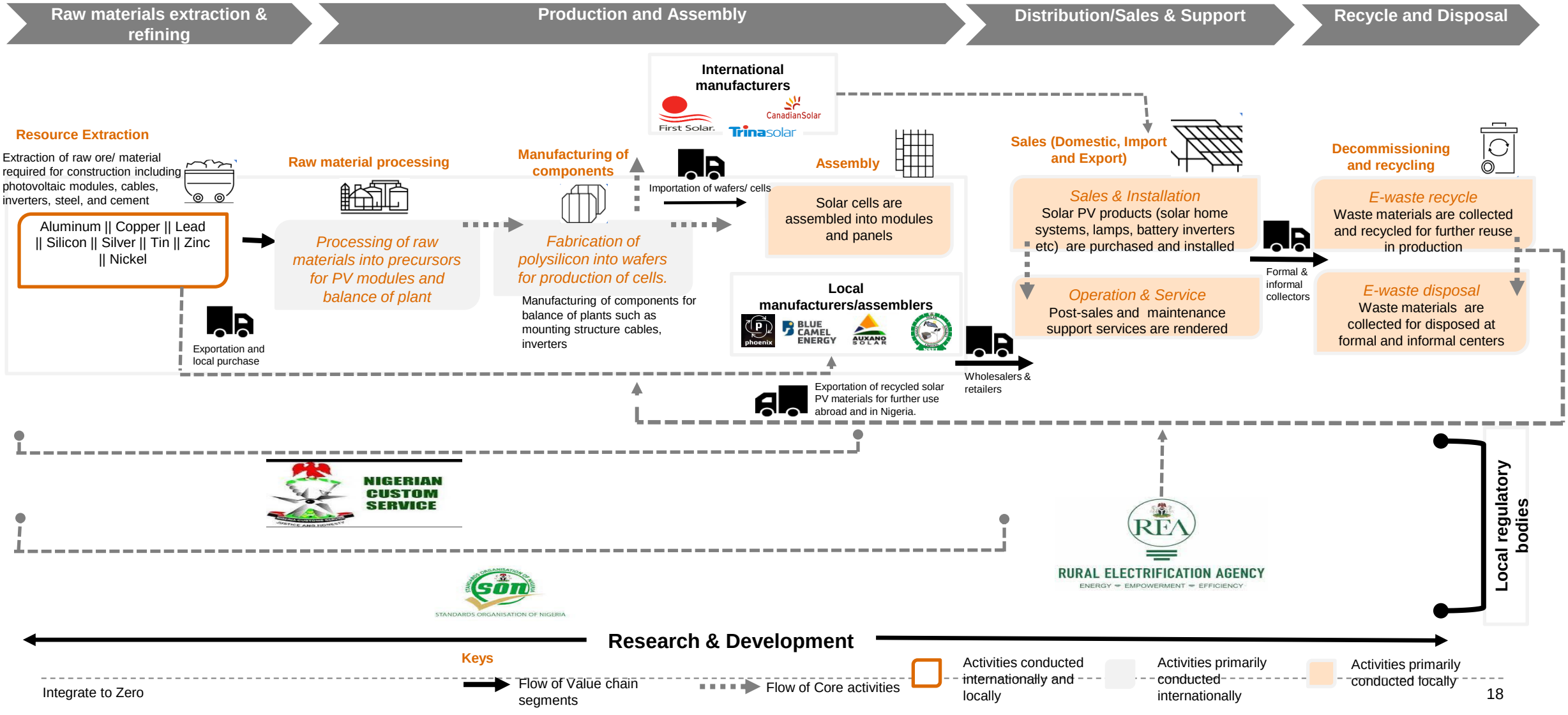
However, with increasing demand, policy changes and growing industrialisation in emerging markets, China's share of manufacturing capacity could decrease slightly, from 80-95% to 75-90% depending on the segment. A further decrease in China's share in production from 75-90% to 60-75% by 2027 could potentially occur if countries maintain trade policies that limit imports and favor locally produced PV products[2].

As the world transitions to alternative sources of energy, the solar value chain in Nigeria is expanding with the surge in demand for renewable energy and constant power across the nation. Solar PV is expected to play an important role in Nigeria's power supply in the coming years with government policies, initiatives and institutional finance schemes gearing up to facilitate further growth in the solar industry.

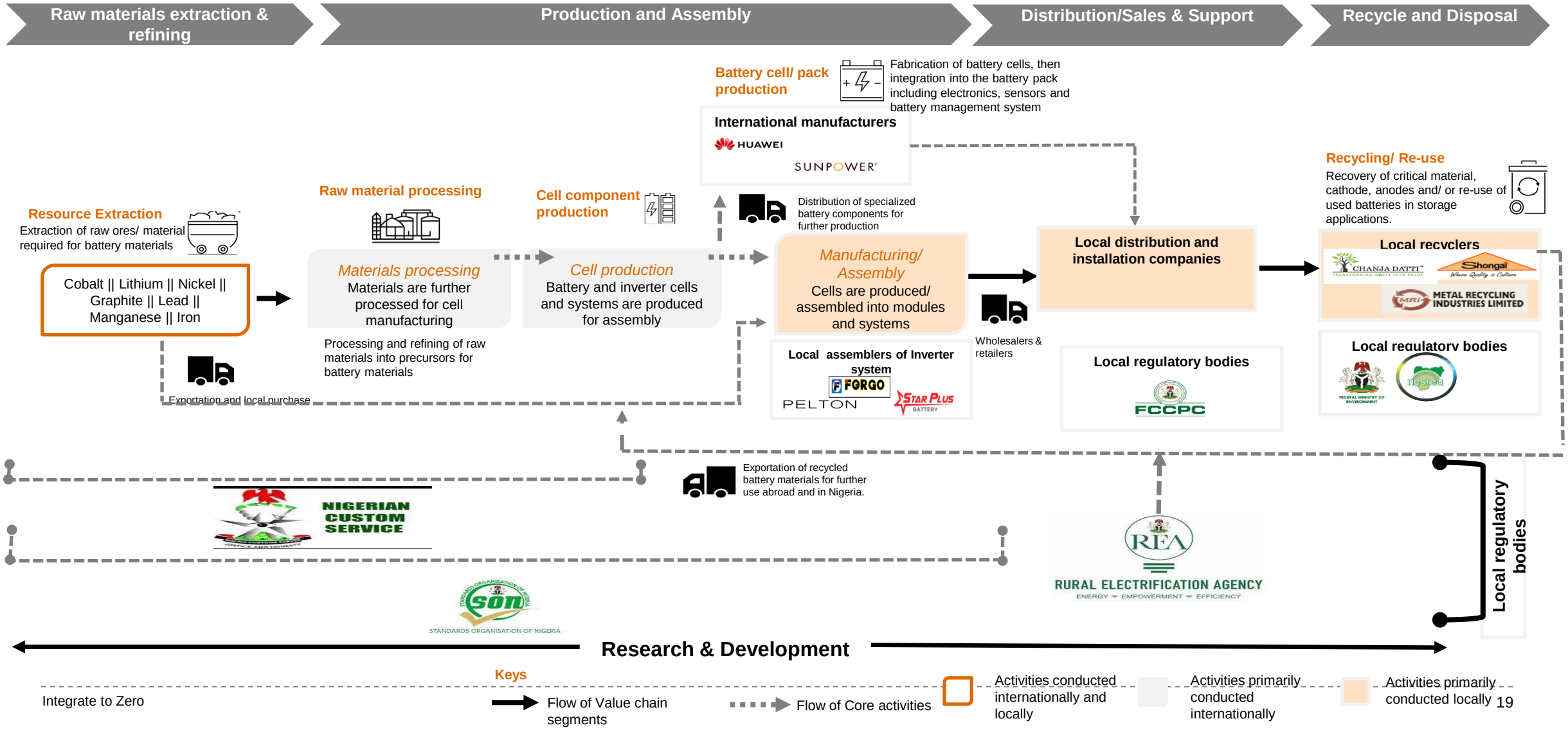
However, local production activities are currently focused in segments related to **assembly and distribution** while expansion in other manufacturing capacities are underway.

1 International Energy Agency "Special Report on Solar PV Global Supply Chains" 2022
2 International Energy Agency "Will new PV manufacturing policies in the United States, India and the European Union create global PV supply diversification?" 2022

Value Chain for Solar PV Module| Throughout the entire spectrum, the solar PV manufacturing value chain is experiencing vigorous growth in Nigeria, spurred by escalating research and development efforts and enhanced supply chain optimization. (1/2)



Value Chain for EV Battery| Also, despite Nigeria's resource wealth, solar-battery production thrives globally, with local markets relying on imports. Meanwhile, Nigeria exports recycled products for various manufacturing needs abroad. (2/2)



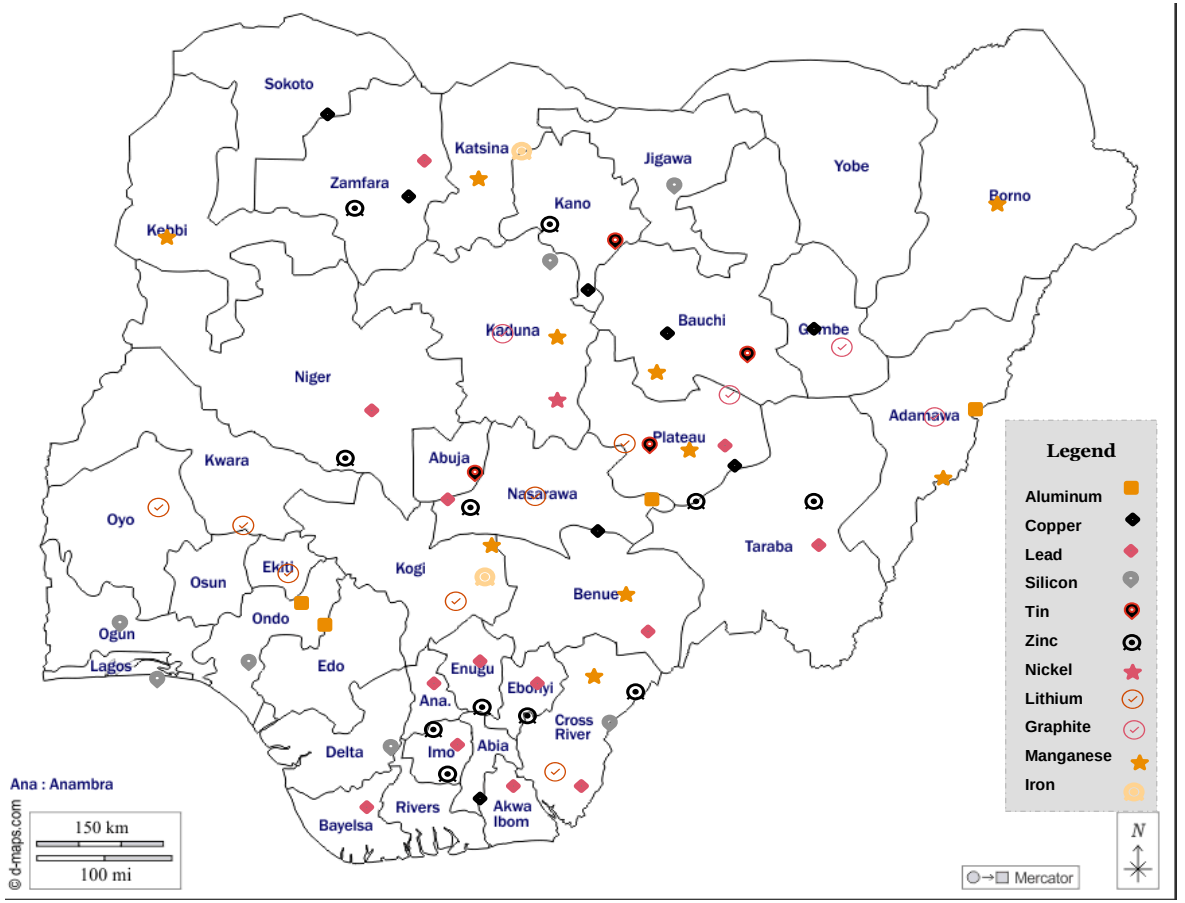
Raw Material Extraction and Refining| Nigeria is still in the early stages of exploring and extracting essential materials for solar PV and battery production. Nonetheless, the existence of raw material reserves presents a significant opportunity for future development, provided that there is an investment in technical capacity building.

Nigeria is endowed with commercially viable amounts of the major raw materials required in the solar PV and battery manufacturing value chain, as evidenced by growing interests in mining minerals such as Lithium by Tesla. However, the exploration of its resources remains strife with incapacities for efficient extraction.

Solar PV technologies predominantly require silicon, supplemented by other materials such as silver and aluminum, as 90% of raw materials needed for its production are available in commercial quantity. Nigeria, blessed with abundant reserves of quartz a form of silicon dioxide, certainly holds the potential for silicon extraction. However, transitioning from raw quartz to high-purity silicon, a critical input for solar cells, necessitates complex, energy-intensive processes which is not available in Nigeria, due to lack of technical competence.

Also, contemporary batteries, exemplified by lithium-ion batteries, utilise a wide variety of materials including lithium, cobalt, nickel, manganese, graphite, and copper. The exact composition may vary depending on the specific battery technology. Nigeria's mineral wealth includes substantial reserves of several of these key metals, particularly nickel and copper as field result suggests that 100% of the raw materials needed for battery manufacturing are available in commercial quantity. However, refining these raw materials into a battery-grade composition represents a significant technical challenge.

Thus, there is a strong reliance on importation of high-technically processed materials from China. Nonetheless, the existence of raw material reserves presents a significant opportunity for future development, provided that there is an investment in technical capacity building, considering global demand and prices.



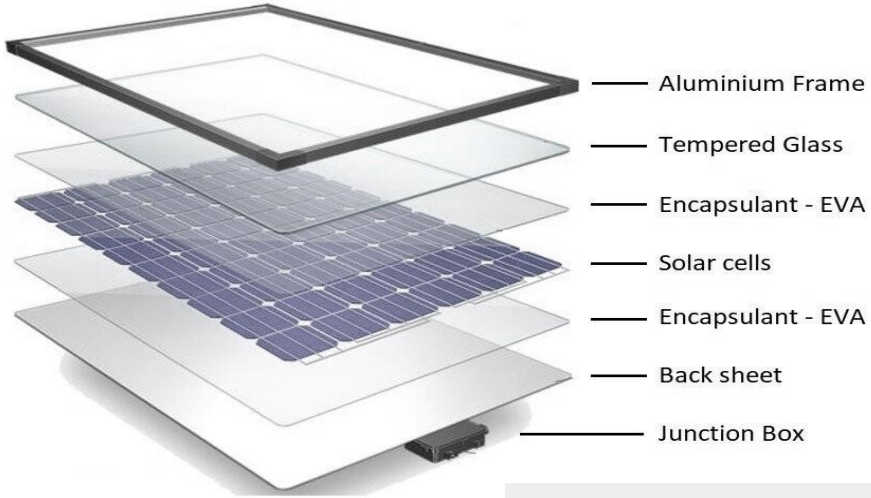
Source: SpringerLink, Finelib, RMRDC GIS Portal, BusinessDay, Kaduna State Government

Known Local deposits of raw materials in Nigeria (in metric tons)

Iron	Copper	Lead	Zinc	Nickel	Manganese
~ 3 billion	~ 10 million	~ 10 million	~ 10 million	~ 5 million	~ 5 million

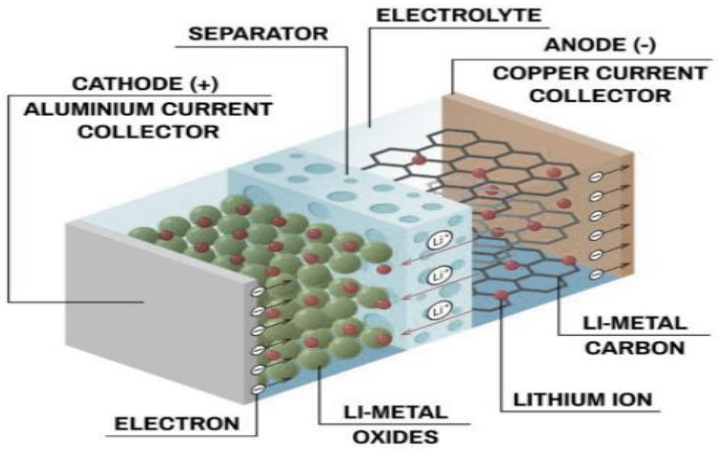
Raw Material Extraction and Refining| Components of Solar PV and EV Battery with available raw material in Nigeria.

Local availability of raw materials for Solar PV manufacturing



		Local Availability of Raw Material
1	Aluminium Frame	✓
2	Glass Cover	✓
3	Ethylene Vinyl Acetate (EVA) film	✓
4	Solar cells	✓
5	Back Sheet	✓
6	Junction Box	✓
7	Cables and wires	✓

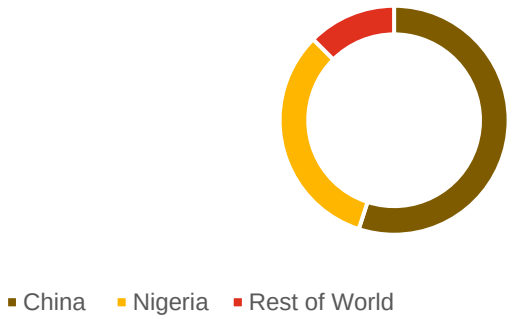
Local availability of raw materials for Battery manufacturing



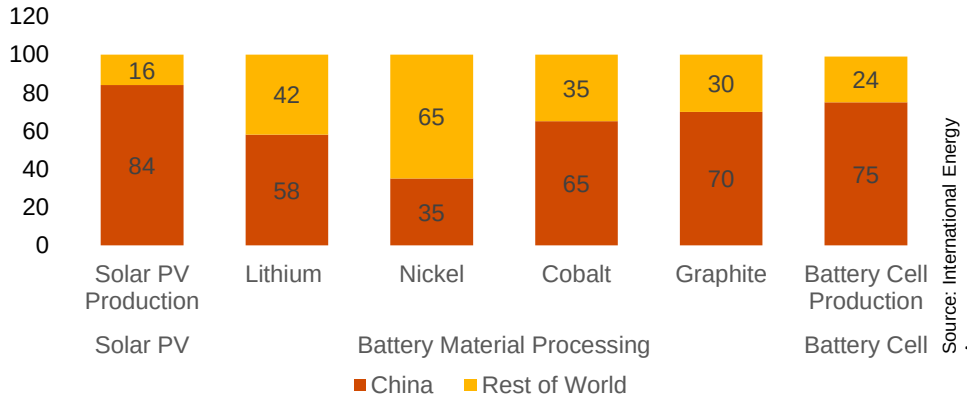
		Local Availability of Raw Material
1	Cathode	✓
2	Anode	✓
3	Electrolyte	✓
4	Separator	✓
5	Container	✓
6	Collector	✓
7	Electrodes	✓

Production and Assembly| China currently leads the production of raw materials and the manufacture of renewable energy products globally…

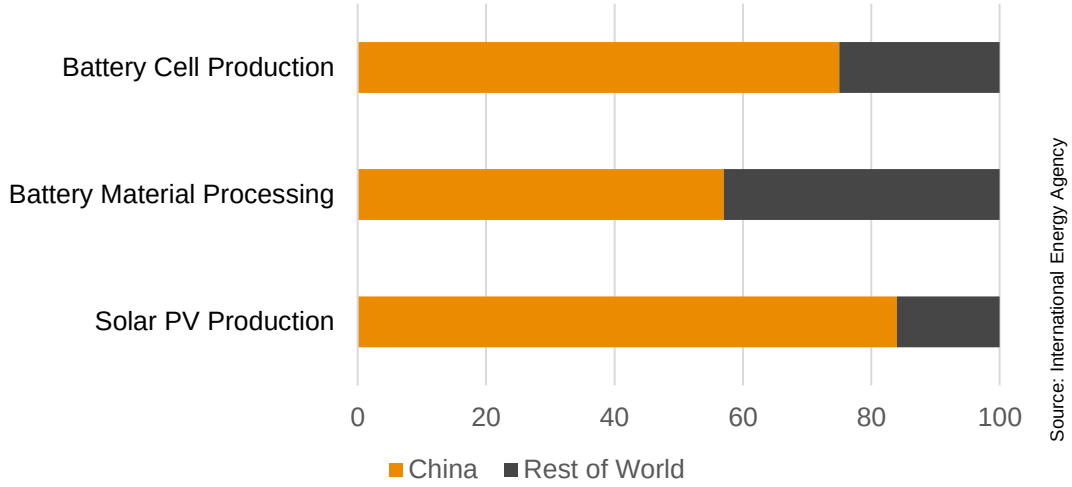
Source region for component materials needed by local manufacturers/assemblers of solar panels in Nigeria



Source: Authors field research, 2023



Geographic distribution of renewable products supply chain in %

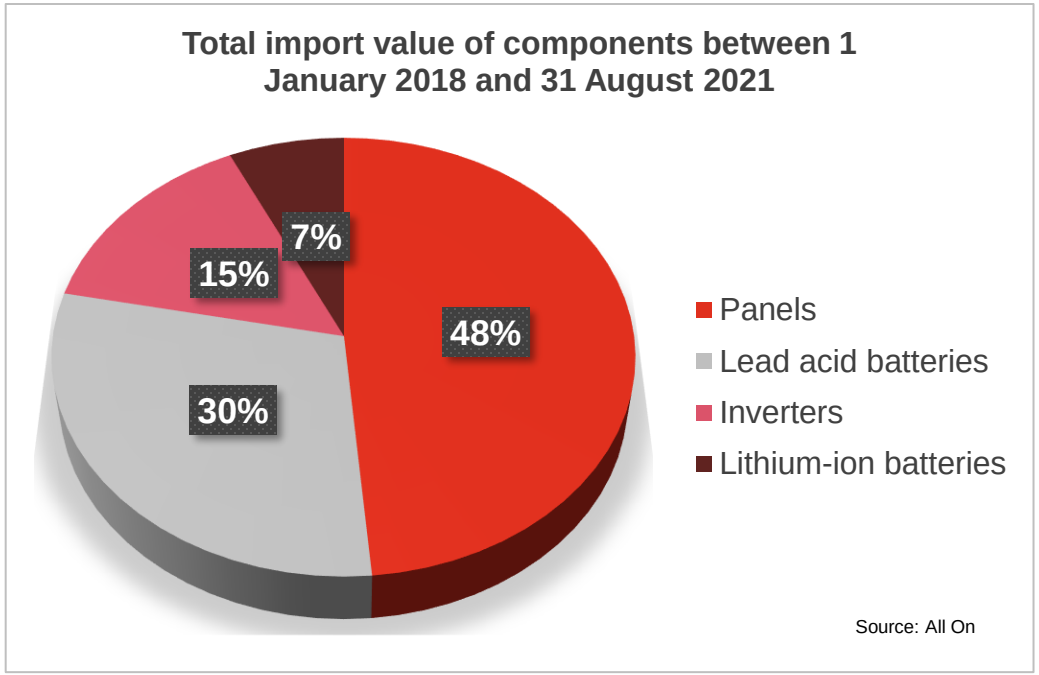


On average, 50% of the cost for the production of a photovoltaic module is due to the cost of production for the silicon wafers. Presently, China is the major hub for photovoltaic module and battery production, it is home to the top suppliers of solar PV manufacturing equipment globally, dominating the global market due to its ready availability of labor and raw materials as well as supportive governmental policies.

Production and Assembly| With the current limited access to locally sourced materials and deficit in relevant extraction infrastructure, most PV manufacturers and assemblers in Nigeria are forced to rely on importation of key component-materials.

Although the Nigerian market is said to be among one of the fastest growing markets, over 85% of the technology components needed for solar PV systems and related products are sourced from other countries and regions, with limited local content additions.

Between 1st January 2018 and 31st August 2021 alone, the total import value for key solar components was estimated at USD 518 million (including few imports not intended solely for use in solar energy generation), with solar panels accounting for 48.6% of total import value3.



Locally, applicable tariffs, Value Added Tax (VAT) and other importation levies for off-grid solar products have contributed to over 40% of their retail prices4. Import tariffs such as 20% duty on batteries, 5% VAT on solar components, a 5% duty on solar panels (with diodes) coming into the country contribute to landing costs and this significantly affects the price of the solar products.

A few incentives do exist to encourage solar assembly and production locally:

- ✓ Duty-free importation of solar panels with diodes
- ✓ Duty-free importation of solar cells and other components used in the manufacture or assembly of solar modules
- ✓ VAT exemption for solar cells (whether or not in modules or made up into panels), photosensitive semiconductor devices, solar DC generators (of outputs between 750 W to 375 kW), solar powered generators

Import waivers can also be requested from the Federal Ministry of Finance through the Federal Ministry of Power, however these are usually not considered for off-grid commercial purposes, but are usually granted for government or donor-funded projects. Depending on factors such as the import value and impact on Nigeria's economic growth, stakeholders such as the Nigerian Investment Promotion Commission (NIPC) can assist renewable energy companies to obtain import duty exemption certificates.

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Seemingly, local manufacturers/assemblers may remain import dependent as numerous investments and effective implementations of reforms and policies will be required to improve Nigeria's extraction capacities in the upstream solar PV manufacturing value chain.

3 AllOn "Market research on the circular economy of the renewable energy sector in Nigeria" 2022
4 Africa Clean Energy "Importation Guide for Solar PV Products and Technologies in Nigeria" 2019

Distribution and Sales| The distribution and installation of PV system is the most locally active segment of the PV system value chain and highly fragmented with numerous players.

Despite solar's levelised cost of electricity (LCOE) fluctuating in 2022 for the first time in over a decade due to supply chain issues and inflation, sale volumes of solar PV systems have been on the increase. Furthermore, the increased levelised cost of electricity (LCOE) of solar is expected to not pose a challenge to cost competitiveness as solar PV remains significantly cheaper than fossil fuels with product prices already declining in recent months and are largely expected to return to previous levels soon.

In 2022, West Africa total sales of total solar energy kit* increased by

53%

*These primarily refer to lanterns, multi-light systems and solar home systems

Units sold in West Africa in reporting cycle

1,560,000

1,188,000

Units were sold in Nigeria alone, representing **76%** of regional sales

Source: Googla "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data –2022" 2022

Distribution of solar PV systems occurs predominantly through business-to-business relationships, connecting manufacturers with distributors, and distributors with retailers. Similar to electricity demand, the largest consumers are residential users with small household solar systems accounting for about 70% of the market. The use of mini-grids currently have a minor share of the market but is set to grow in coming years due to improved policy implementations, interventions from agencies such as Renewable Energy Agency (REA) and private companies as well as increasing adoption by companies and industries.

The most common types of panels used in residential and commercial installations locally are monocrystalline and polycrystalline solar panels. Monocrystalline are favored particularly due to its efficiency, longevity and affected less by high temperatures which is best suited to the Nigerian climate, however due to its high purchase costs, the more affordable polycrystalline panels are used by consumers with limited buying power. Thin-film solar panels are lighter and maneuverable however due to its reduced efficiency, its applications in Nigeria are limited to custom installations (such as commercial installations where the roof can not handle the additional weight of traditional solar equipment).

It is typical to find domestically-operating distribution companies serve as solar engineering, procurement and construction (EPC) contractors - providing end-to-end solar energy services, including system design, procurement, and installation. As an avenue for vertical integration in the value chain, distribution companies often times serve as installation companies, specializing in the set-up of such systems. Another form of integration is to also operate an import arm which purchases PV systems from regions like China, India and USA for local distribution and installation.

Source:Naijalink – Netherlands Enterprise Agency "Sector Study: Solar Renewable Energy in Nigeria" 2021

EV Battery Demand in Nigeria| The need for energy storage is a main concern in renewable energy production, particularly for regions like Nigeria with poor electricity supply. This drives a focus on batteries as a key ancillary component of a solar PV system.

Although batteries are considered the most expensive component of a solar PV system, the solar battery market continues to expand to appease the growing demand for effective storage options

Globally, the market size was worth **USD 148million in 2021**, and is expected to reach an estimated value of **USD 540 million by 2030** with a Compound Annual Growth Rate (CAGR) of 15.5% during the forecast period of 2022-2030. **Locally**, the Nigeria battery market was valued at **USD 73.08 billion in 2021**, with a CAGR of 6.8% in the forecast period of 2022 to 2029 and is expected to reach **USD 136.47 billion by 2029**.

Drivers for the demand of PV batteries

- The trend of adopting low-carbon solution and move away from a fossil fuel-based economy and increasing focus on renewable energy storage solutions
- the growing need for continuous power supply in rural areas and subsequent rise in electrification projects
- the decline in cost for lithium-ion batteries which has created opportunity for battery storage system adoption
- supportive government policies and regulations for the use of photovoltaic technology
- Removal of fuel subsidy nationally and subsequent increase in fuel prices. This affects costs implications associated with continued use of fuel generators as primary alternative source of power

Nigeria's battery manufacturing market is primarily focused on assembly and this activity is enabled mainly by import of components from countries like China and India.

Currently assembly of battery systems is carried out by a few local assembling companies while the primary source of batteries in the country is via importation of battery systems from regions like Asia and Europe.

Key players such as the National Agency for Science and Engineering Infrastructure (NASENI), Projects Development Institute (PRODA) are seeking to expand the capacity of local production through collaboration with international companies and investors willing to set up their industries in Nigeria.

Sources: https://straitsresearch.com/report/solar-battery-market
https://www.databridgemarketresearch.com/reports/nigeria-battery-market

Recycling and Disposal| With the rise in uptake of solar PV solutions, the need to take proactive steps to effectively manage solar e-waste and tackle end-of-life challenges in the sector is evident

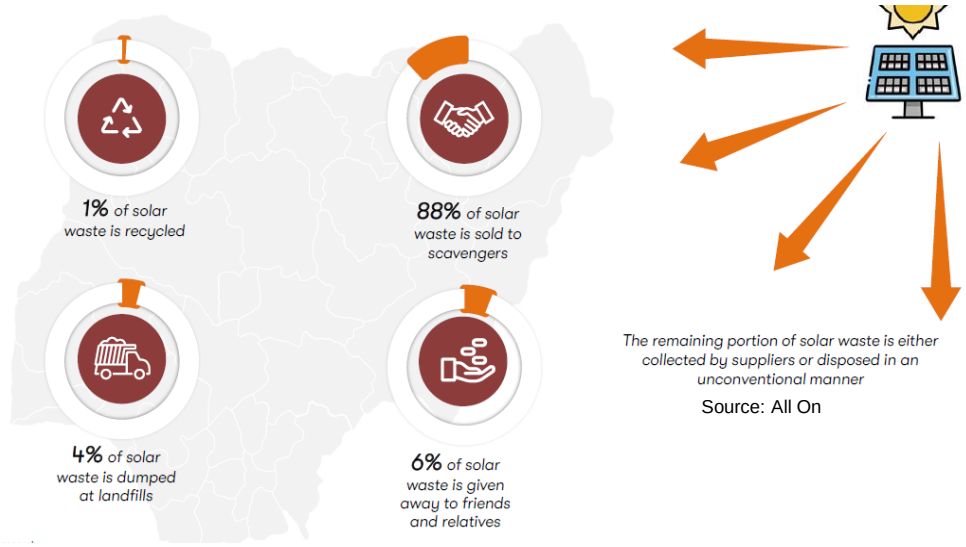
It is estimated that the total volume of solar waste in Nigeria would exhibit a CAGR of 15.6%, growing from 3.3 million kilograms in 2021 to 60.3 million kilograms in 2040, with mini-grid systems accounting for a larger portion of the growth in comparison to solar home systems.

With growing interests and adoption of solar PV products in the country, there are potential solar e-waste (i.e. waste from solar components including solar panels, batteries, inverters and other ancillary components) arising from elements which have reached their end-of-life (EOL). At the moment, solar e-waste management in Nigeria lacks a well-established system for collection, processing, transportation, and disposal as well as adequate regulatory enforcement and monitoring.

Due to the conventional methods of waste management practiced locally, solar waste is predominantly handled by informal players, who either sell to formal players or dismantle and dispose. There are only a few formal local recycling companies typically with more expertise in battery recycling compared to other solar components. Such battery recyclers are encouraged to affiliate with organizations such as the Recycling and Economic Development Initiative of Nigeria (REDIN) and the Alliance for Responsible Battery Recycling (ARBR) who work towards collecting data and evidence of the growing battery usage and recycling activities in the country.

In a bid to further facilitate circular economy practices, the Nigerian government through its National Environmental Standards and Regulations Enforcement Agency (NESREA) has developed an Extended Producer Responsibility (EPR) framework, which focuses the responsibility for waste management on the private industry, ensuring producers and/or importers/distributors internalize waste management costs in their product prices and ensure the safe handling of their products. Recyclers and collectors bear the primary responsibility in the execution of the EPR framework.

Disposal techniques in Nigeria



Source: All On

Although a greater percentage of solar PV and EV batteries and other waste materials are typically exported for further recycling in regions like China due to the limited capacity for recycling locally, the domestic recycling practice is seemingly set to improve in coming years as manufacturing and assembly companies such as Phoenix Renewables, Quad loop make use of recycled materials in their production of solar PV systems and other products. Additionally, an increasing number of companies are focusing on the optimization of the product life cycle and the handling of the product at the end of the value chain.

Source: AllOn “Market research on the circular economy of the renewable energy sector in Nigeria” 2022

Key regulatory requirements | Across the key aspects of the value-chain, the following regulatory requirements are compulsory when setting-up a business in Nigeria. These stands as a cornerstone for a thriving and esteemed presence within the renewable energy sector.

Raw materials extraction and refining

- CAC Incorporation Documents
- Tax Clearance Certificate
- Attestation of Non-conviction from a Legal Practitioner
- Bank Reference Letter
- Mining Permit (quarry lease, water use permit, reconnaissance permit, and exploration license.)
- Possess & Purchase License
- Consent of a Mining Permit Holder
- Warehouse and Environmental Impact Assessment Report
- Mineral Export Permit

The Ministry of mines and Steel Development and the Nigerian Cadastre office oversee mining activities.

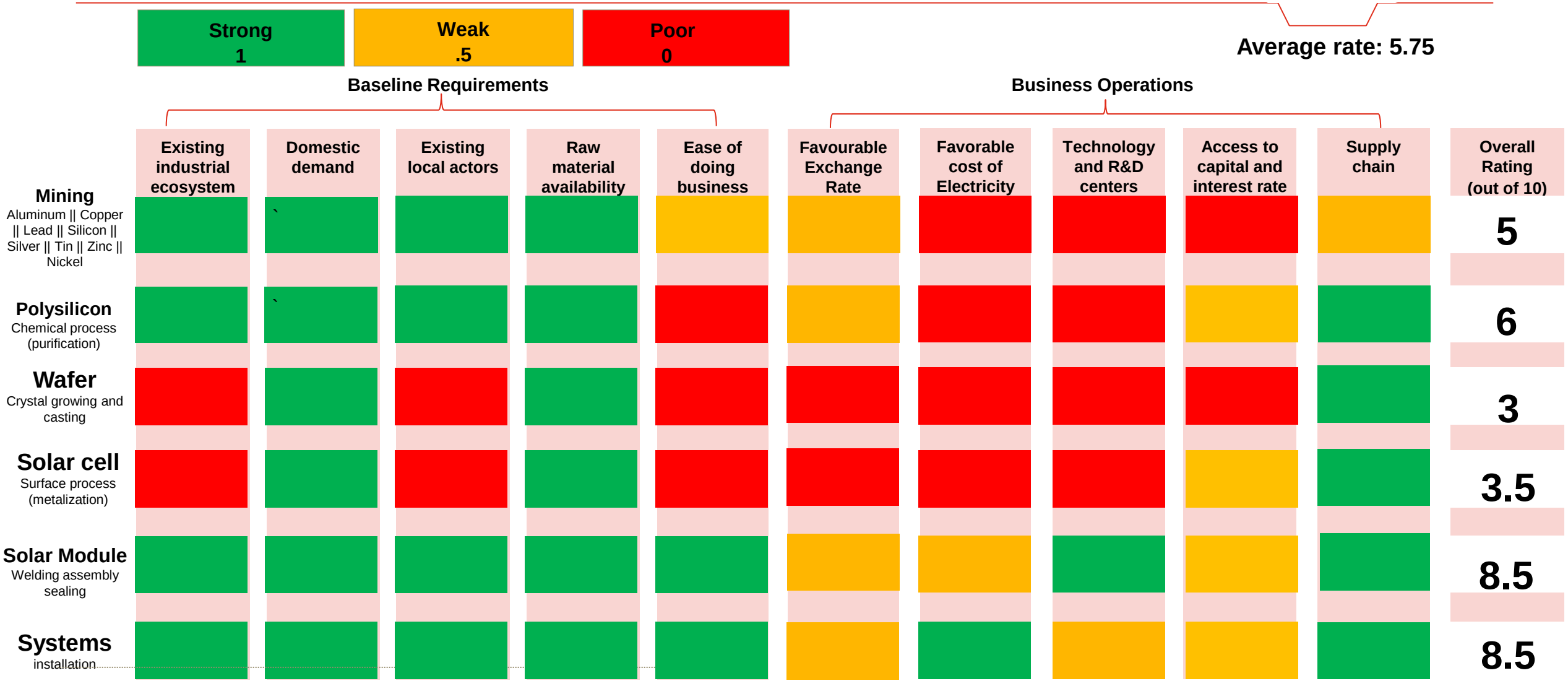
Production and Assembly

- Registration with CAC
- Registration with Standard Organisation of Nigeria (“SON”) MANCAP.
- Tax registration with the Federal Inland Revenue Service (“FIRS”)
- Registration with Manufacturers Association of Nigeria (“MAN”)
- Obtain a Certificate of Capital Importation (“CCI”) to validate the inflow of foreign capital
- National Environmental Standards Regulations Enforcement Agency (NESREA) permit.
- Securities and Exchange Commission (SEC) .
- Registration with Federal Ministry of Labour and Employment.

Recycle and Disposal

- Registration with CAC
- Ministry of Environment for EIA
- Permit from National Environmental Standards and Regulations Enforcement Agency (NESREA)
- Tax registration with the Federal Inland Revenue Service (“FIRS”)
- Waste management and transportation permit with the state government.
- Import and export regulation (customs, ministry of trade and investment)
- Recycling associations

Value Chain for Solar PV Module| Summarily, this is the current viability of establishing and operating solar PV module manufacturing in Nigeria.



*source PwC Analysis (Refer to Appendix I)

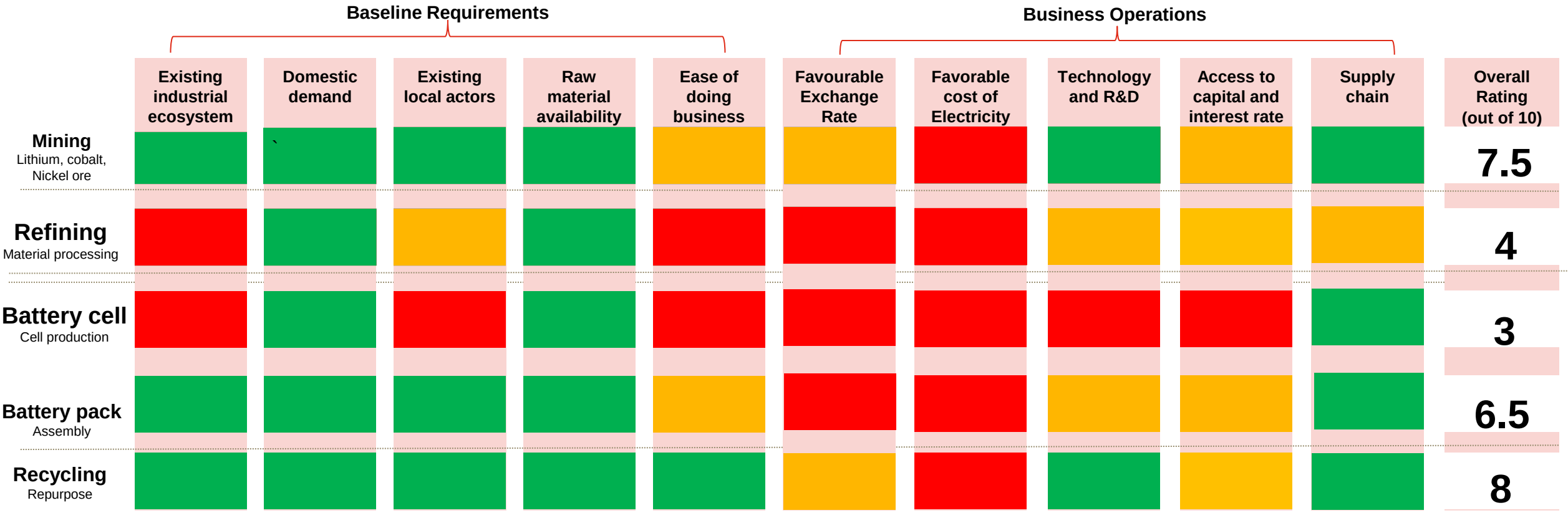
Value Chain for PV Battery| Summarily, this is the current viability of establishing and operating PV Battery manufacturing in Nigeria.

Strong
1

Weak
.5

Poor
0

Average ratating: 5.8



*source PwC Analysis (Refer to Appendix I)

Value Chain Analysis| The distribution and installation of PV system is the most locally active segment of the PV system value chain and highly fragmented with numerous players

Typical solar items distributed locally to consumers such as individuals, households, corporations and Small & Medium businesses include:

Pico-Solar products which typically have a peak power of 10W or less

Solar Home Systems (SHS) and **Micro-solar products** which have peak powers between 10W and 350W, DC voltage of 35V or less.

Large stand-alone solar systems and **Solar PV Mini-grids** which often range above 1kW

Value Chain Analysis| Various stakeholders across the value chain participate in the development and sustained growth of the solar PV manufacturing in Nigeria

Key Stakeholders in Nigeria's solar pv manufacturing value chain

International Manufacturers	Nigerian Manufacturers	Nigerian distribution / installation companies
CanadianSolar, Trinasolar, JinKO Solar, LONGi Solar, First Solar, HUAWEI	AUXANO SOLAR, BLUE CAMEL ENERGY, Phoenix Energy ...unlock the solutions, Eastman, NSEL, LPVenergies, one watt solar, FORGO	arnergy, LUMOS, HAVENHILL SYNERGY LIMITED, SOLAR FORCE RENEWABLE ENERGY, GREENPOWER, RUBITEC POWER RUBITEC SOLAR, GV

Government / Regulators	Funding / Financial Institutions	Other supporting institutions / agencies
NBET NIGERIAN BULK ELECTRICITY TRADING PLC, NERC, NIGERIAN CUSTOM SERVICE, SON STANDARDS ORGANISATION OF NIGERIA, FEDERAL MINISTRY OF POWER, REA RURAL ELECTRIFICATION AGENCY ENERGY EMPOWERMENT EFFICIENCY	BANK OF INDUSTRY ...transforming Nigeria's industrial sector, THE WORLD BANK, DBN Development Bank of Nigeria ...Financing Sustainable Growth, Sterling, ZENITH, access, FirstBank Since 1894, African Development Bank	REAN RENEWABLE ENERGY ASSOCIATION OF NIGERIA, AllON, AFSIA Africa Solar Industry Association, SEforALL, Africa Clean Energy Catalysing Africa's Solar Markets, ROCKEFELLER Philanthropy Advisors, CLIMATE EMERGENCY COLLABORATION GROUP

Key Insights

- Nigeria possesses abundant essential raw materials for solar PV and battery production (90% and 100% respectively).
- Despite this advantage, the nation imports over 85% of crucial technological components for solar PV systems.
- From 2018 to 2021, solar component imports amounted to USD 518 million, with solar panels accounting for 48.6% of the total.
- Battery assembly is conducted by a few local companies, while the main battery supply is imported from Asia and Europe.
- To reduce import dependency, Nigeria needs substantial investments and policy reforms to improve local extraction capacities in the solar PV manufacturing value chain.
- Despite the fluctuating levelised cost of electricity (LCOE) for solar, it's not projected to impact cost competitiveness, as solar PV remains substantially cheaper than fossil fuels. Recent declines in product prices are expected to stabilize at previous levels shortly.
- Distribution of solar PV systems primarily operates via business-to-business relationships, facilitating connections between manufacturers, distributors, and retailers.
- It's common for local distribution companies to act as solar engineering, procurement, and construction (EPC) contractors, providing comprehensive solar energy services including system design, procurement, and installation.
- Distribution companies often serve as installation specialists, a strategic approach for vertical integration in the value chain.
- With the increasing interest and usage of solar PV products in the country, potential solar e-waste issues may arise from components reaching their end-of-life (EOL), including solar panels, batteries, inverters, and other ancillary elements.

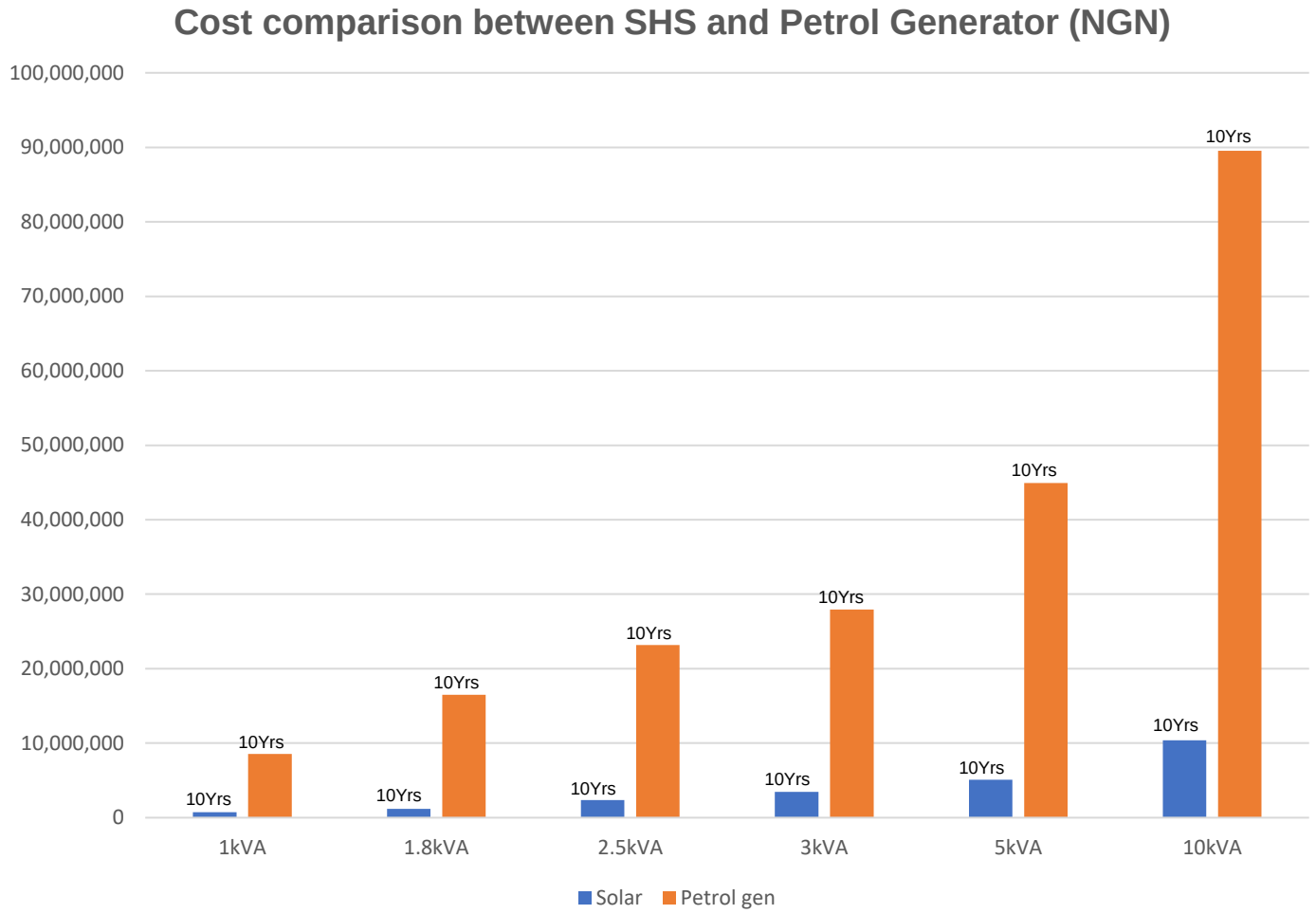
04

Market Sizing of Solar Home Systems

Scenarios for the future of Solar PV System in Nigeria| A deep dive into understanding the market sizing of the solar PV market provides a range of pathways for the future of solar PV market in Nigeria.

- One of the preliminary steps of this segment is to understand the varied common household back-up alternative sources of power, to provide an in-depth perspective into the cost implications of solar-home-system and petrol generators over a period of 10 years.
- To ascertain this, the total cost of ownership and operations were established. This included the initial cost of purchase, installation cost, replacement cost, servicing cost and fueling cost.
- In addition, scenarios were modelled by assuming the future state of adoption by household, installed capacity and revenue by 2030. The methodology established a baseline from year 2022, capturing household size, percentage of socio-economic levels, growth rate, average percentage growth of solar, and the prices of solar components by capacities.
- It is important to highlight that the figures presented in the following sub-sections and used as quantified basis are scenarios and not forecasts. They do not intend to predict what will or should happen. Rather, they intend to provide a range of possible pathways for the future of solar PV market in Nigeria, that could be achieved if a range of conditions are met.

Cost Comparison Back-up Power| The varied back-up alternative sources of power provides an in-depth perspective, validating the required cost implications of Solar-Home-Systems and Petrol generators over a period of 10 years.

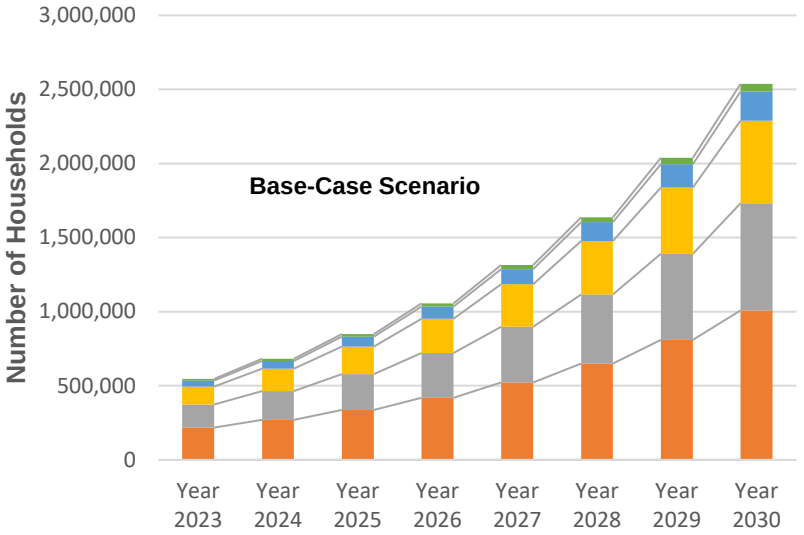


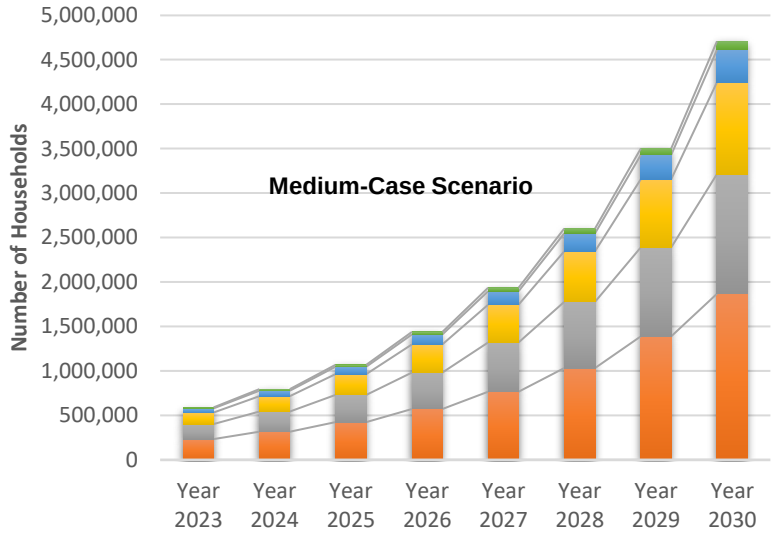
***source PwC Analysis (Refer to Appendix 2)**

Inferences

- In assessing the two alternate energy sources over a decade-long period, it's apparent that the expenditure associated with a generator significantly outweighs those associated with a solar system. This is inclusive of initial investment, running, replacement and maintenance costs—particularly post-petrol subsidy removal.
- Historically, subsidies made generators more affordable for Nigerians. However, with their recent removal, solar system purchases have seen a considerable surge, indicating a shift in the economic behavior.
- According to Kotler and Armstrong (2008), various factors such as psychological, personal, social, and cultural can influence consumer behavior. In the context of alternative energy choices amidst an unreliable power supply, these factors determine preferences for generators or solar systems and significantly impact Nigerian consumption patterns.
- Nigeria's spending culture tends to prioritize immediate benefits, often at the expense of long-term advantages, an inclination shaped by income levels and short-term cost-benefit assessments. There, there may be a significant rise in the offtake of smaller sizes of SHS in swift switch from petrol generation due to the removal of subsidy.

Market Sizing of SHS Analysis by Household| An Analysis showing the possible progressive adoption of Solar Home Systems (SHS)/off-grid solar system in Nigeria in the face of a prevalent usage of fossil fuel generator, shows that there will be a rapid adoption of SHS across a 3-case scenario.





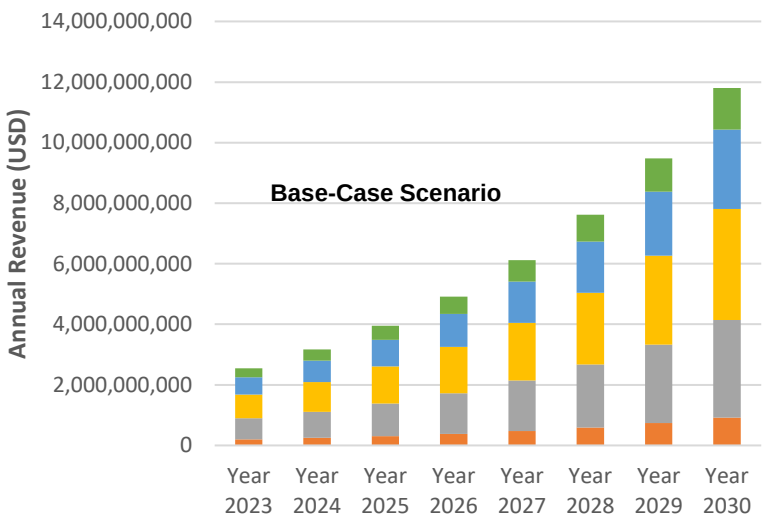
*source PwC Analysis (Refer to Appendix 3)

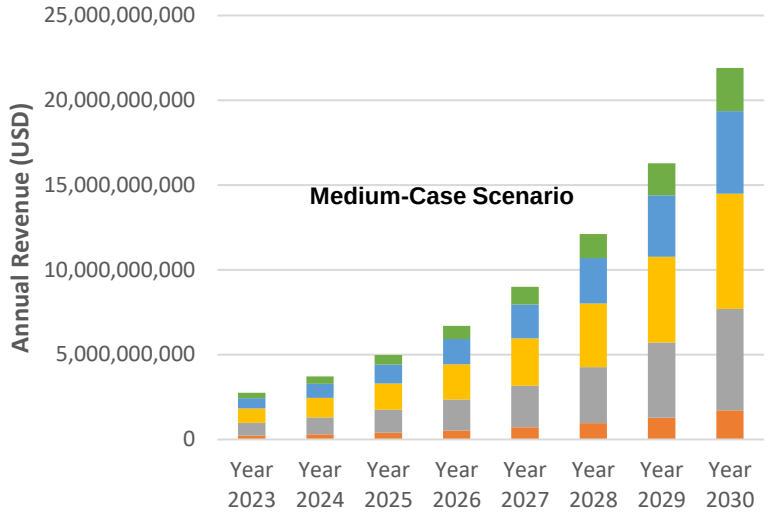
Lower Income Class | Lower-Middle Income Class | Upper-Middle Income Class | Lower-Upper Income Class | Upper Class

Inferences

- Based on the Base-Case scenario of SHS/ off-grid solar system adoption, it is projected that the number of households that will adopt SHS by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **521,966; 375,397; 288,652; 101,701 and 26,921** respectively. This is a total of **2,536,960 household adoption by 2030.**
- Based on the mid level-case scenario of SHS/ off-grid solar system adoption, it is projected that the number of households that will adopt SHS by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **1,868,847; 1,344,070; 1,033,488; 364,131 and 96,388** respectively. This is a total of **4,706,924 household adoption by 2030.**
- Based on the High level-case scenario of SHS adoption/ off-grid solar system , it is projected that the number of households that will adopt SHS by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **3,316,945; 2,385,539; 1,834,299; 646,281 and 171,075** respectively. This is a total of **8,354,138 household adoption by 2030.**
- According to SeforAll, It is estimated that 5 million households will adopt SHS by 2030, this somewhat corroborates the projection of the mid-level case scenario that estimated the total number of household adoption to be 4,706,924 households. https://www.seforall.org/system/files/2022-01/Nigeria_IEPT-Executive_Summary.pdf

Market Sizing of SHS Analysis by Revenue| An Analysis showing the possible progressive adoption of Solar Home Systems (SHS)/off-grid solar system in Nigeria in the face of a prevalent usage of fossil fuel generator, shows that there will be a rapid adoption of SHS across a 3-case scenario.



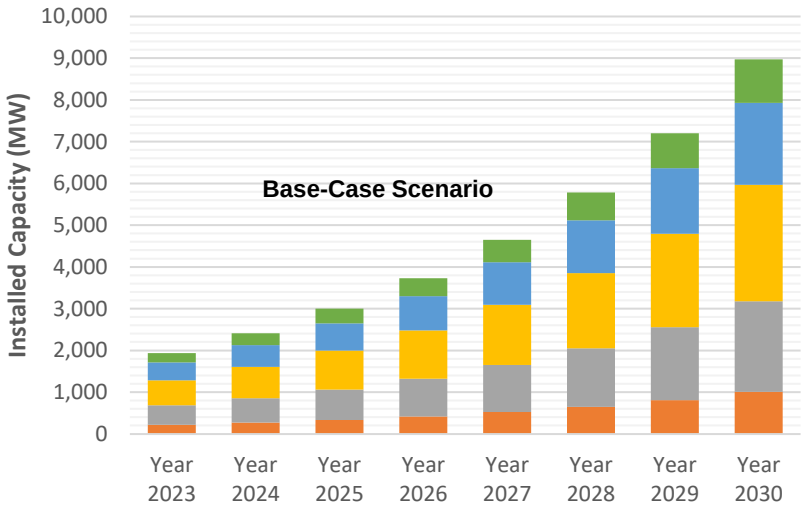


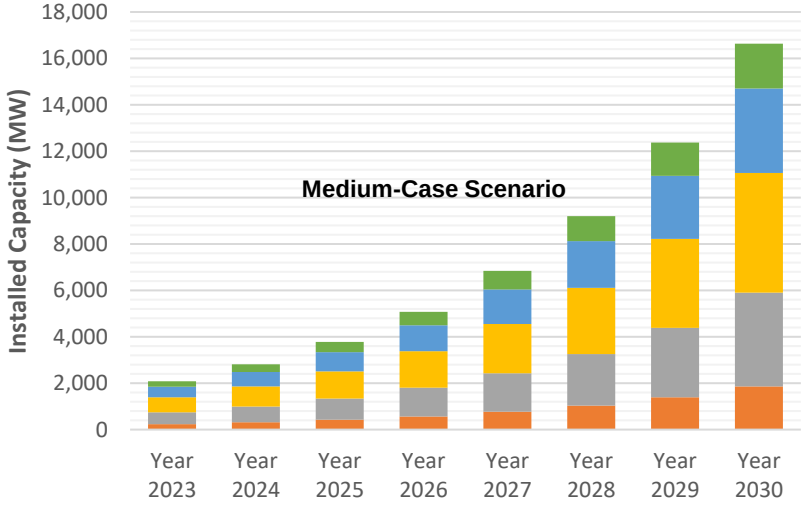
***source PwC Analysis (Refer to Appendix 3)**

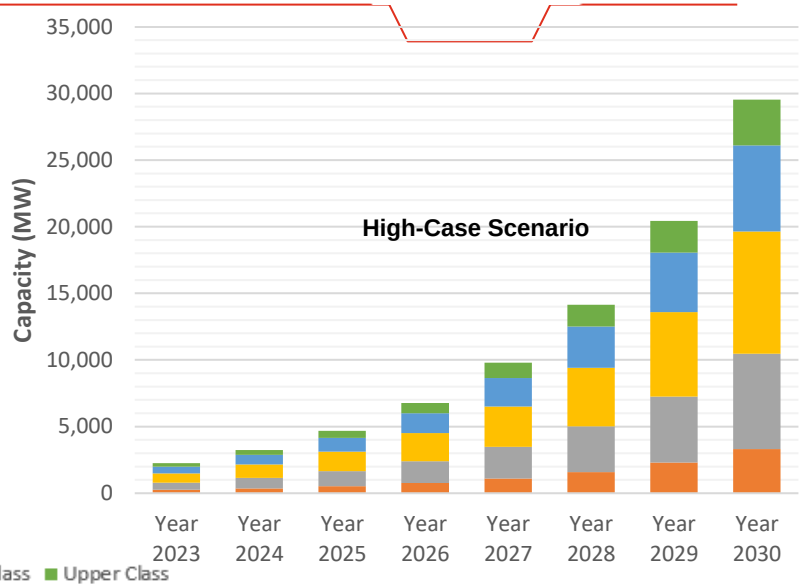
Inferences

- Based on the Base-Case scenario of SHS/ off-grid solar system adoption, it is projected that the total revenue generation by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **$921,870,701; $3,221,655,166 ; $3,661,961,060 ; $2,631,046,288 and $1,372,816,856** respectively. This is a total revenue of **$11,809,350,070 by 2030.**
- Based on the mid level-case scenario of SHS/ off-grid solar system adoption, it is projected that the total revenue generation by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **$1,710,383,411 ; $5,977,265,082 ; $6,794,182,136 ; $4,881,484,919 and $2,547,041,764** respectively. This is a total revenue of **$21,910,357,312 by 2030.**
- Based on the high-case scenario of SHS/ off-grid solar system adoption, it is projected that the total revenue generation by 2030 (following the removal of subsidy) across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **$3,035,693,898 ; $10,608,818,480 ; $12,058,733,217 ; $8,663,960,308 and $4,520,646,711** respectively. This is a total revenue of **$38,887,852,614 by 2030.**
- According to Rural Electrification Agency (REA), off-grid alternatives may create an average of $9.2 billion per year market opportunity. This somewhat corroborate the projection of the low case scenario that estimated the annual average market revenue to be $11,809,350,070. https://www.thecable.ng/renewable-energy-solution-to-connecting-nigerian-off-grid-communities

Market Sizing of SHS Analysis by Installed Capacity| An Analysis showing the possible progressive adoption of Solar Home Systems (SHS)/ off-grid solar system in Nigeria in the face of a prevalent usage of fossil fuel generator, shows that there will be a rapid adoption of SHS across a 3-case scenario.







***source PwC Analysis (Refer to Appendix 3)**

Inferences

- Based on the Base-Case scenario of SHS/ off-grid solar system adoption, it is projected that the number of installed capacity of adoption following the removal of subsidy across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **1,007MW; 2,173MW; 2,785MW; 1,963MW and 1,039MW** respectively. This is a total installed capacity of **8,967MW by 2030.**
- Based on the mid level-case scenario of SHS/ off-grid solar system adoption, it is projected that the number of installed capacity of adoption following the removal of subsidy across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **1,869MW; 4,032MW; 5,167MW; 3,641MW and 1,928MW** respectively. This is a total installed capacity of **16,637MW by 2030.**
- Based on the High level-case scenario of SHS/ off-grid solar system adoption, it is projected that the number of installed capacity of adoption following the removal of subsidy across the Lower income class, Lower—middle income class, Upper-middle Income class, Lower-Upper income class and Upper class, are **3,317MW; 7,157MW; 9,171MW; 6,463MW and 3,421MW** respectively. This is a total installed capacity of **29,529MW by 2030.**
- According to AllOn and NREEP Vision 30:30:30, It is estimated that by 2030, a total of 8,000MW and 9,000MW respectively Solar PV module would have been installed. This somewhat corroborates the projection of the low case scenario that estimated the total number of installed capacity of solar PV module to be 8.967MW by 2030. https://businessday.ng/energy/article/nigerias-installed-pv-capacity-likely-to-reach-8gw-by-2030-report/ https://guardian.ng/opinion/strategies-for-vision-303030/

Key Insights

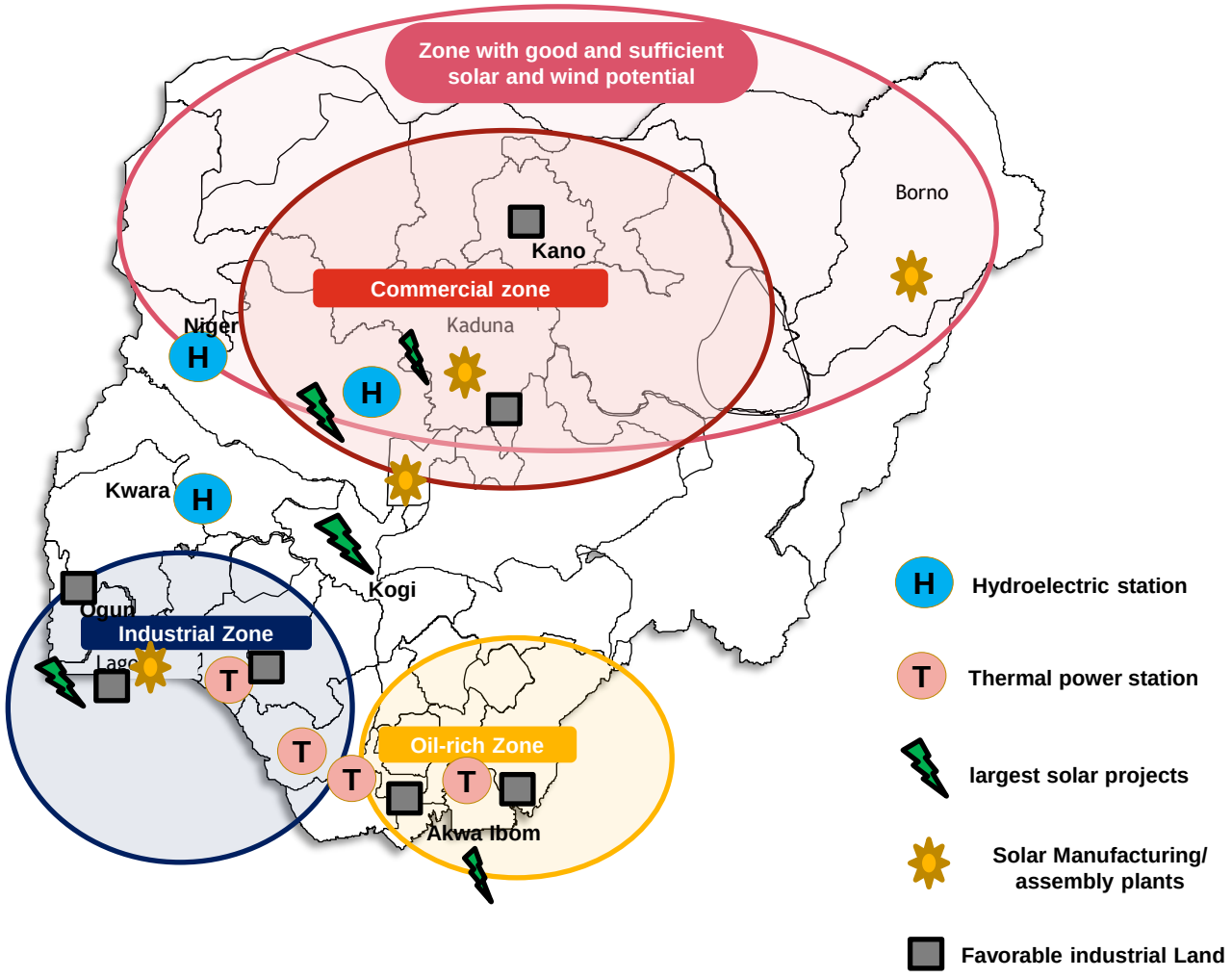
- The recent removal of subsidies and the potential rise in electricity tariffs will impact the cost dynamics of installing solar appliances in Nigeria.
- Previously, the cost was mainly determined by installed capacity, resulting in higher expenses. However, these changes are anticipated to make solar PV more affordable.
- The Federal Government has introduced the Sustainable Energy for All Agenda (SE4ALL-AA), aiming to elevate Nigeria's current power generation of 3,000 Mega Watts (MW) to an impressive 45,101 MW by 2030. In our baseline scenario, we projected an installed capacity of approx. 9,000 MW, accounting for 20% of solar energy generation by 2030. This aligns closely with the BAU projection, where the generation of solar electricity is expected to reach 15% by the same year.
- Additionally, solar PV has demonstrated greater effectiveness compared to grid alternatives, and the presence of backup generators further emphasizes its value.

05

Competitive Landscape

Comparative Analysis| Solar manufacturing in Nigeria shows that the market attractiveness in comparison to selected African countries varies (1/2)

Map of Nigeria showing energy resources distribution and socio-economic zones



*source GENI1, GOGLA, PwC Analysis

Nigeria's Progress in Solar Manufacturing: Progress and Factors for success

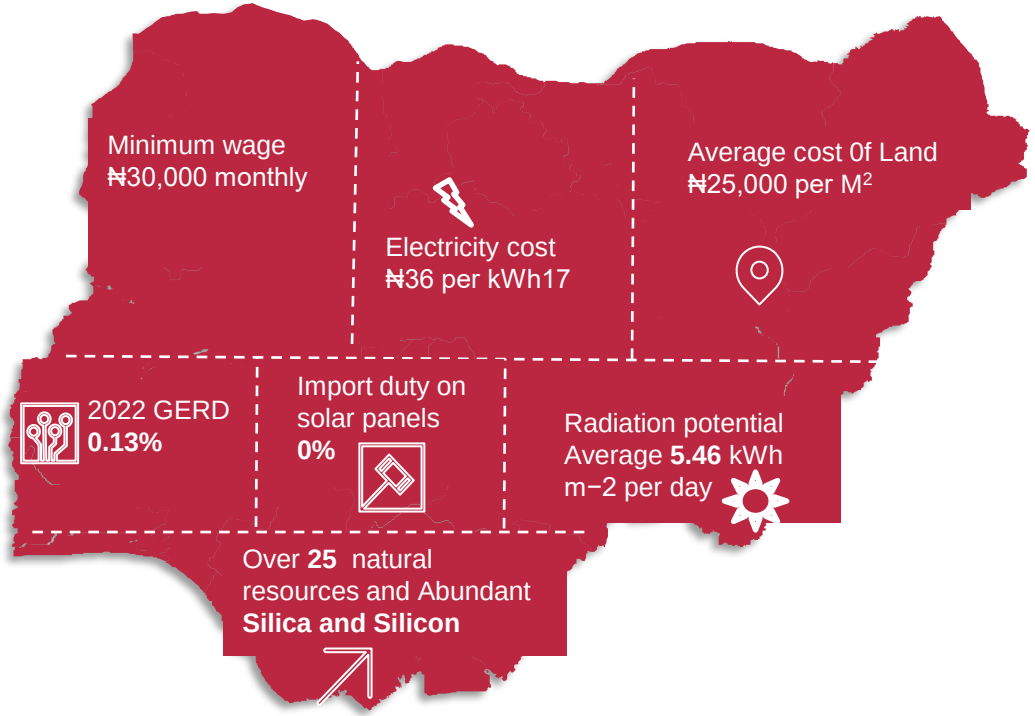
- Nigeria is ascending as a leader in solar manufacturing within Africa, illustrating substantial strides in building its capacity. Solar components, including panels and inverters, are being produced by local manufacturers/assemblers, with Blue Camel Energy, Auxano, Arnergy, and Phoenix standing out as prominent Nigerian solar manufacturers.
- While solar manufacturing capabilities remain relatively limited across the African continent—with only a few countries like South Africa and Egypt exerting substantial effort—Nigeria's accomplishments in this domain are noteworthy. They point to the growth potential for the continent to amplify its manufacturing prowess, contributing to the development of the renewable energy sector.
- There's a significant market growth in Nigeria, bolstered by local manufacturing capacity, governmental backing, and capital investments. However, the continent's overall solar manufacturing is still at an evolving stage.
- The competitiveness of manufacturers in the solar photovoltaic (PV) landscape is heavily influenced by the cost of manufacturing PV components. A reduction in these costs enables companies to present more competitive pricing structures for their solar PV systems.
- Around the globe, technological innovation is the driving force behind advancements in solar manufacturing. This progress has resulted in increased efficiency, superior performance, and lower costs for solar panels and their related components.
- Regarding innovation, South Africa leads in Africa, securing the 29th position in the Global Innovation Index (GII) with a rating of 29.8. Nigeria, on the other hand, is positioned at 113th place with a rating of 16.920 on the GII 6.6.
- The Solar manufacturing sector in Africa is influenced by a range of factors, such as the cost of electricity, cost of land, labor, access to raw materials, regulations, cost of finance, competitive landscape, research and development efforts, and technological breakthroughs.

Comparative Analysis| Solar manufacturing in Nigeria shows that the market attractiveness in comparison to selected African countries varies (1/3)

Factors that Influence Manufacturing in Africa

- **Land:** One of the most expensive parts of establishing manufacturing facilities is the cost of land. It accounts for the majority of the capital costs. Land conversion is a lengthy and intricate procedure that necessitates considerable amounts of finance and time.
- **Cost of Electricity:** Cost of electricity is a significant factor in manufacturing operations, as electricity is often a crucial input for various processes and machinery. The price of electricity used in households in Nigeria amounted to around 23 Nigerian naira per kilowatt hour. On the other hand, industrial electrical energy was priced at approximately 36 NGN per kilowatt hour.
- **Labor:** The cost of labor including wages, benefits, and training, contribute to the manufacturing cost. The availability of skilled labor and the prevailing wage rates in the region has impacted the overall manufacturing expenses
- **Raw Materia**l: According to the CEO of NASENI silica is commonly found in sand, a resource that Nigeria has in abundance but is often neglected and it is a critical component of PV systems.
- **Research and Innovation**: Ongoing research and development efforts drive innovation in solar PV manufacturing. Collaboration between industry, academia, and research institutions has fostered advancements in areas such as materials science, process optimisation, and efficiency improvements. In 2022, Nigeria's gross domestic expenditure on research & development (GERD) accounted for 0.13 percent of its GDP
- **Competition:** Solar PV manufacturers in Nigeria face competition from global players in the industry. The competitiveness of Nigerian manufacturers is influenced by how they stack up against international companies in terms of pricing, quality, technology, and market reach. Nigeria currently does not have the capacity to manufacture solar panels but does limited assembly in volumes that cannot meet up to 10% of market demand by only two operators.

- **Government Support and Policies**: The level of government support, incentives, and policies promoting solar manufacturing is an important parameter. This includes factors such as tax incentives, subsidies, and favorable regulations. According to AFSIA report, Nigeria has implemented certain government policies to support the solar industry. These policies include a 0% import duty on solar panels, a 5% duty on SHS, a 20% duty on other solar components, and a 5% Value Added Tax (VAT) on solar components. Additionally, the solar Nigeria Programme (NSP) has been launched to provide support to the off-grid solar market in the country.



Map of Nigeria showing Key Indexes *source Statista,ILO, Afsia, GOGLA, PwC Analysis

By-Country Analysis| Comparative factors Influencing Solar PV Manufacturing in Six Selected Countries and revealed Nigeria's Competitiveness. (2/3)

Parameters	South Africa	Kenya	Egypt	Morocco	China	India	Nigeria
Government Support	• Renewable Energy development Zones (REDZs) • Tax incentive and grants- No import duties • Renewable energy targets and policy framework..	• Solar panels & inverters are import duties free and between 0%-25% to the rest of solar products • 50% tax relief on initial investment for off grid power firms.	• 5% import duties on solar • State can authorize reduced rates or total VAT exemption depending on the nature of activities of investors	• 10% import duties on solar panels but exempted for water heaters • Net metering available	• Feed-in Tariffs • Research and development funding such as (High tech R&D program) • Export support policies	• Production linked incentive scheme • National solar mission • Make in India initiative • export promotion scheme	• 0% import duty on solar panels, 5% on SHS and 20% for other components. • Solar Nigeria Programme (NSP) supporting the market for off-grid solar
Resource Availability	• The average maximum potential of global horizontal irradiation on a physical level is 5.629 kWh/m2 • Quartz, silicon, lithium, rare earth elements	• The average maximum potential of global horizontal irradiation on a physical level is 5.780 kWh/m2 • Silicon, quartz, lithium, copper, and bauxite	• The average maximum potential of global horizontal irradiation on a physical level is 5.579 kWh/m2 • Quartz and silica	• The average maximum potential of global horizontal irradiation on a physical level is 5.563 kWh/m2 • Quartz and phosphates	• The average maximum potential of global horizontal irradiation on a physical level is 4.127 kWh/m2 • Silicon, rare earth elements, copper	• The average maximum potential of global horizontal irradiation on a physical level is 5.098 kWh/m2 • Silica, skilled labor	• The average maximum potential of global horizontal irradiation on a physical level is 5.436 kWh/m^2 • Silicon, bauxite, copper, lithium, silica and EVA
Labor cost and productivity	• Minimum wage R 23.19 (US$1.34) per hour • labor productivity GDP per hour worked is $23.74	• KSh. 269/40 (US$0.26) per hour • labor productivity per working hour is $4.75	• Minimum wage is LE 3,000 (US$152) per month. (US$0.90) per hour • labor productivity per working hour is $20.86	• Minimum wage 84.37 Dh, (US$1.75) per hour • labor productivity per hour worked is $11.85	• Minimum wage RMB 21 (US$3.30) per hour • labor productivity per working hour is $13.53	• Minimum wage ₹ 160 /day (US$2.16) (US$0.27) per hour • labor productivity per working hour is $8.47	• ₦30,000 per month due to the recent devaluation of the naira has fallen to US$76.92(US$0.48) per hour • Labor productivity is $8.27

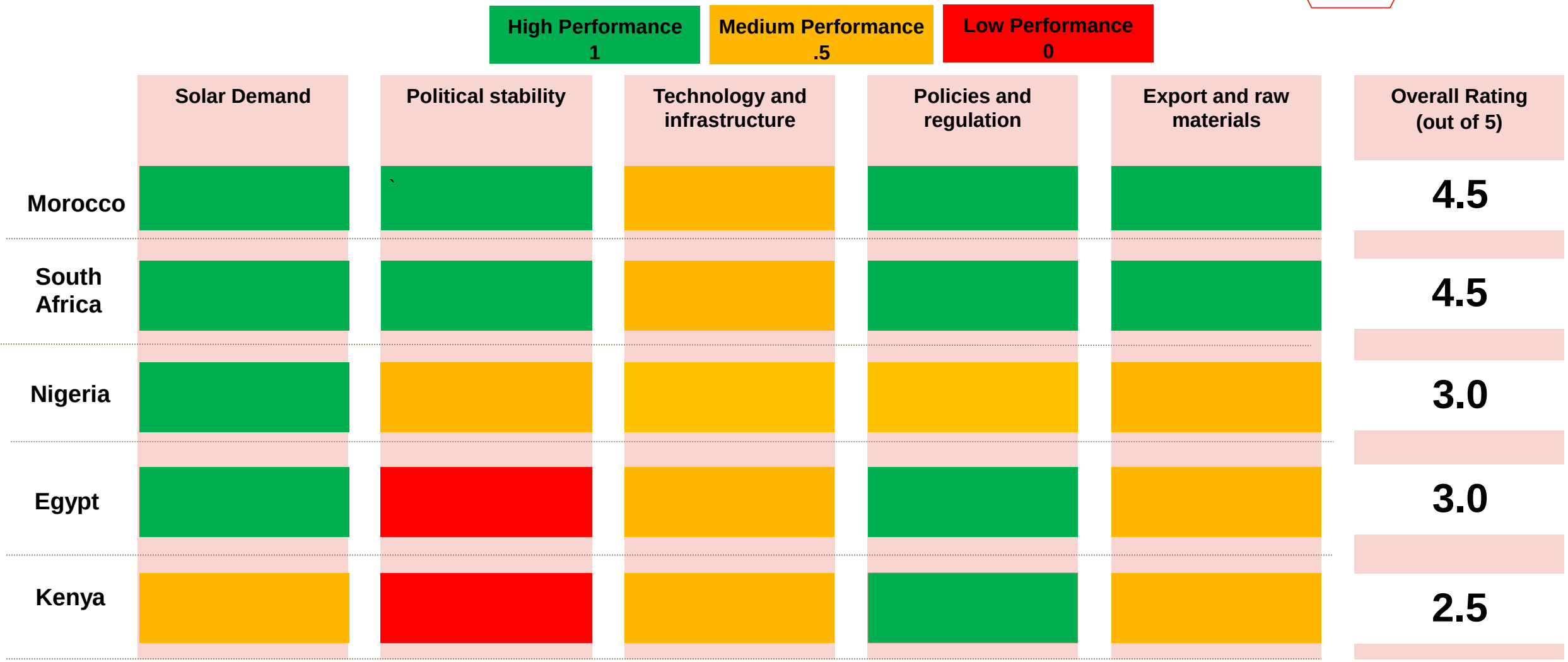
***sources:** Wikepedia, ILO, Afsia, PwC Analysis (Appendix 4)
Afsia- Annual outlook report 2023
Global solar atlas- Global PV potential 2022

By-Country Analysis| Comparative factors Influencing Solar PV Manufacturing in Six Selected Countries and revealed Nigeria's Competitiveness. (3/3)

Parameters	South Africa	Kenya	Egypt	Morocco	China	India	Nigeria
Research & innovation	• The expenditure on (R&D) amounts to US$ 6.6 billion and represents 0.9% of the nominal GDP. • 124 research and publications in renewable energy have an H-index	• The expenditure on (R&D) amounts to US$ 2.06billion and represents 0.81% of the nominal GDP • 53 research and publications in renewable energy have an H-index	• The expenditure on (R&D) amounts to US$ 6.8 billion and represents 1.4% of the nominal GDP. • 143 research and publications in renewable energy have an H-index.	• The expenditure on (R&D) amounts to US$ 1.7 billion and represents 0.8% of the nominal GDP. • 76 research and publications in renewable energy have an H-index.	• The expenditure on (R&D) amounts to US$556 billion and represents 3.1% of the nominal GDP • 436 research and publications in renewable energy have an H-index.	•The expenditure on (R&D) amounts to US$ 15.1 billion and represents 0.66% of the nominal GDP •302 research and publications in renewable energy have an H-index.	• The expenditure on (R&D) amounts to US$ 1.5 billion and represents 0.13% of the nominal GDP • 102 research and publications in renewable energy have an H-index.
Access to Finance	• REIPPP program for private companies to develop solar PV • Establishment of the Development Bank of South Africa and industrial development corporation	• Kenya industrial transformation program • Energy and petroleum regulatory framework are meant to promote and finance solar PV manufacturing	• Renewable energy financing facility • International financial institutions • The 1.8 GW Bendon solar park in Egypt shows the successful mobilization of finance for solar manufacturing in Egypt	• Moroccan Agency for solar energy (MASEN) plays pivotal role through its financing mechanism. • Integrated industrial platform aims to develop a local value chain for solar PV	• China development bank • Export and import of China scale up manufacturing through access to low-cost financing • Favourable policies, and access to capital	• Indian renewable energy development Agency (IREDA) • Solar manufacturing expansion plan (SMEP)	• Nigeria electrification project (NEP) • Commercial banks and financial institutions • Development agencies (IFC, AFDB) stimulate growth in the industry
International Collaboration and partnership	• USAID, JICA,EU,IRENA, and AFDB	• UNIDO, IFC, GGGI,AFDB,EU and power Africa initiative	• EBRB,EU, USAID, GIZ, IFC, AIIB, and IRENA,	ISA, EU, AREI, ACWA, GSEP, TOTAL, SECI and EBRB	• EU, ASEAN, Africa cooperation, belt and road initiative, India collaboration, international research, and development	• ISA, USICEF, US, Japan, Germany, France Australia, Sweden and Israel and Africa partnership	• World bank, UNDP, Global Environment Facility(GEF), BOI, TBEA Co Ltd, ISA, GIZ, and EU. • Generated over $600million

***source:** Statista, Scimago, PwC Analysis (Appendix 4)

By-Country Analysis| A feasibility assessment was conducted to evaluate the potential for manufacturing solar photovoltaic (PV) systems in Nigeria, along with four other countries. The assessment considered five dimensions.



*source : Seforall, PwC Analysis (Appendix 5I)

Comparative Analysis| The Nigerian solar PV manufacturing landscape is dominated by a few local players. The market is not saturated and hence there exists the potential for new entrants for local manufacturing.

Competition and Opportunities in Nigeria's Growing Solar PV industry

- Nigeria's solar PV industry has several key players throughout the value chain. The market is far from saturated, presenting ample opportunities for local and international investors to thrive. While foreign companies currently dominate the solar energy market, an increasing number of players have entered the Nigerian market, considering it as the next significant frontier for solar companies. As the solar market in Nigeria expands, competition among these companies increases
- Competition in the Solar industry is influenced by a variety of factors, such as product type, distribution areas, and price. Price continues to play a vital role in the sector's competitive environment, but product quality is the primary factor that influences competition. In addition, stock availability, because of COVID-19-caused supply chain issues, has been a significant driver of competition in the past two years.
- During the pandemic, global supply chain disruptions, such as shipping delays and increased logistics costs, caused stock shortages and raised the overall cost of products. As a result, there was a general decline in sales. However, these challenges also created market opportunities for domestic manufacturers like Auxano, Phoenix and Blue Camel.
- A potential game-changer for Nigeria's PV electrification is on the horizon with government initiatives like the NASENI Solar Energy Limited (NSEL) solar manufacturing facility. In a joint venture between the National Agency for Science and Engineering Infrastructure (NASENI) and a foreign partner, a PV panel manufacturing plant has been established in Karshi, Abuja, and Nasarawa. These plants have an impressive capacity of 7.5 MW/year and 100 MW/year respectively, and they have the potential to significantly reduce the cost of PV systems. As a result, PV electrification in Nigeria could become more competitive.

Domestic Manufacturers/ Assemblers

BLUE CAMEL ENERGY · AUXANO SOLAR · phoenix · Eastman ENERGY. UNLIMITED. · LPVenergies · NSEL · one watt solar

Distributors

arnergy · LUMOS · SOLAR FORCE RENEWABLE ENERGY · GV "...Creating a Reliable Renewable Energy Future!!!" · GREENPOWER

Rapid Expansion of Distribution and growing competition

- In the solar energy market, vertically integrated companies dominate, engaging in business-to-business (B2B) and direct distribution. These companies have control over various stages of the value chain, including the manufacturing and distribution/installation of solar PV systems.
- They oversee the entire process, from the production of solar panels to the integration of components such as batteries, inverters, and charge controllers. However, the market landscape is changing, as more distributors are entering the Off-grid Solar market and forming partnerships with Chinese and Canadian manufacturers. This indicates increased competition and the widespread presence of foreign solar products in Nigeria through these distributors 4.
- These new entrants are expanding the market and offering alternative options to consumers, potentially diversifying the range of products available.
- This trend highlights the evolving nature of the solar energy market in Nigeria, with a shift towards greater competition, increased availability of products, and partnerships between local distributors and international manufacturers.

By-Company Analysis| Based on the Competitive Parameters identified, we selected Five key players in the Manufacturing and Assembly of Solar PV systems in Nigeria (1/2).

Parameters	Auxano	Blue Camel	Onewattsolar	Levene	Phoenix
Company Highlights	Auxano are one of the first Privately owned Solar PV manufacturing company in Nigeria. They are continually re-inventing new and better ways to provide more efficient and more affordable solar, inverter systems.	Blue camel design and Integrate renewable energy solutions which cut across all levels of energy demands ranging from small household solar and hybrid systems to mini solar grid systems for rural electrification and industrial power backup systems.	OneWattSolar is a mobile technology platform that delivers tokenized digital services and products enabled by blockchain architecture and backed by IoT & AI.	Levene is an innovative solutions provider to the global energy sector leveraging on advanced technology, highly qualified professionals and global best practices to create value for its stakeholders.	Phoenix is a renewable energy company focused on solar PV solutions. They offer a diverse range of renewable energy solutions, including solar home systems, solar street lights, mini grids, EV conversion and manufacturing, as well as solar vehicles and tricycles.
Market information	Target market is to provide quality locally assembled solar panels for the local market and West African markets.	Provider of efficient Solar Power Solutions to leading companies, major oil companies, homes, schools, and Governments in Nigeria	Provider of solar electricity and a host of additional services across Africa to meet the day-to-day needs of people and businesses.	Provides locally assembled solar panels to the renewable energy industry in Nigeria.	Phoenix aims to serve as the target market by offering solar energy solutions to governments, businesses, and households in Nigeria and West Africa. They currently provide their services to neighboring countries such as Cameroon, Chad, and Niger.
Products and Services	Auxano Solar offers a range of solar modules, including mono crystalline modules with power capacities ranging from 100W to 380W, as well as polycrystalline modules with capacities from 100W to 330W. Their services encompass assembling, installation, sales of components, and other tailored solutions.	Blue Camel offers a range of solar products, including solar perimeter and street lighting (60W to 100W), solar borehole and water reticulation systems, and solar water heating systems. Their services cover power backup, UPS, solar refrigeration, as well as repair and maintenance.	Products include Chioma (Solar Energy management systems) and Amina (remotely monitors solar infrastructures) services are installations, maintenance, operations, and management of Solar rooftop systems.	Levene Energy provides solar home system kits and panels, offering comprehensive solar technology solutions.	Offers renewable energy solutions, and products include solar home systems, solar street lights, mini-grids, EV conversion, and manufacturing, as well as solar vehicles and tricycles

***sources:** PwC Analysis (Appendix 4); https://auxanosolar.com/, https://bluecamelenergy.com.ng/, https://onewattsolar.com/, https://leveneenergy.com/

By-Company Analysis| Based on the Competitive Parameters identified, we selected Five key players in the Manufacturing and Assembly of Solar PV systems in Nigeria (2/2).

Parameters	Auxano	Blue Camel	Onewattsolar	Levene	Phoenix
Technology Integration	Auxano Solar introduces a newly enhanced 5kW 48V Must Power Inverter Hybrid, featuring an 80A MPPT inbuilt solar charge controller.	Blue Camel boasts of an R&D department and a training workshop, where they have developed various integrated lighting solutions and greenhouse technologies..	Technology capabilities in AI, IoT, big data, machine learning, and blockchain enable a unified platform for all stakeholders	Installing integrated photovoltaic technology in buildings to generate power and also improve the overall aesthetic of the building.	They have introduced an automated tabber and swinger technology, where robots perform a majority of the assembly processes. This high-precision technology has positioned Phoenix Energy as a giant in the industry.
Local and Distribution Network	The plant is situated in Lagos, Nigeria, and their products are distributed throughout various regions including the southwest, south-south, and north-central parts of the country, namely Lagos, Delta, Abuja, and Rivers. With over 20000 People Reached	The plant is located at heart of the Kakuri Industrial layout in Kaduna State. Products are distributed across Northwest, and northcentral (Kaduna and Abuja)	One watt solar is located in Lagos and they have over 744 Solar Associates and 6696 Customers across West Africa.	Levene Energy has offices in Abuja and Lagos in Nigeria and their products are distributed across Nigeria. .	The manufacturing facility is situated in Borno, Nigeria, and the company distributes its products across West Africa. While Nigeria serves as the major market, their products also reach other countries in the region such as Chad, Niger, Cameroon, and the Central African Republic (CAR).
Project Capacity	• 100MW solar panel solar factory. • **Key projects** VON-240kWp Solar power system, Bourdillion- 70kWp Solar power system with 216kWh battery storage capacity	• Production Plant and a Training Academy seating on a 3 hectares piece of land. • Key Project Guzape- unique 10-apartment block building, running totally off the grid	• 4018MWh Generated Capacity so far	• 100MW capacity Solar PV manufacturing plant. • Plan to deploy Pay As You Go (PAYG) Solar Home Systems to over 250,000 homes	• 80MW capacity Solar PV manufacturing plant.

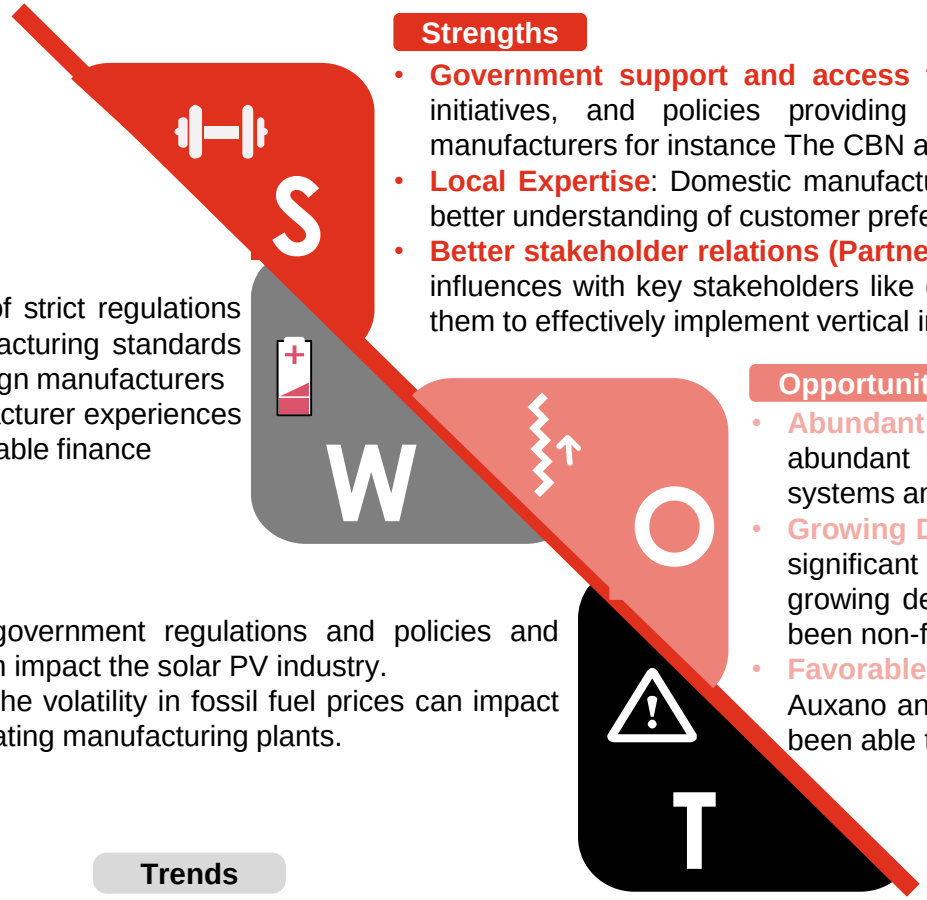
***sources** : PwC Analysis (Appendix 4) https://auxanosolar.com/ https://bluecamelenergy.com.ng/ https://onewattsolar.com/ https://leveneenergy.com/

By- Company Analysis| Comparative analysis of Comprehensive solution companies, Distributors, and Indirect Competitors in Nigeria's Solar PV Industry

The solar photovoltaic (PV) industry in Nigeria is witnessing rapid growth and competitiveness, extending beyond solar PV manufacturers. Indirect competitors, such as battery manufacturers, solar PV distributors, and comprehensive solutions companies, are also vying for market share. These entities play a critical role in supplying essential components, offering support, and providing expertise to ensure the effective deployment of solar PV systems. In this analysis, we will delve into Nigeria's solar PV market, examining six selected competitors from the battery manufacturing, solar PV distribution, and solutions sectors. By studying their offerings and strategies, we aim to gain insights into the broader solar PV ecosystem in Nigeria and its diverse range of players.

Forgo battery	Star plus battery	Pelton battery	Solar force	Arnergy	Gennex technologies
• leading player in automotive and Solar battery sector in Nigeria. • Installed capacity of about one million units (1,000,000) of battery annually • Trade relation with China, and Turkey	• manufacturing company for Inverter Battery in Nigeria • The plant produce an annual output of (10,000) Units of Ampere-Hours of industrial power • Partners with PAN Nigeria business and leading international manufacturers	• Pelton batteries are manufactured in Nigeria and aimed to satisfy the need for sustainable renewable energy in Nigeria • batteries are designed to last more than 15 years of everyday usage,	• involved in the retail, distribution, and installation of Solar Energy products and systems in Nigeria. • 1035 Successful projects and 2034 unique designs in 32 states across Nigeria., • Affiliates of Solar Force Corporation USA	• Provides solar power solutions for homes, businesses and communities • 4.5GWh generated, over 6.5MWp installed solar PV capacity and 17.8MWh active storage system	• specialize in solar and backup solutions for residential and commercial facilities • offers a range of products from global manufacturers like Canadian Solar and Jinko Solar.

SWOT Analysis| The Strengths and Opportunities We Identified in Our Analysis of the Key Players in Nigeria outweighs the threat and weakness, indicating a favorable market and immense potential for growth



Strengths

- **Government support and access to finance**: They benefit from government incentives, initiatives, and policies providing a supportive environment for domestic solar PV manufacturers for instance The CBN and NEP funds.
- **Local Expertise**: Domestic manufacturers have knowledge of the local market. They have a better understanding of customer preferences, market dynamics, and regulatory environment.
- **Better stakeholder relations (Partnership)**: Domestic manufacturers may benefit from strong influences with key stakeholders like distributors, installers, and financial institutions, allowing them to effectively implement vertical integration within the solar industry's value chain.

Weakness

- **Lack of stringent Regulations**: Lack of strict regulations and poor adherence to solar PV manufacturing standards make it challenging to compete with foreign manufacturers
- **Cost of finance:** The domestic manufacturer experiences issues associated with assessing affordable finance

Opportunities

- **Abundant Natural Resources and Raw Materials**: Nigeria possesses abundant raw materials required for the manufacturing of solar PV systems and components readily available for domestic manufacturers.
- **Growing Demand**: Nigeria has an extensive energy deficit, this provides significant opportunities for Domestic solar PV manufacturers to meet the growing demand, for instance, in Maiduguri where the national grid has been non-functional for the past two years due to damage
- **Favorable Regulations and government initiatives**: Companies like Auxano and Onewattsolar are benefiting from these incentives and have been able to access funding from financial institutions

Threats

- **Political Stability:** Changes in government regulations and policies and Insecurity and terrorist activities can impact the solar PV industry.
- **The cost of energy:** Energy and the volatility in fossil fuel prices can impact the expenses associated with operating manufacturing plants.

Trends

- Currently, Nigeria is witnessing an expansion in the deployment of solar home systems, driven by the rising prices of fossil fuels and electricity tariffs. The government has implemented initiatives and incentives to encourage the adoption of solar energy such as PAYGO. Additionally, trends include a focus on raising awareness and providing education about solar energy, research and development efforts, increased investments, and a wider range of financing options.

Trend Analysis| Nigeria's Solar PV industry as a whole has a positive outlook with a number of trends positively impacting the sector (1/2)

Solar PV Industry themes and headlines

S/N	Themes	Description	Impact on the Sector and its Players	Implications for the nation / industry players
1	**Increasing demand for electricity**	• Nigeria's electricity consumption rate is significantly below its demand for electrical energy. • This electricity demand-supply gap is expected to grow significantly, if nothing is done to improve the state of power supply in the nation as the demand for electricity will continue to rise with the nation's growing population which is currently above 200 million. • The erratic power supply and inability of the national grid to meet electricity demand in the country has led to the growth of private companies who provide alternative means of power off the national Grid	Driver ↑	• This electricity demand-supply creates the need for new power projects. • This creates a market for the renewable energy generation for industry players
2	**Available raw materials in the country**	• Nigeria boast of a huge reserves of minerals and ores. Field result suggests that 100% of the raw materials needed for battery manufacturing are available in commercial quantity. • Nigeria is also endowed with commercially viable amounts of the major raw materials required in the solar PV value chain	Driver ↑	• The Federal Government should develop mineral-specific value addition policies. • These policies would encourage downstream processing before export to increase sustainable economic growth from mining. The policy would also position local industrial activities to be aligned with mining activities.
3	**Low Technical Capability**	• Despite the availability of raw materials for solar PV and battery manufacturing in commercial quantities, exploration of these resources remains strife with incapacities for efficient extraction. Nigeria currently imports over 85% of crucial technological components for solar PV systems.	Barrier ↓	• Government and industry players must place concentration and emphasis on the development of technical capabilities for raw material processing and manufacturing of components required to stimulate the country's production sector
4	**Government focus**	• According to the Renewable Energy Master Plan, renewable energy is expected to supply 36% of power generation in Nigeria by 2030 • Several supportive incentives, initiatives and policies have been launched by the Nigerian government in an effort to boost the adoption of renewable sources of energy. These include the Nigerian electrification program amongst others	Driver ↑	• As Government intensify efforts to improve power generation by focusing on renewable energy projects, Industry players must position themselves to take advantage of the opportunities that presents themselves as a result of Government interventions

↑ Positive ⟷ Neutral ↓ Negative

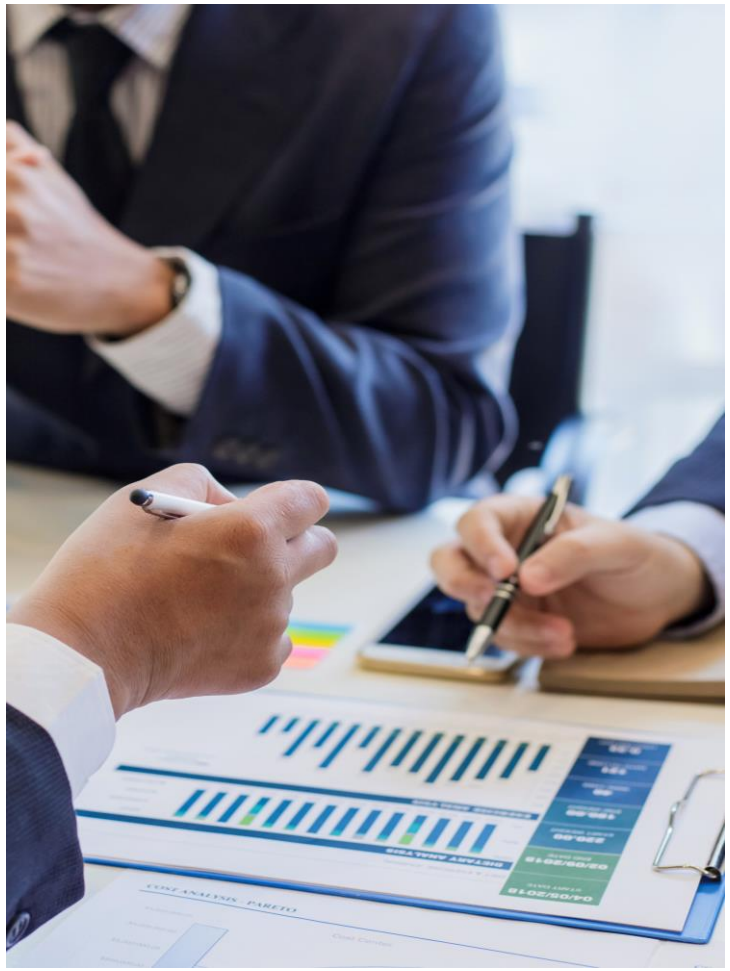
Trend Analysis| Nigeria's Solar PV industry as a whole has a positive outlook with a number of trends positively impacting the sector (2/2)

Solar PV Industry themes and headlines

S/N	Themes	Description	Impact on the Sector and its Players	Implications for the nation / industry players
5	**Technology**	• Advancements in Technology (electric cars, automation, robotics, Aritificial Intelligence, etc..) will boost the need for various forms of energy in the future. The use of these cutting-edge technologies has brought about major disruptions and are major market drivers in various industries including Power. • However, Nigeria is yet to catch up with these trends	Driver / Barrier 	• There is need to intensify efforts in Nigeria's technological developments with special focus on the ones needed in the industrial sector.
6	**Sustainability Concerns**	• Growing demand for a move away from a fossil fuel-based economy to renewable energy solutions has led to an increase in renewable sources of energy including solar energy. The rise in solar uptake leads to increased e-waste which may trigger solar e-waste issues due to components reaching their end-of-life (EOL), including solar panels, batteries, inverters, and other ancillary elements.	Driver / Barrier 	• Industry players are adopting sustainable manufacturing and processing techniques and practices in their manufacturing processes
7	**Rising renewable energy financing**	• Over the recent years, the Solar PV industry has witnessed several initiatives and institutional finance schemes providing funding to the sector. Similarly, several donor organisations have contributed funds to facilitate further growth in the solar industry.	Driver 	• Industry players should take advantage of the increased funding available to the sector as many foreign government and financial institutions are limiting their commitments to financing upstream projects and diversifying such funds to cleaner energy financing
8	**Decreasing cost renewable energy sources**	• The global trend has shown that the costs associated with generating energy from renewable sources has slowly declined. • For example, the cost of generating electricity from utility-scale solar photovoltaics (PV) fell by 85% between 2010 and 2020.This decline is driven by steadily improving technologies, competitive supply chains and developer experience	Driver 	• These reduced costs will facilitate the acceptance of renewable energy especially in developing countries like Nigeria which creates a market for renewable energy products

Key Insights

- Key players like Phoenix, Auxano, and Onewattsolar are actively involved in exporting solar products to various African countries.
- They have established a robust distribution network that covers both West Africa and Central Africa.
- This enables them to reach customers in neighboring countries and contribute to the growth of solar energy adoption across the region.
- Nigeria possesses abundant raw materials required for the manufacturing of solar PV systems and components.
- The CEO of NASENI has emphasized that solar cells- a critical component of PV systems- are derived from silicon, which can be obtained from silica.
- Notably, silica is commonly found in sand, a resource that Nigeria has in abundance but is often neglected.
- Additionally, Nigeria also has ample raw materials for battery production, which holds the potential for relatively lower battery costs.
- The Nigerian government has implemented various incentives and favorable policies to support the renewable energy sector.
- One such policy is the provision of import waivers for renewable energy products, which helps reduce costs for manufacturers and assemblers.
- Companies like Auxano and Onewattsolar are benefiting from these incentives and have been able to access funding from financial institutions and funders.
- These initiatives play a crucial role in encouraging investment and growth in the renewable energy industry in Nigeria.
- Nigeria benefits from abundant solar radiation, providing favorable conditions for solar energy generation.
- The country's geographical location enables it to receive significant solar irradiation throughout the year.
- Moreover, Nigeria possesses access to favorable industrial land, which serves as a competitive advantage for the solar energy sector.
- The availability of suitable land facilitates the establishment of solar projects and supports the growth of the industry by providing space for solar installations, manufacturing facilities, and related infrastructure.



06

Challenges and Recommendations

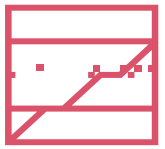
Challenges| In the Nigerian context, the subdued local manufacturing capacity for PV modules can be attributed to pivotal challenges. These encompass limited awareness and an underdeveloped infrastructure, both of which are currently constraining the widespread manufacturing of PV systems.(1/2)

Presently, Nigeria has constrained capacity to manufacture solar panels - through its pioneer Solar PV Module/Solar Panel Manufacturing parastatal – NASENI Solar Energy Limited (NSEL), and till date, NSEL only does batch instead of continuous production due to inconsistent patronage. Nigeria also does limited assembly in volumes that cannot meet up to 10% of market demand by few operators such as: Lagos based Auxano Solar and Blue Carmel Energy Ltd based in Kaduna[5,11]

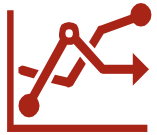
Although the market is said to be among one of the fastest growing markets, it is currently faced with the following challenges:

Underdeveloped local raw materials market with limited mining activities in Nigeria despite known abundance of mineral deposits. Several raw materials such as Lithium, Aluminium, Copper and Silicon have known deposits in most states but are yet to be effectively utilised due to limited research, low technological development and other bottlenecks related to resource management & administration. This also creates a need to import raw materials required for local manufacturing.

Ineffective implementation of enabling policies and incentives in Nigeria which discourages investment. In recent times, the government has made considerable efforts to establish legal frameworks and policies that promote renewable energy development however implementation of those policies remain a problem coupled with uncertainties during government changes.



A lack of clear and easily enforceable quality standards which leads to importation of substandard products and system failure. Several solar energy technologies in the country tend to drop in performance shortly after installation. This failure is mainly caused by to use of substandard products, lack of appropriate maintenance, and/or environmental and climate effects. This makes existing and potential consumers turn away from using solar systems.



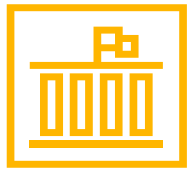
Economic fluctuations and Low Upstream activities: Fluctuations in currency exchange rates, inflation, low purchasing power of consumers and uncertainty in the business environment are affecting the cost of importing raw materials and components needed for manufacturing. This can lead to limited domestic production of raw material and increased production costs which potentially disrupt the supply chain.

Sources: Renewable Energy Association of Nigeria "Perception survey of local manufacturers in the Nigerian renewable energy sector: Local performance along the solar value chain" 2021

Challenges| In the Nigerian context, the subdued local manufacturing capacity for PV modules can be attributed to pivotal challenges. These encompass limited awareness and an underdeveloped infrastructure, both of which are currently constraining the widespread manufacturing of PV systems.(2/2)

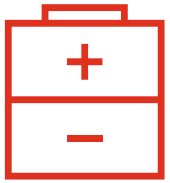
The solar industry in Nigeria is ragged by significant challenges affecting manufacturers, distributors, potential investors and other key players in the value chain alike. In addition to the prevailing economic conditions, the growth of the industry is also influenced by the following factors:

Insurgence and insecurity in certain regions of the country has made manufacturing and assembly difficult. With insecurity concerns and unstable sociopolitical conditions, business operations have been negatively impacted and for some companies, completely halted pending conflict resolution. This has resulted in reduced production and operations, slowing down growth in the industry.



High initial set-up costs for solar PV production and a lack of access to affordable financing for potential manufacturers hinder uptake in the industry. The production and distribution of solar PV systems and products attract taxes and tariffs, resulting in higher costs. With a lack in technological capability & diversity, inadequate local technical know-how, lack of support to research & development as well as the high interest rates, financing has a major impact on the solar PV industry.

Lack of Awareness of domestic Solar PV products - even if it has increased in recent years, a lack of consistent demand for domestic solar PV products hinders scalability of local manufacturing of solar PV systems. This is why manufacturers such as NSEL still produce in batches and not continuously.



Nigeria is infamous for its **insufficient power supply and limited grid development**, which also hinders the scale-up of solar manufacturing. Solar PV production requires significant energy inputs, which may not be readily available to support local manufacturing.

Next Steps| Shining a path forward: Key policy recommendations to grow and strengthen Solar PV Manufacturing in Nigeria(1/2)

S/N	Challenges	Recommendations
1	Underdeveloped local raw materials solar pv market with limited mining activities in Nigeria despite known abundance of mineral deposits.	• Urgent Comprehensive Mineral Resource Survey. • Infrastructure Development • Collaboration & Partnership • Environmental Safeguards
2	Ineffective implementation of enabling policies and incentives in Nigeria which discourages investment.	• Urgent Policy Audit and Review • Enhancement Inter-Agency Coordination • Establishment of Policy Monitoring Units • One-stop Investor Support Services
3	A lack of clear and easily enforceable quality standards.	• Development of National Solar PV Standards • Certification and Labeling • Penalties and Incentives • Foster R&D Initiative
4	Economic fluctuations and Low Upstream activities.	• Investment in Upstream Exploration • Establishment of Strategic Reserves • Incentives for Upstream Activities

Next Steps| Shining a path forward: Key policy recommendations to grow and strengthen Solar PV Manufacturing in Nigeria(1/2)

S/N	Challenges	Recommendations
5	Insurgence and insecurity in certain regions of the country has made manufacturing and assembly difficult.	• Regional Diversification • Risk Mitigation and Insurance • Development of a Supply Chain Resilience framework
6	High initial set-up costs for solar PV production and a lack of access to affordable financing.	• Localized Financing Solutions • Access to tailored International Grants and Funds • Tax Incentives and Subsidies • Establishment of Special Economic Zones
7	Lack of Awareness of domestic Solar PV products.	• Country-wide Industry Roundtable. i.e. investment summits, campaign, roadshows, etc. • Production of solar PV systems that are suitable for domestic climate in Nigeria.
8	Insufficient power supply and limited grid development.	• Incentivise Energy Efficiency

Conclusion| To solidify its leadership in Africa's renewable energy landscape, Nigeria must strategically refine its policy implementation, address security and infrastructure challenges, and prioritise the solar PV sector's development, ultimately driving socio-economic growth and ensuring a sustainable future.

In summary, Nigeria stands on the precipice of a transformative era in its renewable energy journey, particularly in the solar PV sector. Prioritizing the development of the solar PV raw materials market, refining policy implementation, setting clear quality standards, and stabilizing the economy will place Nigeria at the forefront of Africa's renewable energy landscape.

Addressing security challenges, optimizing initial setup costs, raising awareness about domestic solar products, and bolstering power and grid infrastructure are indispensable actions. By strategically focusing on these facets, Nigeria can not only harness its inherent solar potential but also position itself as a beacon of renewable energy, driving socio-economic growth and ensuring a sustainable, bright future for its populace.

07

Appendix

Appendix 1. Approach for the identified requirements in the manufacturing of Solar PV and Battery within Nigeria

This provides an insight into the approach taken when evaluating selected requirements and parameters for the manufacturing of Solar PV and Battery technologies in Nigeria. The approach involves assessing the applicability of these requirements to the unique context of solar PV and battery production

- **Existing industrial ecosystem** in the region or in the country testifies that other actors have succeeded in developing an activity at the industrial level (even in another sector than photovoltaics or renewables at large) and have consequently paved the way for further industrial activities to develop.
- **Domestic solar demand**, the presence of a dynamic and relatively large demand of PV systems locally
- **Existing upstream PV actors** are not only proof that players from the same industry have managed to set up a local manufacturing activity but are also an opportunity to be positioned as a key supplier or off-taker of these existing stakeholders.
- **Availability of raw materials** in the same region or country as the planned manufacturing activity can be key if the manufacturing process largely relies on one raw material or if the needed raw materials can be difficult to transport.
- **Access to capital** refers to an applicant's ability to receive funding based on elements proper to the applicant's project Once the access to capital is granted, interest rates are an important element as they are a key influential factor for the final competitiveness that can be achieved.
- **Favorable exchange rate** this can make your exports more competitive and reduce the cost of importing raw materials and components, potentially boosting your manufacturing sector.
- For the considered industrial activities, **electricity** is a crucial commodity, and access to cheap electricity
- **Technology and R&D** focuses on creating and improving products, processes, and technologies. Investing in R&D enables manufacturers to develop innovative products, improve existing ones, and optimize production methods
- **Ease of doing business** is a broad indicator defined by the World Bank, which includes a series of elements such as the ease of starting a business, ease of receiving a building permit, status of juridical protection, existence of trade agreements, the level of taxation as well as the stability of the currency or of the political environment.
- **Effective supply chain** management aims to optimize efficiency, reduce costs, and ensure timely delivery of products while maintaining quality.

Strong

A rating of 1 signifies a high level, indicating exceptional performance and outstanding results for Nigeria, considering the present trends and favorable circumstances.

Weak

A rating of 0.5 indicates a medium level, reflecting moderately favorable conditions of the chosen parameters in Nigeria, taking into account its performance within the existing trend.

Poor

A rating of 0 corresponds to a low level, representing unfavorable conditions of the chosen parameter in Nigeria, considering its trends and performance.

Appendix 2. Cost comparison between SHS and Petrol Generator (1/2)

NOTE	Description of Assumptions	
According to Investopedia, Total Cost of Ownership (TCO) is the purchase price of an asset plus the cost of operation. To break it down further, TCO can be calculated using the formula: TCO = I + O + M + D - S I = Initial/Purchase cost O = Operating Cost M = Maintenance Cost D = Downtime Cost S = Salvage Value	**Petrol/ Diesel Generator**	**Solar**
	1) Generator is replaced in Year 5 and Year 9 (estimated average of 40,000 hrs-usage) 2) Purchase cost of generator remains constant (Very unlikely) 3) Average cost per KVA of generator in Naira 4) Cost of petrol may not constant (Considering the trends in relation to subsidy removal) 5) Salvage value of the generator is not considered 6) Generator may not develop any mechanical or electrical fault all through its lifespan (e.g. battery problems, carburetor, tank leakage, e.t.c.) 7) Petrol and engine oil consumption is fairly stable all through its lifespan (Very unlikely efficiency drops as engines age) 8) Cost of installing the generator is not considered (since wiring is done once)	1) Total cost of Solar system 2) Batteries are replaced two times in the 10 year period. This is conservative, considering that batteries could last longer than three years. 3) Dry cell batteries are used. These require zero post-installation maintenance 4) Solar panels will serve between 20years and 30 years 5) Inverter is replaced once in a 10 year period 6) Cost of batteries, inverters and solar panels vary across product type and location (Very likely cost of solar equipments increase in price due to FX and economies of scale. This trend is most likely to continue especially with the removal of subsidy) 7) Salvage value of batteries is not considered 8) Savings on utility bill is not considered.

Please note that this analysis was done in respect to 7hrs uninterrupted power supply.

Appendix 2. Cost comparison between SHS and Petrol Generator (2/2)

1kVA Total Cost		
Year	Solar	Petrol Gen
1	460,000	**930,218**
2		820,218
3		820,218
4		820,218
5		**930,218**
6	250,000	820,218
7		820,218
8		820,218
9		930,218
10		820,218
Total Cost	**710,000**	**8,532,175**

1.8kVA Total Cost		
Year	Solar	Petrol Gen
1	720,000	**1,738,435**
2		1,608,435
3		1,608,435
4		1,608,435
5		**1,738,435**
6	450,000	1,608,435
7		1,608,435
8		1,608,435
9		**1,738,435**
10		1,608,435
Total Cost	**1,170,000**	**16,474,350**

2.5kVATotal Cost		
Year	Solar	Petrol Gen
1	1,360,000	**2,498,009**
2		2,239,009
3		2,239,009
4		2,239,009
5		**2,498,009**
6	1,000,000	2,239,009
7		2,239,009
8		2,239,009
9		**2,498,009**
10		2,239,009
Total Cost	**2,360,000**	**23,167,090**

3kVA Total Cost		
Year	Solar	Petrol Gen
1	1,950,000	**2,981,940**
2		2,711,940
3		2,711,940
4		2,711,940
5		**2,981,940**
6	1,500,000	2,711,940
7		2,711,940
8		2,711,940
9		**2,981,940**
10		2,711,940
Total Cost	**3,450,000**	**27,929,395**

5kVA Total Cost		
Year	Solar	Petrol Gen
1	2,900,000	**4,601,018**
2		4,446,018
3		4,446,018
4		4,446,018
5		**4,601,018**
6	2,200,000	4,446,018
7		4,446,018
8		4,446,018
9		**4,601,018**
10		4,446,018
Total Cost	**5,100,000**	**44,925,180**

10kVA Total Cost		
Year	Solar	Petrol Gen
1	5,900,000	**9,063,036**
2		8,908,036
3		8,908,036
4		8,908,036
5		**9,063,036**
6	4,500,000	8,908,036
7		8,908,036
8		8,908,036
9		**9,063,036**
10		8,908,036
Total Cost	**10,400,000**	**89,545,360**

Please note that these prices are estimates and can vary based on different factors, including the location of purchase, currency exchange rates, and other market conditions.

Appendix 3. Market Sizing of SHS by Household, Revenue, and Installed Capacity

Description of Assumptions

- Identified a baseline number of household adoption of SHS as at 2022, which was 500,000 households
- Identified the total number of households in Nigeria as at 2022, which 43,000
- Identified average growth rate of population size in Nigeria of 2.5%
- Estimated household projection till 2030
- Identified the percentage of social economic class by income level
- Identified the average percentage growth of solar adoption between 2019 and 2022. This was used as base case scenario.
- Developed rate of adoptions case scenarios (Base case- 22%; Mid- level case- 32; High-level case- 42%) to estimate adoption by classes of households, projected revenue generation and projected installed capacity of Solar PV system.
- To project sizing, an estimate was done based on different capacities of solar PV system (1kVA – 20kVA) across social classes.
- To project revenue, the average price of different solar PV systems where obtained (1kVA- N710,000 to 20kVA- N20,500,00) across social classes

Average percentage growth of solar adoption 2019-2022	Solar adoption by household	Number of Households in Nigeria as at 2022	Number of households with solar as at 2022	Number of Households with Generator as at 2022 (40% of total households)	Average total spent of fuel per Annum ($)
22%	500,000	43,000,000	500,000	17,200,000	14,705,509,284

Household sizes	Income level	Purchase capacity	SHS Prices (NGN)
The Poor (12.1% of the total population)	USD 600 p.a	DRE (solar lanterns, solar touch, etc)	N/A
Lower Income Class (34.9% of total population)	USD 1,400 p.a	1kW SHS	710,000
Lower-Middle Income Class (25.1% of total Population	USD 14,000 p.a	3kW SHS	3,450,000
Upper-Middle Income Class (19.3% of the total Population)	USD 50,000 p.a	5kW SHS	5,100,000
Lower-Upper Income Class (6.8% of the total Population)	USD 90,000 p.a	10kW SHS	10,400,000
Upper Class (1.8% of the total population)	USD 140,000 p.a	10kW SHS and above	20,500,000

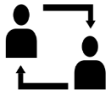
Please note that these prices are estimates and can vary based on different factors, including the location of purchase, currency exchange rates, and other market conditions.

Appendix 4. Comprehensive Approach to assessing competitiveness among countries and key players

Justification

The methodology outlined is a robust and systematic approach to conducting a meaningful and insightful analysis of peer countries, indirect competitors, and key players within a specific market. These offer a comprehensive and actionable approach to understanding market dynamics. Its structured process ensures relevant and valuable insights

The methodology for assessing the competitiveness of countries

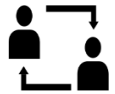


Selection of Peer Countries: In this stage, relevant peer countries are carefully chosen based on specific criteria to ensure a meaningful comparison.

Collection of Data: Comprehensive data on various parameters is gathered from reputable sources for each selected peer country.

A thorough desk-based analysis is conducted using the collected data. This involves a meticulous examination of the information to draw meaningful insights and identify patterns and trends within the selected peer countries' markets

The methodology for assessing the competitiveness of Key players and indirect competitors



Selection of Peer Key Players and indirect competitors: In the initial stage of the competitive landscape analysis, five key players and six indirect competitors were carefully chosen as peers for comparison. These players were identified based on their market presence, industry influence, and relevance to the study's focus.

Data Collection across Various Parameters: Extensive data collection was conducted, encompassing diverse parameters related to the selected key players.

Desk-Based Analysis: A comprehensive desk-based analysis was performed using the collected data. This analytical process will involve an in-depth evaluation and comparison of the key players based on the selected parameters

Outcome presentation: The outcomes of the competitive landscape analysis were derived from the insights gained during the desk-based analysis. This helped in identifying the relative market positions, and competitive advantages, and presenting the findings

Appendix 5. Feasibility Assessment Framework

	High Performance	Medium Performance	Low Performance
Solar Demand	Projected solar energy capacity in 2030 >= 2 GW	Projected solar energy capacity in 2030 < 2 GW and >= 1 GW	Projected solar energy capacity in 2030 < 1 GW
Political Stability	World Bank Governance Indicator >=150	World Bank Governance Indicator =<125	World Bank Governance Indicator >125
Technology and infrastructure	Quality of electricity/ports/ road on WEF executive survey >= 14 and 5% GERD	Moderate electricity/ports/ road on WEF executive survey < 14 and >= 7 and 2% GERD	poor electricity/ports/ road on WEF executive survey < 14 and < 7 and 1%GERD
Policy regulation	Adequate regulation on solar energy Import duty and tax	Moderate regulation on solar energy Import duty and tax	Lack of regulation on solar energy Import duty and tax
Export and Raw material	Availability of quartz sand to produce silicon and Export < USD 20Bn	Partial availability of quartz sand to produce silicon and export USD <15Bn	Absence of quartz sand to produce silicon and export USD <5Bn

High performance received a score of 1; medium performance a score of .5; low performance a score of 0.

Appendix 6. Effective oversight by relevant regulatory bodies is required to accomplish and maintain Nigeria's renewable energy ambitions as well as encourage participation by the private sector

Government /Regulators

FEDERAL MINISTRY OF POWER

The Federal Ministry of Power is the policy making arm of the Federal Government with the responsibility for the provision of power in the country. Its key responsibilities include

- Initiating and formulating broad policies and
- programmes on the development of the power
- sector (electricity) in general. (Generation,
- distribution and transmission of power nationwide).
- Initiating concessions in the power sector of
- the economy
- Implementing Renewable Energy
- progammes/initiatives (Solar, Wind, Biomass,
- Small Hydro etc.)
- Coordinating activities of power sector
- Handling policy matters relating to research
- and development in the Power Sector
- Promoting the development of hydro power
- plants through public private partnership
- (PPP)
- Participating in bilateral and multilateral
- relations affecting the power sector; and
- Facilitating the overall coordination of
- the activities of the Parastatals under its
- supervision.

NIGERIAN CUSTOM SERVICE

The NCS is responsible for the collection of and accounting for revenue, and promoting trade competitiveness between Nigeria and other countries. Core functions include the collection of revenue (Import and Excise Duties) and accounting for same; and prevention and suppression of smuggling.

STANDARDS ORGANISATION OF NIGERIA

SON is the apex standardization body in Nigeria. Its core functions include,

- The preparation of standards relating to products, measurements, materials and processes among others, and their promotion at the national, regional and international levels
- Certification of industrial products
- Assistance in the production of quality goods
- Improvement of measurement accuracy and
- circulation of information relating to standards.

SON has developed about 31 standards for solar systems in collaboration with international bodies such as the International Electrotechnical Commission (IEC).

Appendix 7. The domestic solar manufacturing value chain is driven by key players collaborating with local and international companies to facilitate continuous growth in the industry (1/2)

Nigerian solar pv manufacturers

NASENI SOLAR ENERGY LIMITED (NSEL)

A Solar PV Module/Solar Panel Manufacturing and Solar PV Power Developing and Installing Company located in the FCT-Abuja. NSEL is wholly owned by the National Agency for Science and Engineering Infrastructure (NASENI), a Federal Government Parastatal.

The company currently owns a solar module assembly plant with a 21MW annual capacity in Karshi, Abuja -, up from the original 7.5MW established in 2013. The company has broken ground on a solar cell production plant in Gora, in the Nasarawa state.The plant will reportedly have a vertically integrated supply chain with an annual production of 1,000 tons of polysilicon, 50MW of ingot, 50MW of wafers and 50MW of solar cells

BLUE CAMEL NIGERIA

The company designs and integrates renewable energy solutions which cuts across all level of energy demands ranging from small household solar and hybrid systems to mini solar grid systems for rural electrification and industrial power backup systems.

In the heart of Kakuri Industrial layout in Kaduna State, lies its renewable energy Production Plant and a Training Academy seating on a 3 hectares piece of land with limitless opportunities for rolling out trained technical personnel for the deployment of solar solutions, entrepreneurs in the industry and project developers, customized products through research and development, and other activities that present investment opportunities for both local and foreign investors.

AUXANO SOLAR LIMITED

Auxano Solar Nig. Limited is a renewable energy solution provider with high proficiency in the solar energy industry. Founded in 2014, the company delivers high performance residential and commercial solar system solutions. Headquartered in Lagos,

Auxano Solar is continually re-inventing new and better ways to provide more efficient and affordable Solar & Inverter systems.

Appendix 8. The domestic solar manufacturing value chain is driven by key players collaborating with local and international companies to facilitate continuous growth in the industry (2/2)

Nigerian battery manufacturers

FORGO BATTERY COMPANY LIMITED

Forgo Battery Company Limited prides herself as a successful, innovative company and a leading player in automotive and Solar battery sector in Nigeria with world class facility and top quality product ranges. It is a private owned company registered in Nigeria as manufacturers and international company representative, with many years of experience in battery importation from China, Turkey etc, prior to the establishment of its battery assemblage facility.

With its currently installed capacity of about one million units (1,000,000) of battery annually (for automotive and solar batteries), Forgo plans to be the preferred company for emerging vehicle assemblers in Nigeria, meet the domestic battery replacement demand, and export to other African countries.

STAR PLUS BATTERY

Over the years, Star Plus focuses on manufacturing Inverter Battery in Nigeria and enjoys unmatched reputation and recall. Their constant emphasis on innovation, extensive geographic footprint, strong relationship with marquee clients and steady technology upgradations with PAN Nigeria business partners has made them a distinct front-runner in the lead-acid, wet cell batteries for Inverter.

The company has a dedicated manufacturing plant, with an annual output of 10,000 units of Ampere-Hours of industrial power. The company is constantly upgrading its technology and also acquiring new technology to meet the ever-increasing demands of its customers. They also utilize technical collaboration agreements with leading international manufacturers to acquire new technology.

PELTON BATTERY

Pelton batteries are manufactured in Nigeria and aimed to satisfy the need for sustainable renewable energy in Nigeria. Pelton batteries are made of the LifePo4 chemistry which is know to be the best in the market in terms of life span, efficiency and safety. The batteries are reputedly one of the most advanced lithium based battery in Nigeria, and relatively affordable in comparison to other brands.

Furthermore, the batteries are designed to last more than 15 years of everyday usage, creating value for consumers and minimizing costs in the long-term.

Appendix 9. Distribution and installation is facilitated by companies who continue to strategically market and expand the awareness of solar pv potentials in Nigeria

Nigerian Distribution/Installation Companies

HAVENHILL SYNERGY LIMITED

A clean-tech utility company that uses renewable (solar) energy to generate clean, safe, cost-effective and sustainable electricity in urban and rural areas in Nigeria.

They set up Solar mini-grids to provide rural communities (homes and schools) with their independent power plant (IPP) electricity station with a minimum of 20KW generating capacity.

Their other offerings include:

- Solar powered street light systems
- Solar powered pumping systems
- Power backup systems

SOLAR FORCE RENWABLE ENERGY

Solar Force is an indigenous Solar energy EPC (Engineering, Procurement and Construction) Company operating for over fourteen (14) years in Nigeria.

It is one of the most recognized Renewable Energy Company in Nigeria and remains dedicated to renewable energy as well as providing cutting edge solar technology to the public.

ARNERGY

Arnergy is a cleantech company offering sustainable solar solutions that are tailored to address pressing energy needs and deliver reliable 24/7 electricity to power various capacities of domestic appliances, office devices and commercial equipment