Market Study to Support the Nigeria Electrification Project

Component 2: Results – Based Finance Programme for Productive Use Appliances and Equipment for Off-Grid Communities

REA-NEP/AfDB/QCBS/07/2021

RURAL ELECTRIFICATION AGENCY
ENERGY=EMPOWERMENT=EFFICIENCY
NIGERIA ELECTRIFICATION PROJECT

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Background and Disclaimer

The Federal Government of Nigeria (FGN) is driving strategies to fast-track development initiatives towards achieving the overall objectives of the Economic Recovery and Growth Plan (ERGP) and the Power Sector Recovery Programme (PSRP). In support of the FGN's efforts to improve the country's power sector and in response to a request from the FGN, the Board of the African Development Bank (AfDB or the "Bank") approved a USD 200 million sovereign facility to support and finance the Nigeria Electrification Project (NEP). NEP is being implemented by the Rural Electrification Agency (REA or the "Implementing Agency"). The proceeds of the AfDB's financing for NEP will be applied across the following four components (the "Project"):

(i) **Component 1:** A Minimum Subsidy Tender programme awarding subsidies to private sector developers to catalyse the rollout of solar and/or hybrid mini-grid solutions across up to 300 sites split into at minimum 6 lots;

(ii) **Component 2:** A Results-Based Finance programme incentivizing solar home system installation companies and mini-grid developers to incorporate the distribution and sale of energy efficient productive use appliances in their regular line of activities;

(iii) **Component 3:** Phase 3 of the Energizing Education Programme (EEP), a government-led initiative that aims to install dedicated power systems at eight federal universities;

(iv) **Component 4:** Technical Assistance and Capacity Building for a wide range of public and private sector stakeholders in the country's off-grid sector.

The objective of Component 2 is to increase the productive use of energy in remote communities by facilitating access to energy efficient productive use appliances and equipment for agro-processing and commercial business activities within the communities. Increasing the productive use of electricity in rural communities is expected to (i) improve their economic and social development, as well as contribute to the modernization of their local economies; and (ii) improve the sustainability of the business models of mini-grid developers and off-grid solar companies – the former of which relies heavily on productive loads for revenue.

The Joint Venture (JV) MicroEnergy International GmbH and Creeds Energy Ltd Nigeria, hereinafter referred to as the Consultant, have been assigned to support the development and launching of Component 2. Through this assignment, the Consultants have performed a comprehensive market study and forecasting exercise, mapping out the opportunities and challenges to scaling up the deployment of productive use (PUE) appliances and equipment in off-grid communities in Nigeria, followed by an analysis of the potential market that could be developed by leveraging the proposed result-based finance programme as well as other interventions.

Therefore, this document and its content have been prepared, and are intended solely for the information and use of the REA and its Project counterpart, AfDB in relation to the contract for consultancy services to conduct the "Market Study to Support the Nigeria Electrification Project Component 2: Results – Based Finance Programme for Productive Use Appliances and Equipment for Off-grid Communities" (REA-NEP/AfDB/QCBS/07/2021). The information and views set out in this document are those of the authors contracted for the project and do not necessarily reflect the official position of REA and its project partners. Neither REA or its project partners or any persons acting on their behalf may be held responsible for the use of the information contained herein.

Acronyms

Abbreviations	Full Description
ABP	Anchor Borrowers Programme
ACA	African Capital Alliance
ACEF	Alithea Clean Energy Fund
ACSS	Agriculture Credit Support Scheme
A2EI	Access to Energy Institute
AECF	Africa Enterprise Challenge Fund
AEEP	Africa-European Union Energy Partnership
AFAN	All Farmers Association of Nigeria
AFD	French Development Agency
AfDB	African Development Bank
AFSIA	Africa Solar Industry Association
AGI	Association of Ghana Industries
AGSMEIS	Agri-business Small and Medium Enterprises Investment Scheme
AIIF	Africa Infrastructure Investment Fund
AIIM	Africa Infrastructure Investment Managers
AMDA	Africa Mini-grid Developers Association
ARE	Alliance for Rural Electrification
BMZ	German Federal Ministry for Economic Cooperation and Development
BNEF	Bloomberg New Energy Finance
BOA	Bank of Agriculture
BOI	Bank of Industry
CAP Fund	Cottage Agro Processing Fund
CAPEX	Capital Expenditure
CBEA	Cross Boundary Energy Access
CBN	Central Bank of Nigeria
CFAN	Cocoa Farmers Association of Nigeria
CKD	Completely Knocked Down
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
COP	Conference of Parties
COVID	Coronavirus Disease

DART	Demand Aggregation for Renewable Technology
DBN	Development Bank of Nigeria
DESCO	Distributed Energy Services Company
DFI	Development Finance Institutions
DFID	Department For International Development, now Foreign Commonwealth and Development Office
DMB	Deposit Money Banks
EAP	Energizing Agriculture Programme
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Center For Renewable Energy and Energy Efficiency
EE	Energy Efficiency
EEP Africa	Energy and Environment Partnership Trust Fund Africa
EnDev	Energising Development
EREF	Environmental Research and Education Foundation
ERGP	Economic Recovery and Growth Plan
ESMAP	Energy Sector Management Assistance Program
ESP	Economic Sustainability Plan
EU	European Union
EUR	Euro
FACAN	Federation of Agricultural Commodity Associations of Nigeria
FCMB	First City Monument Bank
FEBKAN	Federation of Beekeepers Association of Nigeria
FEC	Federal Executive Council
FFV	Fresh Fruits and Vegetables
FGN	Federal Government of Nigeria
FOREX	Foreign Exchange
GCIP	Global Cleantech Innovation Program
GDP	Gross Domestic Product
GEAPP	Global Energy Alliance for People and Planet
GEEP	Government Enterprise and Empowerment Programme
GEMS	Growth and Employment Mobility in States
GIZ	German Agency for International Cooperation
GOGLA	Global Off-grid Lighting Association
GTB	Guaranty Trust Bank
GW	Gigawatt
GWh	Gigawatt Hour
IAAS	Ice As A Service
ICREEE	Inter-Ministerial Committee on Renewable Energy and Energy Efficiency
ICT	Information and Communication Technology
IDC	Industrial Development Centres

IFC	International Finance Corporation
IITA	International Institute of Tropical Agriculture
ILO	International Labour Organization
IMAS	Interconnected Mini-grid Acceleration Scheme
IoT	Internet of Things
IRENA	International Renewable Energy Agency
JV	Joint Venture
KCIC	Kenya Climate Innovation Center
KFW	Kreditanstalt für Wiederaufbau Development Bank
KW	Kilowatt
LPG	Liquified Petroleum Gas
MANCAP	Manufacturers Association of Nigeria Conformity Assessment Programme
MEPS	Mimimum Energy Performance Standards
MFB	Microfinance Banks
MFI	Microfinance Institutions
MG	Mini-grid
MSME	Micro Small and Medium Enterprises
MTN	Mobile Telephone Network
MW	Megawatt
MWh	Megawatt Hour
MWp	Megawatt Peak
NABPAN	National Banana and Plantain Growers, Processors and Marketers in Nigeria
NACOTAN	National Cotton Association of Nigeria
NAPTIN	National Power Training Institute of Nigeria
NASENI	National Agency for Science and Engineering Infrastructure
NATPAN	National Tomato Growers, Processors and Marketers Association of Nigeria
NBS	Nigeria Bureau of Statistics
NCGA	National Cassava Growers Association
NCR	National Collateral Registry
NCS	Nigeria Customs Service
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NEP	Nigeria Electrification Project
NESP	Nigerian Economic Sustainability Plan
NEXIM	Nigeria Export and Import Bank
NGN	Nigerian Naira
NGO	Non-governmental Organisation
NIGP	National Income Generating Programme

NNDC	Nigeria's Nationally Determined Contributions
NPCC	National Policy on Climate Change
NREAP	National Renewable Energy Action Plan
NREEEP	National Renewable Energy and Energy Efficiency Policy
NSIA	Nigeria Sovereign Investment Authority
OEM	Original Equipment Manufacturer
OGEF	Off-Grid Energy Access Fund
OGS	Off-Grid Solar
OLOP	One Local Government One Product Programme
OPGAN	Oil Palm Growers Association of Nigeria
OSSAP-SDGs	Office of the Senior Special Assistant to the President on Sustainable Development Goals
PA	Power Africa
PAYGO	Pay As You Go
PAYS	Pay As You Store
PBG	Performance Based Grant
PE	Private Equity
PEBEC	Presidential Enabling Business Environment Council
PFI	Private Finance Institution
POFAN	Potato Farmers Association of Nigeria
PSB	Payment Service Banks
PSRP	Power Sector Recovery Programme
PU	Productive Use
PUAFF	Productive Use Appliance Financing Facility
PUE	Productive Use of Energy
PULSE	Productive Use Leveraging Solar Energy
PV	Photovoltaic
QCBS	Quality Cost-Based Selection
RBF	Results Based Financing
RE/EE	Renewable Energy/Energy Efficiency
REA	Rural Electrification Agency
REAN	Renewable Energy Association of Nigeria
REF	Rural Electrification Fund
RESIP	Rural Electrification Strategy and Implementation Plan
RETTI	Renewable Energy Technology Training Institute
RFAN	Rice Farmers Association of Nigeria
RMI	Rocky Mountain Institute
SACCO	Savings and Credit Cooperative Organisation
SAF	Sterling Alternative Finance
SCTY	SolarCity

SDG	Sustainable Development Goals
SEFA	Sustainable Energy Fund For Africa
SEforALL	Sustainable Energy for All
SELF	Small Entreprenuers Loan Fund
SES	Solar Energy Systems
SHS	Solar Home System
SIDO	Small Industries Development Organization
SIR	Solar Irrigation Rwanda
SME	Small And Medium Enterprise
SMEDAN	Small and Medium Enterprise Development Agency of Nigeria
SMERAN	Small and Medium Enterprises Rating Agency
SON	Standards Organization of Nigeria
SONCAP	Standards Organization of Nigeria Conformity Assessment Programme
SPN	Solar Power Naija
SSA	Sub-Saharan Africa
SSPU	Standalone Solar for Productive Use
SUNREF	Sustainable Use of Natural Resources and Energy Finance
SWAY	Sterling Bank Alternative Banking Agriculture
SWP	Solar Water Pump
TA	Technical Assistance
TGT	Tanzania Growth Trust
TV	Television
TVET	Technical and Vocational Education Training
UBA	United Bank for Africa Plc
UEF	Universal Energy Facility
ULAB	Used Lead Acid Battery
UN	United Nations
UNCDF	United Nations Capital Development Fund
UNEP	United Nations Environment Programme
UNREEEA	Uganda National Renewable Energy and Energy Efficiency Alliance
US	United States
USADF	United States African Development Foundation
USAID	United States Agency for International Development
USD	United States Dollar
VC	Venture Capitalist
VI2	Vulcan Impact Investment
VIA	Village Infrastructure Angels
WB	World Bank
WFAN	Wheat Farmers Association of Nigeria
WRI	World Resource Institute

Increasing the productive use of electricity in rural communities is expected to improve their economic and social development, as well as contribute to the modernization of their local economies.

PART I

MARKET STUDY

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1. Introduction

This report sifts through available literature, case studies, and research on Productive Uses of Energy (PUE), highlighting validation of equipment that could serve as PUE business models for PUE across Sub-Saharan Africa and their applicability in the Nigerian context, estimating the market for PUE appliances and equipment in Nigeria, highlighting the key stakeholders, policies, and enabling factors in the context of enabling Mini-Grids sustainability.

1.1. Productive Use

World Bank's ESMAP defines Productive Uses of Energy (PUE) as "those that increase income or productivity, referred to as value-adding activities." Various categorization of PUE has been proposed by available literature for instance, by type of activity it supports – Agricultural, Industrial, Commercial, Social, and Public, or by the type and level of energy it consumes – electrical, non-electrical or both [1], others have focused on the socio-economic impacts and benefits that the PUE provides.

Productive use of energy is a significant stimulant for economic development [2], it is significantly different from domestic use of energy in many forms. In **Table 1**, some criteria for use of energy to qualify as productive are highlighted. For example, user class matters such that energy use for domestic purposes do not qualify as productive use despite having impact on the business owner/manager's interests. Secondly, another quality is the need for an alternative energy source to meet a business process. Thirdly, the business concerned should ordinarily be a going concern and not a special arrangement type of business for a short time.

Table 1: Criteria for Productive uses

Criterion	Remark/Qualification
User class	Energy use can be categorised as for domestic or business/enterprise level uses. *Productive use qualifies for only business purposes*
Alternative source	Among sources of energy are traditional and alternative. *Productive use qualifies if there is a significant need for an alternative source for the same business needs.*
Going concern criteria	Businesses can be formed to run in perpetuity or for a short time to meet a specific need. *Productive use relates to the business use of energy in/by a business that will continue to exist into the foreseeable future.*

Use intention/ Financial consideration	Energy users may produce goods or render services without express intention to exchange economic value. *Productive use qualifies if the use of energy is for product development and/or service delivery for economic value exchange.*

Source: Adapted from Asibey et al. (2021)

An overarching advantage of productive uses of energy is energy justice [3] allowing every business in need of energy access to be measured based on some criteria such as:

1. **Availability;** making energy available for use by businesses willing to use them.
2. **Acceptability;** making energy adoption acceptable. This is significant, because cultural norms for example still drive the adoption of energy use in Africa.[2]–[4]
3. **Affordability;** this has always been an issue because the cost of producing and maintaining the power supply to rural dwellers usually trumps revenue from them. However, adoption is significantly tied to affordability. Affordability has driven various business model that has been practiced for the use of PUE.
4. **Accessibility;** making energy accessible across urban and rural communities.

In addition, Applicability is also an important criterion for most productive users in that any appliances or equipment being proposed need to replicate or enhance upon the capacity and consistency of their current output. This has been a major factor affecting the adoption of the PUE because there have been cases of doubting the quality of production in most rotating machine equipment. The implication is that there is need to ensure that equipment is designed to standard and specifications while improving on the value of services that it offers. For instance, grinding machines should be able to produce finer blends and electric mobility should be able to charge faster and battery run longer to compete with counterparts.

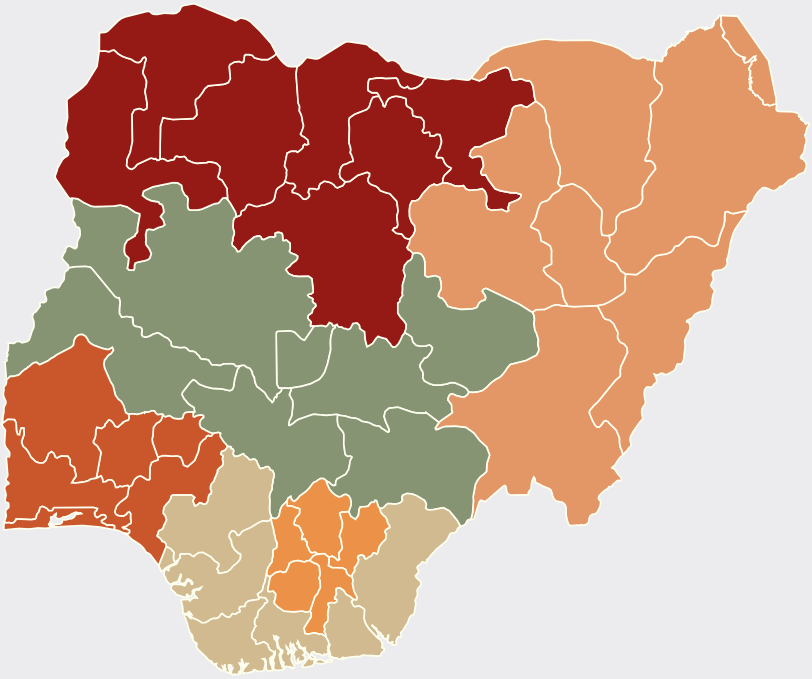
In the context of this study, one thing is pertinent across all categorizations, energy for productive use refers to electricity for productive use. **PUE therefore refers to the use of technology, equipment, and appliances, powered by electrical and/or thermal energy as direct inputs for value adding, income generating activities that trigger socioeconomic development. Value adding, income generating activities refer to production of goods or provision of services.**

1.2. Access to Electricity

As of 2020, 55% of Nigeria's population had access to electricity and are on-grid while the remaining 45% have no access and are off-grid. In urban areas, 84% had access compared to 25% in rural areas [5] By virtue of electrification rate per geopolitical zone, North-Central (48%), North-West (40%) and North-East (27%) have the least electrified population in the country compared to South-East (78%), South-South (81%) and South-West (85%) [6].

The three technologies used for the generation and distribution of electricity are the national grid powered by thermal and hydro plants, mini-grids and standalone systems which are mainly solar or solar hybrids. Fuel generators are widely used across both urban and rural communities for lack of grid power availability. In terms of total installed PV capacity, Nigeria has 8.25MWp large scale, 89.34MWp C&I, 7.33MWp mini-grids and 24.3MWp SHS and residential systems [7].

The Federal Government of Nigeria is targeting 100% electrification by 2030 using a least-cost technology mix approach. This approach consists of a mix of 28% grid, 46% mini-grids, and 26% SHS connections. Mini-Grids are shown to be the least cost option for most new connections in densely populated rural settlements by 2030, estimated to reach 51 million people, mostly in rural off-grid locations [5]. This has been orchestrated in the latest Energy Transition Plan which is the most recent policy driving the energy sector.



Electrification rate per geopolitical zone:

- 27% NORTH-EAST
- 40% NORTH-WEST
- 48% NORTH-CENTRAL
- 78% SOUTH-EAST
- 81% SOUTH-SOUTH
- 85% SOUTH-WEST

As of 2020:

55% had access to electricity + on-grid

45% have no access + off-grid

Access:

84% *Urban areas*

25% *Rural areas*

1.3 PUE Framework

The methodology adopted for categorizing applicable PUE activities is essentially based on the adopted definition of PUE with a focus on economic activities and the energy technology required. The relevant economic activities within rural off-grid communities are therefore categorized as PUE Category and limited to Agriculture, Commercial and Industrial categories, excluding residential, social, and public service use such as lighting, leisure, education, and health.

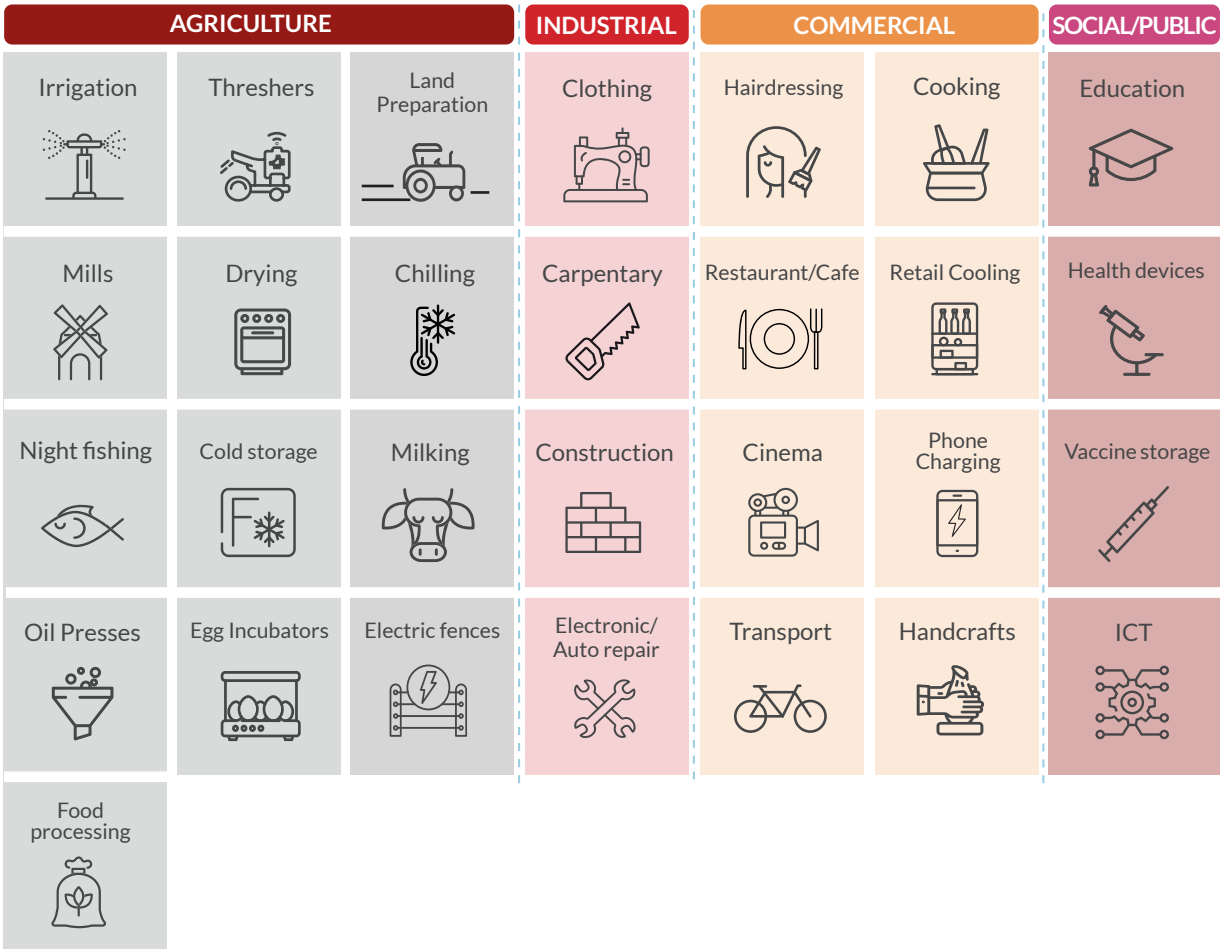


Figure 1: Non-exhaustive examples of Productive Uses relevant for Off-grid markets in Sub- Saharan Africa (Source: PULSE Report, 2022)

Secondly, the type of energy technology considered for powering the PUE activities and having impact potential for income generation are standalone systems, mini-grids, SHS or a combination of these. Based on these criteria, a PUE matrix is illustrated in Table 2 below.

Examples of agricultural applications include milling, threshing, drying, chilling, cold storage. These tend to be the large power users within communities, often referred to as productive users and they make up about 10% of customers in rural off-grid communities. Rural Commercial and Industrial applications and users are the second largest group within communities making up about 20% of customers in rural off-grid communities[1]. They engage in activities such as hairdressing, viewing centers/local cinemas, restaurant business, phone-charging, retail cooling, tailoring, carpentry, electronic and auto repair. As the largest power users within mini grids, it is therefore important to consider agriculture, commercial and industrial PUE activities for estimating the size of the market and its potential in Chapter 2.

[1] From site visits to over 500 communities, profiling, and assessment of over 10,000 SMEs within the communities between 2015 to 2022.

Table 2: PUE Framework

PUE Tiers	Energy Technology	PUE Category	PUE Application	PUE Appliance/Equipment	Impact potential
Small scale Tier: 2 50W – 199W	SHS	Agriculture	Poultry incubator, fan dryer	Egg incubator, fruit/vegetable drying	High volumes and fast moving to achieve high impact, but limited in scope
	Standalone systems	Commercial	Barbing salons, phone charging	Hair clipper, Mobile phone charging stations	
Medium scale Tier: 3 200W – 799W	Mini-grid (and/or standalone systems)	Agriculture	Irrigation, storage, food processing, drying, milling, cooling	Surface or submersible water pumps, freezers, mills, hullers, threshers, oil presses, egg, incubators, ice-making machines, refrigerators, and drying chambers	Broader impact scope, but supply push needed to achieve outreach
	Mini-grid	Commercial and Industrial	Bars, Restaurants, printer shops, hairdressing, retail cooling, phone charging, handcrafts, tailoring	Printers, music systems, fridges, freezers, refrigerators, charging stations, battery swapping stations	
Large Scale Tier:4 800W – 1999W	Mini-grid (or hybrid petrol/diesel/gas + mini-grid)	Agriculture	Milling, threshing, drying, husking, cooling	Mills, threshers, de-husking machines, thermal dryers, fridges, freezers, refrigerators	Financial and operational models to be determined to achieve large- scale impact
	Mini-grid or Standalone	Commercial and Industrial	E-mobility-People and goods transportation, electronic repair	Charging stations, Battery swapping stations,	
Extra Large Scale Tier: 5 2000W and above	Standalone Multifunctional Platforms	Agricultural, Industrial	Carpentry, Wood processing, Mechanic, Ironing, workshops, Welding, Bakery, Parboiling, Cooling	Powertools, Sawmills, electric cookers Industrial parboilers. Bakery ovens, cold rooms, clothes iron	

1.4. PUE Appliances and Equipment, Overview of Technologies

Agricultural productive uses remain significant in rural Africa and enhancing the productivity of rural dwellers driven by provision of alternative, safe, affordable energy is significant for economic development amongst other benefits. Consistent with the agriculture share of GDP in West Africa [7], agriculture in Nigeria accounts for 30% (NGN 6 trillion) of overall real GDP, predominated by crop production from smallholder farmers[2]. The number of smallholder farmers is undocumented, however, estimates state that Nigeria has approximately 35 million smallholder farmers engaged in crop production (90%), livestock farming, fishing, and forestry.

PUE appliances and equipment within agriculture crop production can be viewed from pre- harvest and post-harvest angle. Pre-harvest, the use of standalone or mini-grid tied solar water pumps (SWP) for irrigation and cold storage for perishable fresh fruits and vegetables (FFV). Post-harvest, common agro-processing equipment includes threshers, parboilers, milling machines, grinding machines, hullers, oil press, graters, dryers.

Rural farmers across Africa have become increasingly aware of the potential of solar PUE technologies, and in particular solar irrigation. However, access to modern irrigation for small holder farmers in West Africa is especially low, at only 1%. The potential demand for modern irrigation is estimated at 50 million SWPs for the whole of West Africa. Amongst other inputs, enabling more access to solar irrigation for smallholders can have a transformational effect by boosting economic opportunities and productivity to the farmers who produce the largest proportion of food crops across the nation and contribute to national GDP.

SWP can significantly improve crop yields and reduce the cost of irrigation from displacing the use of diesel generator-powered pumps, to the benefit of the farmer and the environment. For example, a 3kW pump powered by diesel emits 3,744kg of CO_2 per year compared to a no emissions solar-powered pump. Farmers in Kenya, Uganda and Tanzania who owned SWPs attested to improvement in their disposable income and livelihoods as their previous expenditure on operating diesel-powered pumps reduced [8].

Although not a key market for SWP, Nigerian smallholder farmers can potentially benefit from the adoption of SWP for irrigation especially for dry season farming [7]. The size of the farmland considered, and type of crops farmed determine the level of irrigation required and appropriately sized SWP. On average, to irrigate a one-hectare farmland, the maximum requirement for solar power is less than 1kW to meet the daily irrigation need of 25-35m^3. Rice farms have the highest irrigation requirements estimated at roughly 4kW power required to meet the daily irrigation needs of 130 m^3 per hectare. Irrigation for most of the other crops grown in Nigeria can be met with between 1kW and 3 kW power requirement [8].

Proximity of farmland to the energy source is another key determinant of the type of SWP to use. Where mini-grid pairing is not economically viable due to the additional cost of extending the distribution network, it is best to employ the use of standalone SWP. Apart from farmer survey estimates, no available literature exists on mapping of distances between farmland to existing or planned mini-grid sites in Nigeria. This deficiency also limits the volume approximation of the number of water pumps powered by mini-grids or standalone solar systems in this report.

[2] NBS Q3 GDP 2022

Cold storage system capacities vary depending on the size of the storage unit and application. For example, some are modular and stationary e.g., cold rooms, industrial blast freezers, refrigerators, ice makers, while others are mobile units e.g., refrigerated trucks or trailers (reefers). No current open-source literature exists on either the number of cold storage systems powered by mini-grids or standalone solar systems [9]. Although in 2021, Nigeria recorded the highest sales volumes for refrigerators in West Africa. Like the sales of fans, tv, radio, and lighting, the sales of freezers were documented as part of accompanying appliances sold together with SHS by GOGLA. However, there is no available documentation on the approximate number of cold storage systems powered by either mini-grids or as standalone systems on their own.

Rural off-grid commercial and industrial small businesses tend to make use of lightning, TVs for bars, viewing centers and restaurants and freezers for selling cold drinks, water and making ice. Locally fabricated cold rooms are commonly used for freezing yogurt.

Renewables-based electric cooking has increasingly garnered interest. However, it remains a nascent solution for most African countries. Recent global market assessment reveal that Algeria and Kenya were the only African countries with the greatest potential for a scaleup of electric cooking, while South Africa, Nigeria and Algeria scored well for specific opportunities in mini-grid cooking, and Kenya, Morocco, Nigeria, Rwanda, South Africa, and Uganda for stand-alone off-grid cooking. For most Sub-Saharan African countries, the viability of a scaleup of electric cooking is most significantly hindered by access to electricity, absence of or emerging clean cooking market, lack of awareness, affordability of appliances and electricity and most importantly resistance to new methods of cooking [10].

Other emerging technologies within the PUE space include containerized or built Multi- Purpose Platforms catering independently or collectively to cold storage and agro- processing. An example is in Uganda where an interconnected solar mini grid of 40kWp is tied to an anchor load of a containerized milling and drying unit which consumes a quarter of the generated power and rest is supplied to 300 households connected within Kiwumu community [10].

Technology and digital solutions have emerged as important frontiers for distributed renewables and specifically productive use applications. Segments and value chains across textiles, agriculture, and livestock farming, as well as cottage industries are increasingly requiring tailormade technological innovation that directly impact on livelihoods of rural ecosystems. A key example here is Cold Hubs, a Nigerian cold storage company currently providing 58 containerized solar powered cold rooms at crop production sales points across 28 states in the country, to reduce post-harvest losses and improve food security. Beyond the stationary cold rooms, Cold Hubs diversified into logistics and included refrigerated trucks to extend the freshness of their customers produce across the transportation stage of value chain services. They also linked their customers to buyers on digital marketplace to improve market access and ensure increased incomes. Overall, the company has managed to reach over 6,000 customers (majority of whom are women) and increased their income by 50% through the shared cooling services, transportation, and digital marketplace linkage [11].

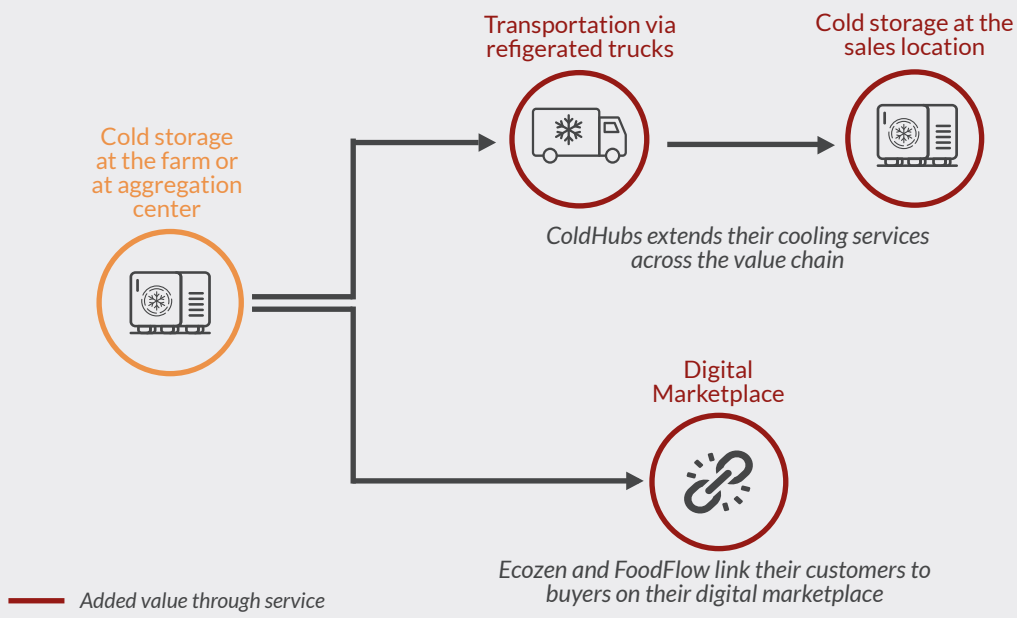


Figure 2: Enhancing cold storage models to increase value to end-users and drive PUE demand

The tables below provides an overview of appliances and equipment according to the categories of PUE.

Agriculture

Table 3: PUE Appliances and Equipment's in agriculture

Appliance/ Equipment	Size	Power Rating and Tier	Estimated Unit Price
Solar Water Pump	Small <2ha Medium/Large up to 2ha Large up to 5ha Extra Large >5ha	2,00 - 999W, Tier 3,4 1,000 -1,999W, Tier 4 2,000+ W, Tier 5	USD 754 USD 1,105 USD 2,082[3]
Agric cold chain refrigeration	>50kg	>2,000W Tier 5	-
Coolers	1,000L	>2,000W Tier 5	-
Containerized Cold Rooms	2,000L – 10,000L	2,000+ W, Tier 5	-
Mills	25-160kg/hr	>2,000W, Tier 5	USD3,211[4]
Threshers		>2,000W, Tier 5	USD1,820
Hullers		>2,000W, Tier 5	USD1,960

[3] Prices were gotten from GOGLA reports.
[4] Prices were gotten from local manufacturer OWK Metal Construction Company

Appliance/ Equipment	Size	Power Rating and Tier	Estimated Unit Price
Grater (Cassava)	100kg/hr	250W, Tier 3	USD857
Fan Dryers	10 – 100kg	50W - 100W, Tier 1	USD440
Oil /Nut Press	20kg/hr	1.5kW, Tier 4	USD350
Poultry incubator	48 – 1,000 eggs	75W – 100W Tier 1	USD313
Parboilers	500Kg/day	>2,000W, Tier 5	USD6,000[5]

Commercial and Industrial

Table 4: PUE Appliances and Equipment's in Commercial and Industrial

Appliance/ Equipment	Size	Power Rating and Tier	Estimated Unit Price
Commercial/SME refrigeration	Small: <100L Medium: 100 -200L Large: 200L - 300L	125W, Tier 2 277W, Tier 3 386W, Tier 3	USD264 USD624 USD651
Standalone Solar Freezers	Small 108L Medium 158L Large 210L Extra Large 538L	60W 80W 100W 180W	USD377 USD675 USD846 USD1347[6]
TV for viewing centers, bars and restaurants	Small Medium Large Extra Large	<100W, Tier 2 100W - 250W, Tier 2 250W - 500W, Tier 3 600W, Tier 3	USD200 USD 250 - 300 USD320 - 400 USD 596
Fans for viewing centers, bars and restaurants	Ceiling Wall Pedestal	18 - 20W, Tier 2 47 - 50W, Tier 2 100 - 140W, Tier2	USD28 - USD43 USD32 - USD150 USD22 - USD170
Sound system/ Radio for viewing centers, bars, and restaurants	Small Medium Large	26W, Tier 2 60W, Tier 2 180W, Tier 2	USD 270 USD 500 USD 660

[5] Prices were gotten from local manufacturer OWK Metal Construction Company
[6] Prices were gotten from Koolboks Nigeria

Mobility

Table 5: PUE Appliances and Equipment's in mobility

Appliance/ Equipment	Size	Power Rating and Tier	Estimated Unit Price
E-Mobility	2- Wheeler	250W - 750W, Tier 3	USD1,700
E-Mobility	3- Wheelers	1,000W, Tier 4	USD2,400
Mobile Cooling vans	-	-	-

100KWP Solar Hybrid Mini Grid at Kasuwan Magani, Kaduna Source: REA

2. Market for Productive Use Appliances and Equipment in Nigeria

2.1 Market sizing

In sizing the PUE market for agriculture, rural commercial, and industrial, the interdependency between productive use demand for electricity and the viability of mini grids cannot be over-emphasized. With access t o electricity, efficient equipment and appliances, productive users can attain productivity and economic improvements that can impact positively on their livelihoods. Likewise, with the uptake of electricity by productive users, mini-grid electricity suppliers can benefit from higher capacity utilization, reduced costs per connection and overall higher revenue per user, eventually reaching commercial viability. Husk Power [12] has demonstrated this through its ecosystem approach.

It is important to note that the sizing of the market is affected by the potential sizes of the Mini-grid and the amount of power that will be produced to support these equipment.

The aim is to evaluate the size of these equipment, their cost, and compare it with the acceptable subsidy value. Then the amount earmarked by REA USD 20 million can be used to check the tentative volume of PUE that could be supported in each category.

Sizing based on existing and planned mini grids in relation to crop production

Nigeria's Integrated Electrification Plan analysis forecasts that with productive use in consideration, 108,000 mini-grids (9.1 million connections) will be needed. 89% of these will be developed in rural off-grid settlements, having small-scale agro-processing typified by both maize and rice milling which is common in all parts of the country [5]. This means at least 96,000 mini-grids (roughly 8.1 million connections) will be in locations where primary agro- processing activities exist. Going by the estimate that 30% of the customers within rural off- grid communities engage in agricultural, commercial, and industrial activities, it is safe to assume that potentially 2.4 million[7] rural smallholder farmers and small businesses would directly be impacted by PUE market stimulation across

> *"REA however plans for 10,000 mini-grids by 2030, which brings the number of impacted farmers and small businesses to 250,000 within mini-grid settlements.*

[7] 8.1 m connections divided by 96,000 settlements will give 84 connection per MG on average. 30% productive users is 25 connection for rural agriculture, commercial and industrial businesses.

the 96,000 mini-grid settlements. This is the total addressable market. REA however plans for 10,000 mini-grids by 2030, which brings the number of impacted farmers and small businesses to 250,000 within mini-grid settlements.

Current estimated installed mini-grid capacity is 2.8MW, with 59 projects serving rural communities [10] located in Sokoto, Niger, Kaduna, Abuja, Plateau, Ogun, Edo, Cross River, and Rivers States. The projection of the size of the PUE market in existing mini-grid communities based on the same assumption of 30% of customers engaging in agricultural, commercial, and industrial activities will amount to **1,475[8] potential PUE connections within 59 existing mini-grids.**

Category	Quantity	Potential PUE connection Volume	Potential Value USD[9]
Existing Mini-grids	59	1,475	5,021,047
Likely Mini-grids from NEP Project	200	6,000	20,424,600
REA Estimate	10,000	250,000	851,025,000
Potential MG with PU by 2030	96,000	2,400,000	8,169,840,000

The PUE market can be estimated to be a reasonably sizeable market that will drive investment in the electrification sector but will be through various business models. From the projection of the existing mini-grids and the likely NEP projects, there is an estimated need for about 26 Million USD to finance PUE. This is an attractive market not only for investors but also for policymakers who will need this to further build financing models around PUE.

Sizing based on percentage connections within mini-grid communities

Literature reviews show that 80% MG revenues comes from 20% of its customers within the three categories – agriculture, commercial and industrial, while residential customers make up 80% of connected customers but contribute 20% of the revenue share.

For the purpose of the NEP PUE Subsidy calculations, the assumptions made are that Agriculture appliance and equipment will account for 40% share (pre-harvest, post-harvest processing, preservation-cooling and drying)), Standalone appliance and equipment will account for 15%, while Commercial and Industrial small business appliance and equipment will account for 45% (hair salons, barber shops, tailoring, phone charging, commercial cooling, e-mobility, carpentry, welding).

Sizing based on appliance or equipment

The sizing of the PUE appliance and equipment required can be seen from the three categories which include the agro-processors, the standalone systems, and the small business.

The agro-processors will amount to about 40% of the PUE market which will include the pre- harvest machines, the post-harvest machines, and the preservation systems. This is estimated to be about 2,400 units for the 200 Mini grids planned under the NEP project.

[8] Conservative estimate using assumption of 25 connections for rural agriculture, commercial and industrial businesses per MG, multiplied by 59 existing MG
[9] Calculations in NEP Subsidy Dashboard Sheet

However, for the fast benefit, standalone systems especially for pre-harvest agro-systems like the SWP will take a sizeable chunk of about 15%. The SWP market size based on 3.7 million hectares[10] of land used for rice farming in Nigeria suggests that 2.5 million pumps are required going by the estimate of4kW solar pump per hectare and the fact that typical farming land is 1.5 hectare per farmer. However, for quick deployment, it is assumed that an early 1,000 units could be tested under the NEP programme.

Commercial and Industrial Small businesses is sized at about 45% of the total sum provided with 2,700. The logic behind this is that SMEs are sizeable within the mix of customer profiles in rural communities.

This is expected not to only increase power offtake from the mini grids but also stimulate the rural economy to be able to afford the payments for their energy bills.

2.2 Policies and Enabling Environment

National Policy on Climate Change (NPCC) 2013

The NPCC sets out Nigeria's response strategy to climate change as well as measures for the adoption of climate smart practices aimed at fostering sustainable development. It describes adaptation and mitigation measures for responding to the threat of climate change in the country. [13]

National Renewable Energy and Energy Efficiency Policy (NREEEP) 2015

The National Renewable Energy and Energy Efficiency Policy (NREEEP) sets out the Nigerian government's blueprint to increasingly harness the country's renewable energy and energy efficiency resources in driving sustainable development across the country. Developed in line with the country's national energy policy, the NREEEP outlines the government's programs and measures for deploying renewable energy and energy efficiency technologies and practices towards facilitating Nigeria's green transition [14].

Nigeria's Nationally Determined Contributions (NNDC) 2015, updated 2021

Nigeria's Nationally Determined Contribution (NDC) shows its global commitment towards embracing sustainable development measures that limit the rate of global warming and negative impacts of climate change. It shows the country's climate targets and measures to be adopted in actualizing them. [15], [16].

Rural Electrification Strategy and Implementation Plan (RESIP) 2016

The Rural Electrification Strategy and Implementation Plan (RESIP) was developed in line with the federal government's plan for rural electrification and provides the implementation framework and measures for driving rural electrification across the country by means of - on and off-grid energy solutions [17].

[10] Rice cultivated area in Nigeria https://farmcenta.com/shop/prod/31#:~:text=Rice%20is%20cultivated%20on%20about,area%20is%2 0rain%2Dfed%20rice%2C

Sustainable Energy for All Action Agenda 2016

Nigeria's Sustainable Energy for All Initiative Action Agenda is the country's implementation document for the global Sustainable Energy for All. It shows Nigeria's commitment towards global sustainable development, and links to the country's policy and regulatory documents on sustainable energy such as the National Renewable Energy and Energy Efficiency Policy (NREEEP), the National Renewable Energy Action Plan (NREAP), the National Energy Efficiency Action Plan (NEEAP), and Nigeria's Nationally Determined Contribution (NNDC) to the COP 21 Paris Agreement [18].

National Energy Efficiency Action Plan (NEEAP), 2016 (2015-2030)

The NEEAP is a supporting strategy document to the NREEEP and guides its implementation. It currently provides the general framework for Nigeria's energy efficiency strategy with reference to other specific energy efficiency related documents. The NEEAP includes baseline data and information on energy efficiency in the country as well as suggested achievable energy efficiency targets, including gender disaggregated indicators, based on national potentials and socio-economic assessments.

Quality standards, Minimum Energy Performance Standards (MEPS) and Testing Methods are emerging for most PUE technologies such as solar water pumps, and cooking and cooling appliances despite being in early technology or market development stage. Verasol for instance has quality standards for refrigerators currently under public review, while test methods for solar water pumps and pressure cookers are readily available. Countries like India are developing their own test methods for SWPs, UNEP is developing models to help governments deploy, adopt and enforce energy efficiency regulations for refrigerators. Various countries have adopted MEPS for energy efficient cooling appliances, either at voluntary (Uganda, Rwanda, Seychelles) or mandatory (Kenya, Mauritius, South Africa) implementation levels across Africa [11].

For Nigeria a mandatory approach to MEPS is recommended to be developed in line with the Guidelines[11] and Standards for Solar PV Components[12] recently developed by Standards Organization of Nigeria (SON) with support from the GIZ.

[11] https://africa-energy-portal.org/news/nigeria-fg-releases-guidelines-solar-power-operations

[12] https://guardian.ng/business-services/son-unveils-standards-for-meters-solar-pv-components/

3. Key stakeholder mapping of PUE in Nigeria

Stakeholders in the PUE space consists of supply side (providers), enablers and demand side (end-users), illustrated below. Note that some of the identified stakeholders play multiple roles. For instance, Non-Governmental Organisations (NGOs) have been enablers and suppliers of PUE equipment and appliances, Micro-Finance Institutions (MFIs) have played the role of funders and suppliers, Development Agencies have played the role of researchers, capacity developers, and funders.

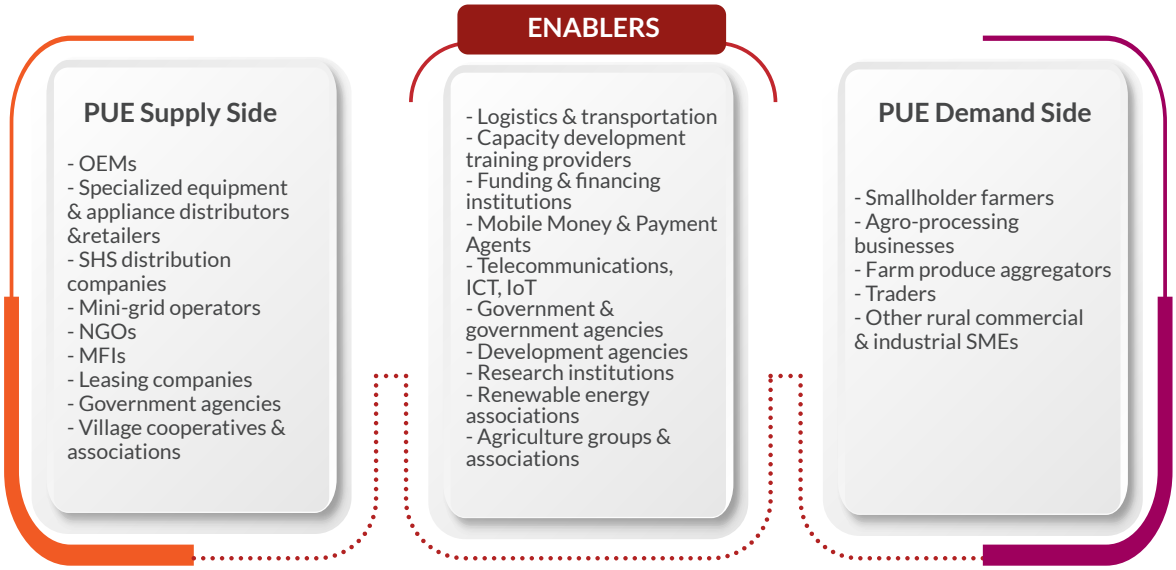


Figure 3: PUE Key Stakeholders

PUE suppliers on the supply-side of the market include:

Early-stage innovators, focusing exclusively on developing tailor-made products for segments of the small scale off-grid market.

Large appliance Manufacturers who are increasingly taking interest due to the market opportunity and adapting conventional appliances to the needs of the small- scale, off-grid market.

- **SHS/PAYGO companies** serving the last mile markets, having successfully included household appliances (e.g., televisions, fans) into product offerings and now diversifying into mostly standalone PUE appliances as the next line of products to roll-out.
- **Mini-grid companies** starting to actively promote the use of appliances as a demand and revenue stimulation strategy within their sites.
- **Original Equipment Manufacturers (OEMs)/Specialist Distributors** with established networks in one or more markets for productive use appliances such as irrigation solutions, farming machinery & equipment or solar equipment.
- **Leasing, MFIs, NGOs** interested in fulfilling demand from their customer target base.

PUE Enablers include:

- **Development Agencies, Research Institutions and Renewable Energy Associations** such as USAID-Power Africa, World Bank, AfDB, Cross Boundary, USADF, GIZ, RMI, GOGLA, A2EI, SEforALL, AMDA and REAN have been instrumental in pushing PUE within the agriculture and distributed renewable energy access space.
- **Agriculture Groups and Associations are key to Funding and Financing Institutions** active in the PUE and Off-grid space include both financial institutions, non-financial institutions, Development Finance Institutions, Government agencies, as well as private sector companies. Although not specifically measured for PUE, funding has been in the form of debt, equity, grants, or blended financing.
- **PUE end-users on the demand side** within rural communities include smallholder farmers, agro-processing businesses, aggregators, other small-scale SMEs in the commercial and industrial category.

4. Repository of SSA Business Models for Productive Use Appliances and Equipment

Delivery or Business Models in the context of PUE, refer to the responsibilities and relationships between stakeholders to enable the purchase, deployment, and efficient powering of PUE appliances and equipment using mini-grid or standalone electricity technologies.

Some literatures have recommended business models according to type of electricity supply technology (mini-grids or standalone systems), others have classified based on the type of equipment and appliances, others still have classified based on types of funding and financing. There is no clear-cut prescription as one may start off with a particular model and engage in another along the way, depending on the dynamics of the community and service in question.

Most developers tend to serve productive use customers more to increase revenues and this has been shown to critically improve income. A few mini-gird developer models highlighted here include the Supplier off-taker model, Business Acceleration Model and Energy Supply Model.

- **Supplier Off-taker Model:** In supplier off-taker model, the mini grid developer fills the demand gap by serving as the primary off-taker and initiator/operator of a productive activity. By engaging in both electricity supply and productive use activities, this supports revenue generation and profitability for the developer.

- **Business Acceleration Model:** Here the developer combines electricity supply with appliances and equipment direct sales and/or financing. This model has been proven to boost revenue generation for both the developer and the end-users.

- **Energy Supply Model:** In this model, the developer combines electricity supply with the activities of off-takers who interfaces with the consumers and the market, taking off the burden of appliance purchase loan administration while managing the PUE appliances and the mini grid.

These models improve consumption patterns because of the exposure of the end users to electricity usage. The longer users have access to electricity, the more power they are likely to consume. This is true for all customer types, and not only commercial customers. The steady growth in consumption consolidates that the longer people have access to a stable electricity supply the greater consumption of power. Evidence of this was presented in AMDA's report[19] where customers connected in 2019 had an average monthly consumption of 8.9kWh as against the previous report of 6.1kWh per month.

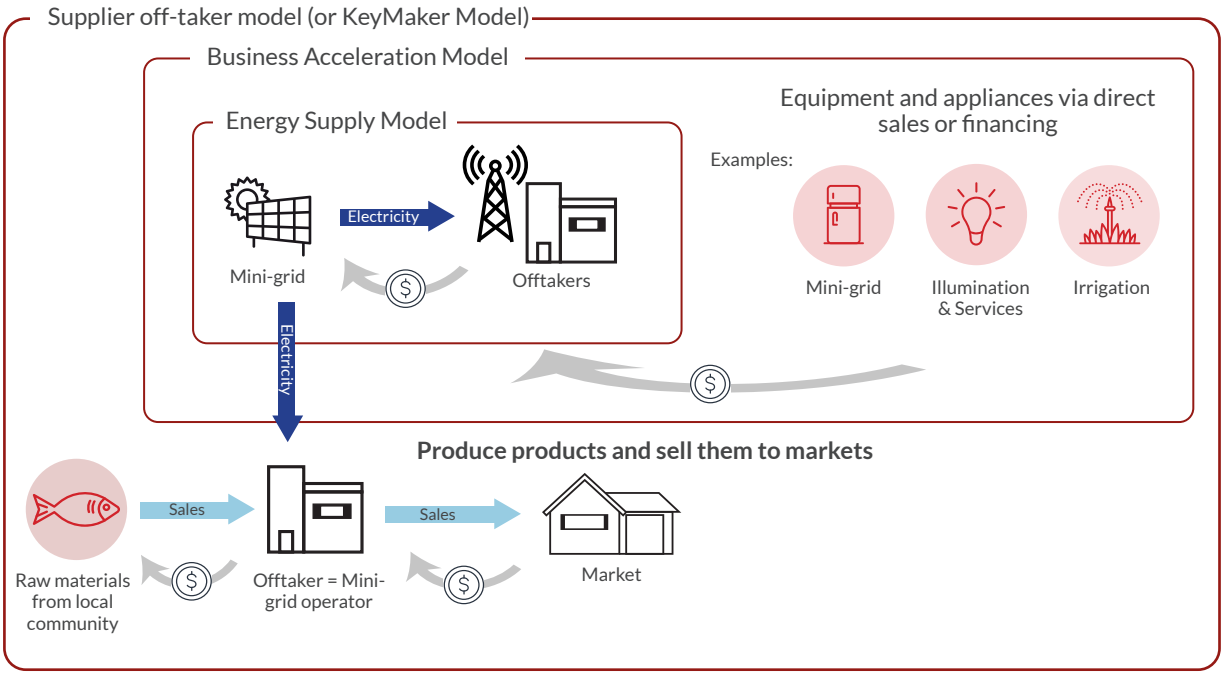


Figure 4: Operation Models for improved profitability for Mini-Grids Source: Adopted from EEP Africa, Inensus, BloombergNEF

The three types of standalone solar system business models highlighted here include Supplier Model, Out-grower Model, and Shared Model.

- **Supplier Model:** here the equipment provider is also the service provider, with a range of options for repayment models. This could be instalment payment plan such as lease- to-own (with or without upfront cost); capital subsidy model where the supplier provide equipment or appliances (that meet prescribed technical and warranty standards) at a discounted rates to end-users and a portion of the cost is borne by the government or donors as a capital subsidy; Pay-As-You-Go (PAYG) where end-users pay weekly instalments or whenever they are financially liquid. Under the PAYG model, the supplier retains ownership of the equipment or appliance in perpetuity. This credit system removes the initial financial barrier for the end-users by allowing them to make a series of modest payments to purchase units of time (pay-per-use period) instead of paying upfront for the entire system. In Nigeria, most small-scale solar systems and irrigation system suppliers (< 10 kW) operate using a PAYG business model.
- **Out-grower Model:** In this model, an out-grower (also known as an off-taker) enters binding arrangements with individuals or groups of farmers for the production and supply of agricultural products at some future time and meeting certain requirements. This model is largely dependent on the availability of a major off taker requiring a constant supply of farm produce, who is able to invest in equipment and appliances on behalf of a group of farmers.
- **Shared Model:** Under the shared model, equipment, and appliances provider (also a service provider) rents the hardware equipment or service to a community (typically farmers) in exchange for payment. Group sharing, water-as-a-service and renting are examples of a shared model. This type of model's design caters to the needs of a community of farmers, usually farmer cooperatives. Through renting, the service provider owns, maintains, and rents the equipment and appliances.

Some examples of ownership models include the following:

- **Commercial Partner Model:** This model is employed when equipment or appliances are not easily accessible on demand within target communities where a mini-grid exists. In this model, a partnership is established between the mini-grid developer and a cold storage provider for example to bring cold storage systems such as a milk-chiller, cold room, and ice-maker to the target community.
- **Developer-owned Model:** In a developer-owned model, the mini-grid developer is also the provider of the equipment or appliances. For instance, both the mini-grid utility and the cold storage system are owned and operated by the same party. This model is used to drive the productive use of energy by the mini-grid developer in a target community with cold storage needs.
- **Shared Community-owned Model:** In a shared community model, members of the community form a group or association and purchase an equipment or appliance for shared use. The mini-grid developer works with the community, providing technical support such as recommendations on equipment compatibility based on energy needs. For instance, the community can own the cold storage system in this model but requires funding through grants, loans, and community contributions/savings to make the initial purchase.
- **Provider-owned Model:** In this model, the provider owns, constructs, and operates the required equipment or appliances or multi-functional platforms that house various machinery. This model requires a facilitator to go into the rural off-grid communities to increase awareness among target customers. As mentioned earlier, the mini-grid developer can also be a provider under the developer-owned model. Subsidy, rental, pay-as-you-store (PAYS) and ice-as-a-service (IAAS) are all examples of the repayment arrangements of the solar powered cold storage service provider-owned model. This model is end user oriented as it tends to bring the developer closer to the end users and this association is usually critical to the survival of the mini-grid project and business.

5. Considerations

Although non-exhaustive, some apparent factors to consider for PUE deployments across Nigeria are:

1. Prevalent PUE activities in the areas of deployment.

2. Replacement factor such as the applicability, cost of existing alternatives, awareness, and familiarity with proposed/new PUE technology.

3. Efficiency factor of the new PUE technology vis-à-vis the old PUE technology in use.

4. Environmental sustainability in terms of the emissions reduction factor.

5. Quality standards need to be addressed.

6. Income profile of PUE businesses and accessible finance within the community or the state of deployment.

7. Availability of after-sales operations and maintenance support in country.

8. Collaborative PUE programme and intervention development, most programs are developed in isolation by the energy sector, agriculture sector, private sector, DFIs. PUE sector is cross-cutting, and it would be of greater benefit and impact to both developers and end-users if the siloed approach to developing interventions shifts to a more collaborative approach..

9. Market linkages through digital platforms; a common denominator in Nigeria is the proliferation of mobile phones (90% of population) and to some extent internet connectivity (50% of population) [20] across both rural and urban communities. Digital platforms working in the agriculture space can easily be leveraged to promote PUE amongst smallholder farmers groups. An example is Coamana's Amana Market digital marketplace, linking 50,000+ active farmers to financial services (10,000 accessed financial services) and digital education content (over 150,000 farmers benefitted from this).

10. Demand-Side subsidies targeted at the end-users to make the PUE appliances and equipment more affordable by directly reducing the price paid by end users to the supplier. To strengthen this, a financial modelling expert could be engaged to build upon REA's existing PUE subsidy scheme, which is more supply-sided.

6. Appendix

6.1 List of PUE Appliance and Equipment and Suppliers (Database)

S/No	PUE APPLIANCES AND EQUIPMENTS	SUPPLIERS
1	SOLAR WATER PUMP	FUTURE PUMP INDIA, SUN CULTURE KENYA LTD
2	AGRO COLD CHAIN REFREGERATION	OWO KELLY METAL CONST
3	STAND ALONE FREEZERS	KOOL BOKS NIGERIA
4	COOLERS AND CONTAINERIZED COLD ROOMS	OWO KELLY METAL CONST
5	ELECTRIC VEHICLES (2 WHEELERS AND 3 WHEELERS)	METRO AFRICA XPRESS NIGERIA
6	MILLS, THRESHERS, GRATERS, DEHAULERS AND PARBOILERS	OWO KELLY METAL CONST
7	POULTRY INCUBATORS	OWO KELLY METAL CONST
8	TELEVISIONS	FOUANI STORES
9	FANS	GZ INDUSTRIAL SUPPLIES
10	RADIOS AND SOUND SYSTEMS	FOUANI STORES
11	OIL NUT PRESS	OWO KELLY METAL CONST

6.2 Non-Exhaustive List of Existing Mini-grids in Nigeria

S/No	DEVELOPER	LOCATION (STATE)	SYSTEM DESIGN	SOLAR POWER CAPACITY (KW)
1	A4&T Power Solutions	Ogun	Solar PV – Battery S	6
2	A4&T Power Solutions	Ondo	Solar PV- Battery-Diesel Hybrid System	12
3	A4&T Power Solutions	Ondo	Solar PV – Battery	15
4	ACOB Lighting Technology Limited	Kaduna	Solar PV – Battery	16
5	ACOB Lighting Technology Limited	Delta	Solar PV – Battery	16
6	ACOB Lighting Technology Limited	Rivers	Solar PV – Battery	16
7	ACOB Lighting Technology Limited	Lagos	Solar PV- Battery-Diesel Hybrid	40

8	ACOB Lighting Technology Limited	Kaduna	Solar PV- Battery-Diesel Hybrid	50
9	Arnergy	Osun	Solar PV – Battery	24
10	Arnergy	Edo	Solar PV – Battery	40
11	Renewvia Energy	Bayelsa	Solar PV- Battery-Diesel Hybrid	134.64
12	GVE	Rivers	Solar PV – Battery	24
13	GVE	Gombe	Solar PV – Battery	34
14	GVE	Niger	Solar PV – Battery	40
15	GVE	Plateau	Solar PV – Battery	50
16	GVE	Plateau	Solar PV – Battery	50
17	GVE	Akwa Ibom	Solar PV – Battery	100
18	CREDC	Cross River	Solar PV – Battery	50
19	Leading Diagonal Engineering Nig Ltd	Gombe		85
20	GoSolar	Sokoto	Solar PV – Battery	80
21	HavenHill Synergy Limited	Abuja	Solar PV – Battery	20
22	HavenHill Synergy Limited	Abuja	Solar PV – Battery	30
23	HavenHill Synergy Limited	Abuja	Solar PV – Battery	40
24	HavenHill Synergy Limited	Oyo	Solar PV- Battery-Diesel Hybrid	100
25	AY Global Integrated Consulting Ltd	Niger		40
26	AY Global Integrated Consulting Ltd	Niger		40
27	AY Global Integrated Consulting Ltd	Sokoto		60
28	Rubitec	Ogun	Solar PV- Battery-Diesel Hybrid	85
29	PowerGen	Niger	Solar PV – Battery	64
30	Nayo Tropical Technology Limited	Niger	Solar PV – Battery	100
31	Nayo Tropical Technology Limited	Kebbi	Solar PV – Battery	98.8
32	Sosai Renewable Energies Limited	Kaduna	Solar PV – Battery	10
33	Newmoon	Kogi	Solar PV – Battery	80
34	Ashipa Electric Limited	Ogun	Solar PV – Battery	32
35	Ashipa Electric Limited	Abuja	Solar PV – Battery	100

36	Protogy Global Services Limited	Sokoto	Solar PV – Battery	60
37	Protogy Global Services Limited	Sokoto	Solar PV – Battery	60
38	Cloud Energy Photoelectric Limited	Ebonyi	-	100
39	Husk Power Systems	Nassarawa	Solar PV- Battery-Diesel Hybrid	50
40	Husk Power Systems	Nassarawa	Solar PV- Battery-Diesel Hybrid	50
41	Husk Power Systems	Nassarawa	Solar PV- Battery-Diesel Hybrid	50
42	Husk Power Systems	Nassarawa	Solar PV- Battery-Diesel Hybrid	50

Solar panel installation. Source: Shutterstock

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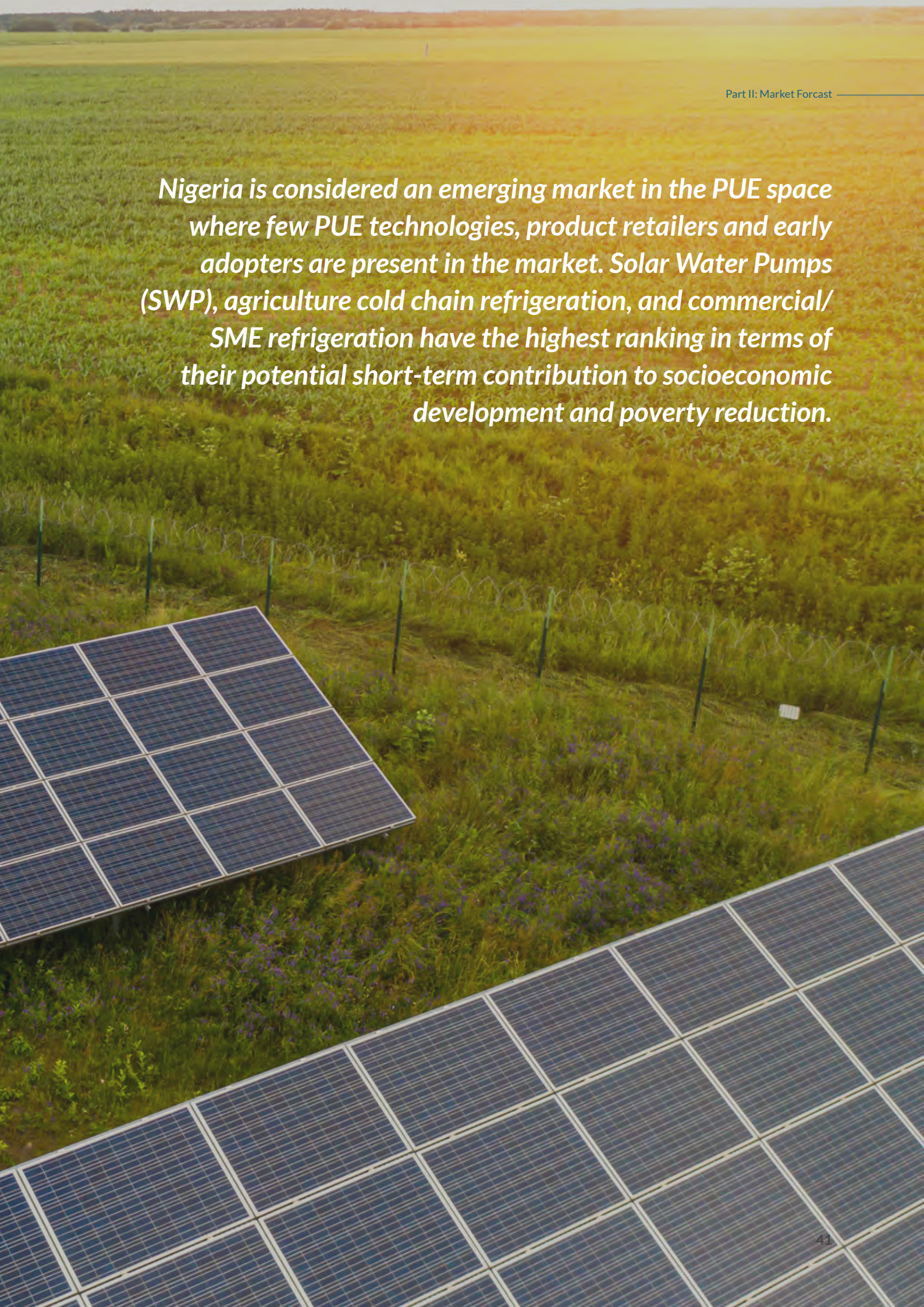
[19]"Benchmarking Africa's Mini Grids Report 2022." Africa Minigrid Developers Association (AMDA), 2022. Accessed: Feb. 27, 2023. [Online]. Available: https://africamda.org/wp-content/uploads/2022/06/Benchmarking-Africa-Minigrids-Report-2022-Key-Findings.pdf

[20]P. Gilbert, Editor, and C. Africa, "Nigerian Internet and mobile penetration grows," *Connecting Africa*, Feb. 16, 2021. http://www.connectingafrica.com/author.asp?section_id=761&doc_id=767400 (accessed Feb. 27, 2023).

PART II

MARKET FORECAST



Nigeria is considered an emerging market in the PUE space where few PUE technologies, product retailers and early adopters are present in the market. Solar Water Pumps (SWP), agriculture cold chain refrigeration, and commercial/ SME refrigeration have the highest ranking in terms of their potential short-term contribution to socioeconomic development and poverty reduction.

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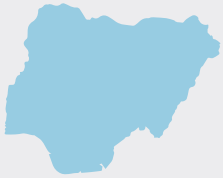
1. PUE Market Forecast

This chapter provides information concerning PUE market capacity based on the existing and projected market size in the various technology and PUE category space.



3000 – 4000MW
Current energy demand

2030
100,000MW
Energy demand in Nigeria

1.1 Analysis of Market Environment

Currently, Nigeria is only able to provide about 3000 – 4000MW of power, which is mostly consumed in urban areas. There is compelling evidence[1] that demand for energy in Nigeria will increase in coming years to about 100,000MW by 2030. This is higher than existing installed grid capacity and exposes a significant gap to be filled by other solutions.

Recent hikes in costs of petrol and diesel also create a strong case for solar powered solutions. Grid and petrol- and diesel-powered generators are the significant providers of energy to Nigerian households and businesses. It was estimated[2] that Nigerians spent USD14 billion on self-generated energy in 2020. It is even reported[3] that Nigeria's reliance on alternative energy from generators is alarming with a combined power of 10 – 15GW being triple national grid distribution. This trend is not likely to change much except with significant investment in Off-grid Solar (OGS) solutions and its uptake by especially MSMEs which make up the majority of businesses in Nigeria. It is also agreed that while planned grid extensions and strengthening solutions continue to be developed, progress is slow and expensive compared to OGS with better viability and accessibility for underserved or unserved locations.

Similarly, interest in solar as an alternative energy is growing in Nigeria considering its benefits such as the provision of cleaner, noiseless, less stressful energy. This is asides the abundance of radiation available that makes solar a viable alternative. The increasing number of active OGS industry players is evidenced in the Renewable Energy Association of Nigeria's (REAN)[4] membership; where the association started with about 20 members at inception (2016), now it has over 120 members, majority

[1] Solar Report Nigeria. May 2021
[2] Nairametrics (2020). Nigerians spend USD14 billion on generators, fuel.
[3] Power for All. Research Summary: Nigeria Finance
[4] https://rean.org.ng/about-us/

of whom are indigenous Nigerian companies. Under the REA's NEP alone, there are 48 REA qualified mini grid companies and 51 qualified SHS companies. Similarly, there are 81 completed mini grids and 150 mini grids in progress. This shows a significant growing trend in the market. Furthermore, looking through the proposal and achievements of the NEP, there are significant grounds to cover especially with MSMEs empowerment. For example, the NEP plans to energise 109,000 MSMEs, of which only 4,795 MSMEs have been covered as of March 2023. It is worthy of mention that NEP has trumped their projections in other areas such as households and individuals connected.

Market studies point to the fact that Nigeria potentially has the largest African market for OGS solutions, in part due to the number planned and existing underserved and unserved communities, and the urban-rural energy access gap. The annual potential market for OGS in Nigeria is estimated at USD9.2 billion. Given this potential and the current move towards OGS solutions as preferred alternative, the market is large and open. Unfortunately, capacity utilisation is currently low despite the soaring number of key stakeholders; there is still room for significant entrants to maximise their value. Sales of off-grid solar however saw a major decline in 2020[5], while default increased for existing PAYG customers. This is easily attributable to the effect of COVID-19 and the general decrease in commitment to pay. Going forward, it is likely that sales of OGS will continue to increase with Government's commitment to total electrification by 2030 and support for OGS solutions as a key component for the policy drive.

It is foreseen that the Nigerian off-grid market will continue to grow into the future. Significantly, the Nigerian Government has pledged its commitment to off-grid solutions to meet its 100% electrification goal using a mix of grid and off-grid solutions. The market is still very much underserved. According to the 2022 Power Africa Nigeria Power Sector Program Off-grid Market Intelligence Report[6] despite significant growth in the OGS sector comprising of solar mini-grids, solar home systems (SHS), and off-grid component manufacturing, there is space for significant scaling up of off-grid clean energy solutions and PUE by extension.

In 2019, ESMAP[7] estimated that there were more than 100 firms developing PUE equipment and appliances for the African market. Further mentioning however that sales were low. Despite this number, most of the PUE equipment and appliances are for household uses such as lamps, TVs, and other charging outlets as highlighted in the market study chapters. With increased adoption of OGS, the need for compatible productive use equipment and appliances will increase accordingly. This demand will ordinarily emerge as a more sustainable option given the increased adoption of OGS.

Funding to produce and support PUE equipment and appliances should no longer be a significant challenge given the support that the OGS sector has received internationally, and locally. Consumer financing as well is expected to become easier with significant increase in Payment Service Banks (PSBs) and Mobile Money. Nigeria is estimated to have approximately 90% mobile telephony penetration which gives significant leverage for easier revenue collection. The CBN as well mentioned during the currency change that it has coverage of the nation through agency banking.

[5] 2021 Standalone Solar System Market Update – Nigeria
[6] https://pdf.usaid.gov/pdf_docs/PA00ZB5X.pdf
[7] IFC (2019). The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa.

Given these financial inclusion policies and strategies being implemented, access to finance for solar energy portends minimal risk, except for unforeseen situations, such as the COVID 19. International finance as well as technical support including knowledge transfer is expanding and speeding up the development of the OGS sector in Nigeria with many international financiers, partners, and companies supplying needed finance, technical know-how as well support to local companies.

Economically, with projected rise in (youthful) population and its effect on economic activities, potentially driving growth, the demand for PUE Equipment and Appliances is expected to rise given its usefulness and contribution to cleaner, climate friendly energy solutions, and national climate targets.

Both demand and supply for PUE equipment and appliances should converge to facilitate and enhance local production, drive nationwide adoption, and stimulate export potential. It is believed that Nigeria is operationally poised to serve other Sub-Saharan countries[8].

Women farming in a Nigerain community Source: Power Africa

[8] Power Africa Nigeria Power Sector Program Off-Grid Market Intelligence Report. April 2022

2. Gap Analysis

The section compares what currently obtains with expectation and draws on available data to generate insights for strategy and implementation.

2.1 Current and future PUE market forecasts

In many surveys and data analysis, the expansiveness of the market as well its capacity to accommodate many players is constantly being highlighted. This expansiveness is attributed mostly to population growth, dwindling generation, transmission and distribution capacities of Nigeria's existing grid, increasing economic activities and need/push for cleaner energy. For this report, the size of the PUE market is largely based on estimates of existing and potential OGS technologies; SHS and Mini-grids. The following projections have been made:

Table 1: List of quantity of OGS by sponsors

OGS	Quantity	Delivery (Year)	Sponsors
Mini-grids	10,000	2023	REA & AfDB
	96,000	2030	Various
	200	2030	NEP
SHS	5 million	2023	Nigerian Government (SPN)

Based on the REA 2022 estimates for 2030, in Table 2 the current stage is compared with the estimated stage which includes installation of 1,459 mini-grids by 2030. Additionally, the total yearly electricity generation through 1,459 mini grids is calculated assuming each mini grid capacity to be 50 kW. With the assumed PV capacity, it is estimated to produce 137.5 GWh of electricity per year which can be directly used for productive use.

Table 2: Proposed strategic directions

Mini Grid data					
Existing Data			REA estimate (2030)		
Variables	Quantity	Potential value in USD	Variables	Quantity	Potential value in USD
Installed Mini grids	217	5,021,047	Total Mini grid by 2030 (REA)	1,617	124,164,548
Yearly available electricity (in GWh)	20.4	10,430,648	Yearly available electricity (in GWh)	152,4	77,725,148

As per the literature review, 80% of mini grid revenue comes from 20% of its customers within the three categories – agriculture, commercial and industrial, while residential customers make up 80% of connected customers but contribute 20% of the revenue share. In Table 3 the market value from residential and PUE applications are expanded with respective market share.

Table 3: Market value based on the REA 2030 estimate.

Market value		
Criteria	Value in USD	Market share
Market revenue from residential	24,832,910	20%
Market revenue from agriculture, commercial and standalone appliances	99,331,638	80%
Agriculture appliance and equipment	39,732,655	40%
Standalone appliance & equipment	14,899,746	15%
Commercial & Industrial small business	44,699,237	45%

Table 4 shows the currently disbursed PUE appliances and the forecast of PUE appliances by 2030 with average capacity in kW. It is estimated that by 2030 there will be 84,499 appliances in Nigeria which will be powered by mini-grids and SHS.

Table 4: PUE appliances market availability

Existing (2023)			Forecast (2030)			
Type of PUE	Quantity	Capacity in kW	Type of PUE	Quantity (REA)	Quantity (Calc.)	Capacity in kW
Agriculture appliance and equipment	434	55.92	Agriculture appliance and equipment	5655	3316	53.55
Standalone appliance & equipment	8,550	1.794	Standalone appliance & equipment	44074	26004	18.5
-	-	-	Commercial & Industrial small business	15414	9094.26	3.19

Table 5 below shows the overall market forecasting of PUE appliances (according to REA and calculations made). By 2030, it is estimated to have 84,499 appliances powered by solar PV system requiring 776.11 MWh. The total cost (without subsidy) required to acquire the appliances amounts to 21,565,366 USD.

It is assumed that appliances which have capacity less than 500 Watts are considered to be connected to Solar Home Systems, while appliances with capacity more than 500 Watts are considered to be connected to solar mini grids. Each mini grid is assumed to be of capacity 50 kW and the total sun-hours for Nigeria are 1885 hours[9]

Table 5: PUE appliances market forecasting

PUE Market Forecasting					
Parameters	Agriculture appliance & equipment	Standalone appliance & equipment	Commercial & Industrial small business	SHS connected appliances	Total
Quantity (Forecast)	12.127	17.630	14,364	26,444	84,499
Capacity in kW	53.55	17.8	2.9	0.99	
Consumption in MWh	616.9	120.5	33.41	5.3	776.11
Potential Market value	11,142,848	6,460,324	3,601,879	360,314	21,565,366

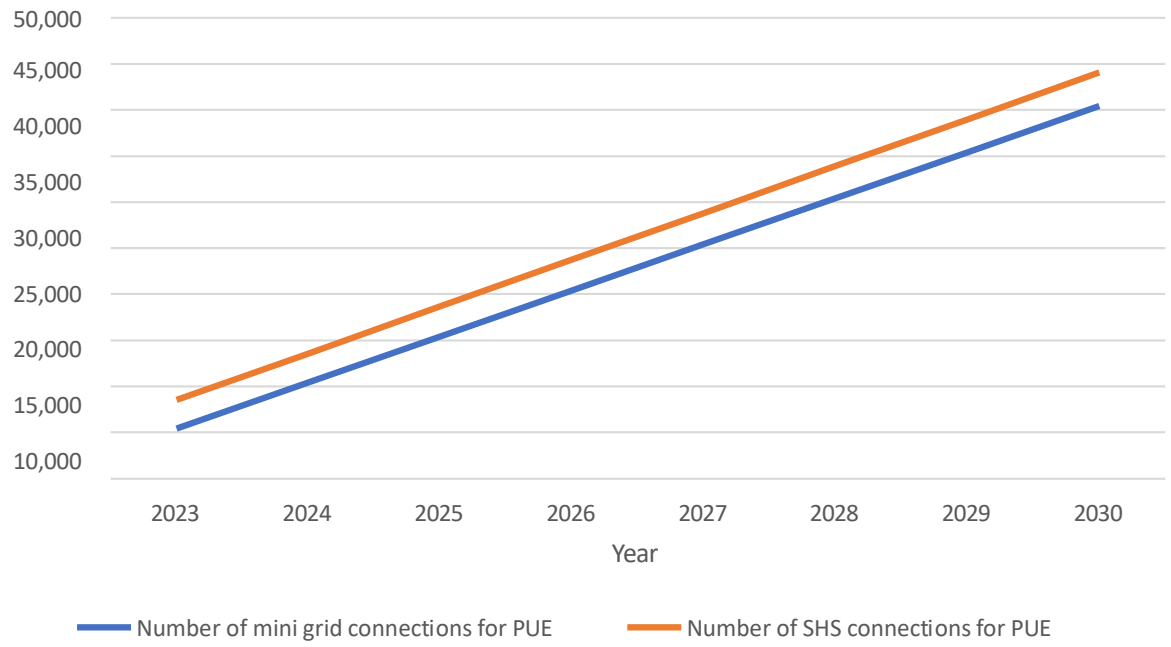


Figure 1: Number of PUE connection with mini grid and SHS

[9] http://www.lagos.climatemps.com/sunlight.php#:~:text=There%20is%20an%20average%20of,haze%20or%20low%20sun%20intensity.

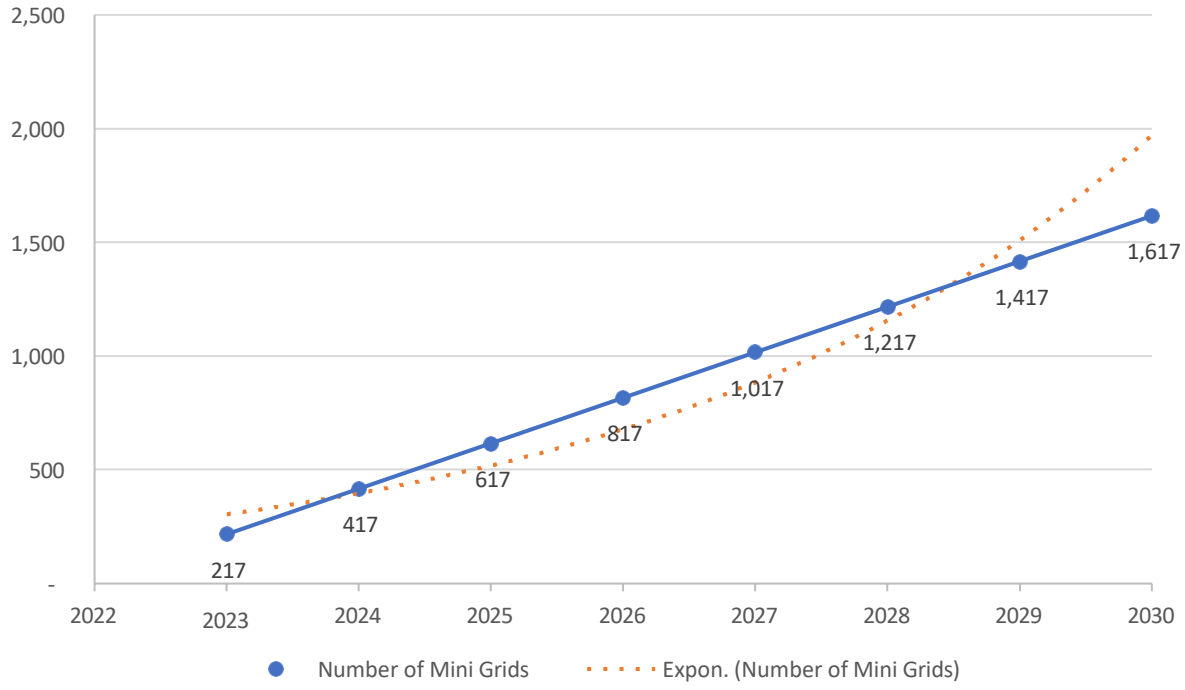


Figure 2: Mini Grid Forecasting

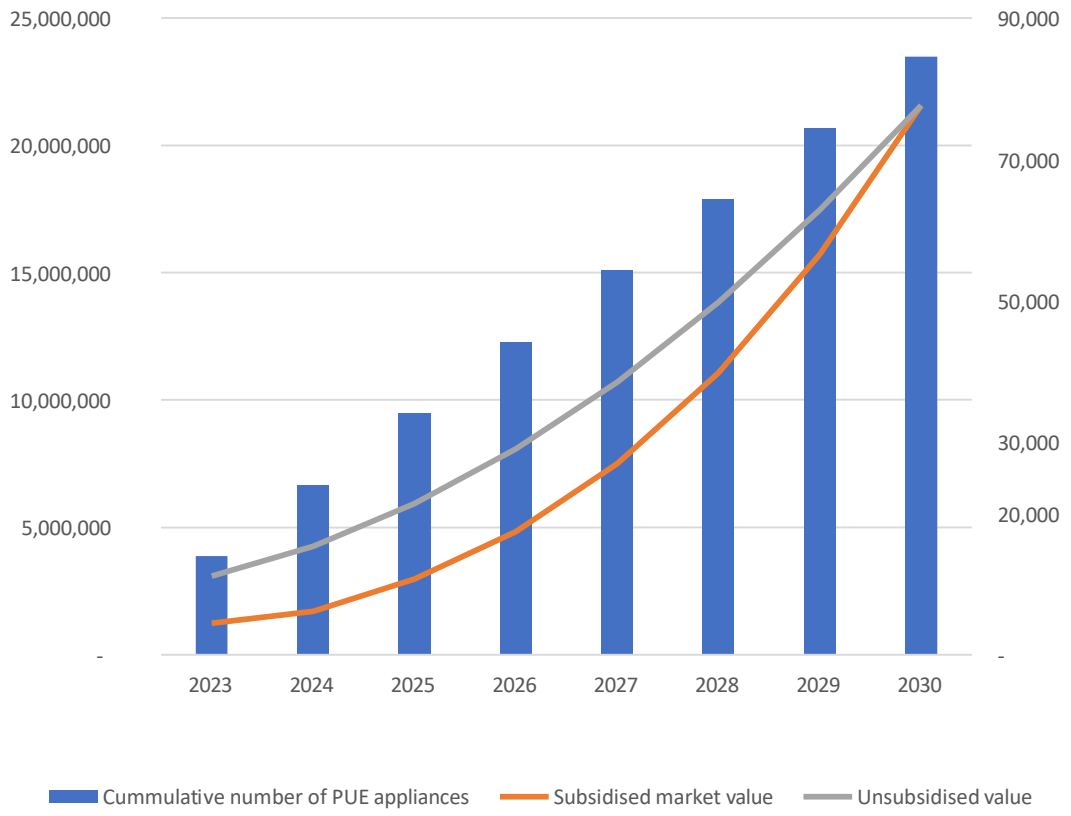


Figure 3: Total PUE number and market value

Figure 3 shows the achievable PUE market (numbers and value) by 2030. Two scenarios were taken into consideration:

1. The value of the current subsidy decreases by 10% per year until 2030, starting from 2025
2. Subsidies are completely removed and PUE appliances sold at market value.

Considering the two scenarios mentioned above, Table 5 provides on overview of the number of PUEs, and capacity of the forecasted appliances.

Assumptions made:

1. Average mini grid size of 50 kW
2. A ratio of 4:1 for mini grid residential connection to mini grid PUE connection
3. A yearly inflation of 22% is considered for carrying out market value forecasting.
4. As of 2023 baseline of 217 mini grids in Nigeria
5. Baseline assumption for total PUE appliances connected to SHS – 8550
6. Expected increase in number of mini-grid to be 200 per year

The forecasting has been performed for the period 2023 - 2030, and is aligned with:

- Nigeria's National Climate Change Policy for the period 2021 - 2030
- Medium Term National Development Plan, that runs until 2025.
- Nigeria's Updated Nationally Determined Contribution (2021)
- UN Sustainable Goals until 2030.

Performing a forecasting exercise beyond 2030 is considered highly hypothetical, in light of the year-on-year inflation in Nigeria, the absence of sufficient market data (supply, demand) beyond 2030 and international agreement on ways forward beyond the UN SDG 2030 Agenda.

3. Analysis of Market Capacity

This section considers the various stakeholders in the PUE Appliance and Equipment Market, and their various capacities guided by the diagram classification below:

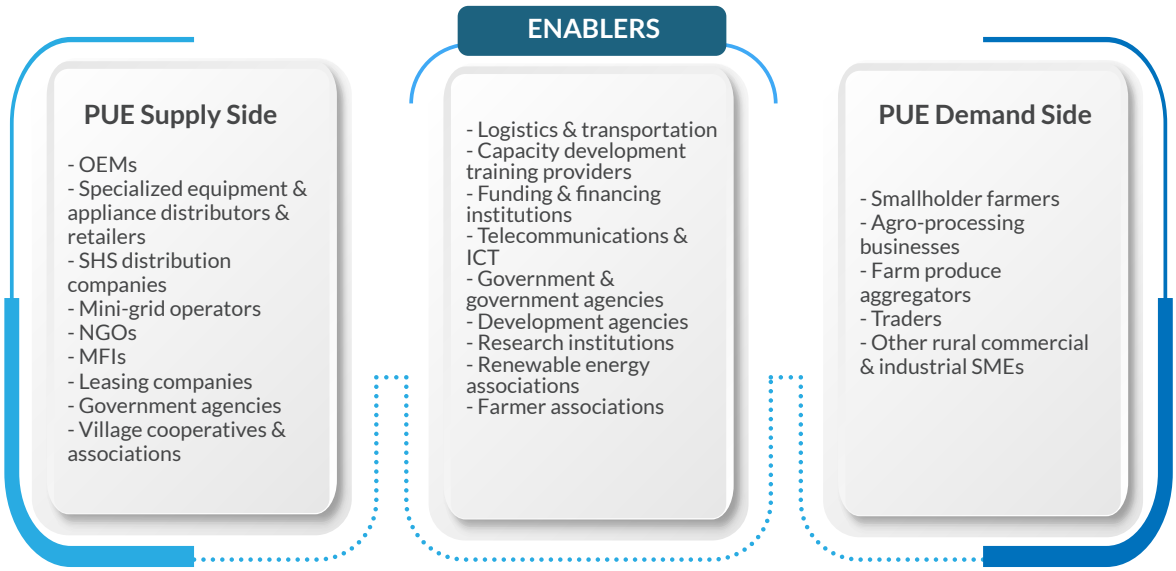


Figure 4: PUE Market Stakeholders

3.1 PUE Supply-side OEMs and Suppliers

Local capacity for the manufacturing of PUE Equipment and Appliances is limited. However, what is not in doubt is the supply chain. Nigerian suppliers of solar systems are numerous, although the market is not yet saturated.

A significant challenge has remained funding and financing on both demand and supply sides. To resolve the challenge, there are many financing options which have been presented in the market study report and as shown in Table 5 below. With growing interest in OGS especially in Africa, funding and financing should become less of a challenge in the coming decade.

For example, the Minimum Subsidy Tender financed by the AfDB and the World Bank seeks to amongst other things provide electricity through mini-grids to over 100 sites, which can connect about 20,000 MSMEs. With this connection rate, the need for PUE Equipment and Appliances will soar requiring manufacturers and suppliers to strategize to cover the burgeoning market. Similarly, there is the Universal Energy Facility – Stand-Alone Solar for Productive Use (SSPU) programme, that is designed to scale up electricity to SMEs[10]. This facility provides significant funding (40% of

[10] https://www.seforall.org/SSPU

CAPEX in two tranches) to PUE Equipment and Appliances Suppliers and Manufacturers to be able to cover the market.

However, the actualization of this need by the manufacturers may be hindered by trust on the part of end users caused by lack of certification of locally produced PUE appliances. The required certifications are SONCAP and MANCAP which are hindered by unfactored cost on the part of the manufacturers. This scenario can be appropriately managed if the financial part of the requirement for the certification are subsidized for the manufacturers to enable them obtain the required certification which will resonate in increased trust, increased patronage and increased production.

Many component parts are developed and manufactured in China, Europe and America and shipped into the country. Some components are imported as Completely Knocked Down (CKD) and assembled in-country. This has impact on cost of production, technical competence as well as service delivery. As mentioned earlier, efforts are increasing to push for local production, however, it is noted that local production is highly dependent on increased uptake by the Nigerian market. Similarly, foreign exchange fluctuations do not make importation easy for many developers and assembly points in Nigeria.

Capacity development and quality enhancement support will also need to be provided to existing manufacturers and suppliers to enable them take advantage of both the Nigerian and West African regional market for PUE.

Research and Development

Specialist training and technical colleges and institutions such as the International Institute of Tropical Agriculture (IITA), National Agency for Science and Engineering Infrastructure (NASENI), Renewable Energy Technology Training Institute (RETTI) and others can be engaged specifically for R&D for country-specific PUE Equipment and Appliances.
Similarly, policies have been developed to enhance competence and practice in the sector with a resounding policy on Used Lead Acid Battery (ULAB) by the REAN whose membership is constantly growing.

3.2 PUE Enablers

Existing enablers of PUE market development are mostly government agencies backed by funding from DFIs, regional bodies such as ECOWAS and EU, and global energy access programs such as the SEforALL. A list of projects and sponsors are provided in Table 6 below.

Table 6: Financing Opportunities for Suppliers of OGS and PUE Equipment and Appliances

S/N	Project name	Project type	Funding	Expected number of connections	Open/ Closed	Sponsor
1	Minimum Subsidy Tender (AfDB)	Mini-grids	USD46 million	105,000 households and 20,000 MSMEs	Open	REA/AfDB
2	Minimum Subsidy Tender (WB)[11]	Mini-grids	USD25 million	250 sites in 10 States	Closed	REA/World Bank
3	DART Equipment Financing Facility Nigeria	C&I Solar, Mini-grids, small-scale solar for productive use (SSPU)/ Solar Energy Systems (SES)			Open	Green Energy Alliance for People and Planet
4	ECREEE – ECOWAS Renewable Energy Facility (EREF)	Mini-Grids	USD1.2million		Closed	ECOWAS
5	NEP AfDB Productive Use Appliances & Equipment (PUE)	Productive use appliances and equipment			Open	REA
6	REA Interconnected Mini-grid Acceleration Scheme (IMAS)	Interconnected Mini-Grids	€3 million	15,000 connections	Closed	EU, German Government, Nigerian Government, REA
7	REA Mini-grid Acceleration Scheme	Mini-Grids with Productive Uses	€6 million	21,000 connections	Closed	EU, German Government, Nigerian Government, REA
8	REA NEP Output Based Grant Program (SHS)	Solar Home Systems	USD60 million	1,500,000 households and micro-enterprises	Open	REA
9	REA NEP Performance Based Grant (PBG)	Solar Hybrid Mini Grids	USD48 million	300,000 households & 30,000 local enterprises	Open	REA

[11] https://nep.rea.gov.ng/mini-grid-tender/

10	Results Based Financing for Productive Appliances & Equipment[12]	Productive Use Equipment	USD19 million	24,500 MSMEs and 1,050,000 individuals	Open	REA
11	The Nigeria Electrification Project – Solar Power Naija/5M Connections[13]	Mini-grids and Solar Home Systems	USD350 million	5million	Open	
12	Trine C&I Debt Facility[14]	Various			Open	Trine
13	Universal Energy Facility: Standalone Solar for Productive Use[15]	Various			Open	Sustainable Energy for All

Source: Various as referenced.

3.3 PUE Demand-side

As earlier highlighted, a viable option for suppliers of PUE Equipment and Appliances in the agricultural sector is the use of registered, recognised, and accredited associations, cooperatives, and unions. Unfortunately, data on the number of these organisations is grossly inadequate. This might be due to the nature of the landscape. It is noted that All Farmers Association of Nigeria (AFAN) mentioned[16] that it is the umbrella body for 56 recognized commodity associations in Nigeria although it appears that the Nigerian Government recognise the Federation of Agricultural Commodity Associations of Nigeria (FACAN) having inaugurated their boards in 2021[17].

[12] https://nep.rea.gov.ng/result-based-financing-for-productive-appliances-equipment/#plan
[13] https://odysseyenergysolutions.com/financing-programs/
[14] https://trine.com/finance
[15] https://www.seforall.org/SSPU
[16] https://www.afan.ng/about.html
[17] https://nairametrics.com/2021/12/11/fg-inaugurates-board-for-all-commodity-associations-under-facan/

In 2020, it was reported that there were 55 commodity associations in Nigeria[18], while only 40 were part of the 2021 Food Systems Summit organised by the UN.

Table 7: List of Commodity Associations in Nigeria

S/N	Value Chain	Name of Association
1.	Cashew	National Cashew Association of Nigeria
2.	Castor	Castor Growers, Processors, Marketers Association of Nigeria
3.	Cotton	National Cotton Association of Nigeria (NACOTAN)
4.	Wheat	Wheat Farmers Association of Nigeria (WFAN)
5.	Rice	Rice Farmers Association of Nigeria (RFAN)
6.	Sorghum	Sorghum/Millet Farmers Association of Nigeria
7.	Soybean	Soybean Commodity Association
8.	Cocoa	Cocoa Farmers Association of Nigeria (CFAN)
9.	Oil Palm	Oil Palm Growers Association of Nigeria (OPGAN)
10.	Coconut	National Coconut Producers, Processors and Marketers Association of Nigeria
11.	Rubber	National Rubber Processors and Marketers Association of Nigeria
12.	Shea Butter	National Shea Products Association of Nigeria
13.	Cassava	National Cassava Growers Association (NCGA)
14.	Yam	Nigeria Association of Yam Farmers, Processors, Marketers and Exporters
15.	Potato	Potato Farmers Association of Nigeria (POFAN)
16.	Irish Potato	Solanum and Vegetable Producers and Marketers Enterprises
17.	Sesame	National Sesame Seeds Association of Nigeria
18.	Ginger	National Ginger Association of Nigeria
19.	Groundnut	National Groundnut Producers, Processors and Marketers Association of Nigeria
20.	Tomato	National Tomato Growers, Processors and Marketers Association of Nigeria (NATPAN)
21.	Banana	National Banana & Plantain Growers, Processors and Marketers in Nigeria (NABPAN)
22.	Sabdariffa	National Hibiscus Farmers Processors, Marketers and Exporters' Association of Nigeria
23.	Onion	National Onion Producers, Processors and Marketers Association of Nigeria
24.	Gum Arabic	Gum Arabic Association of Nigeria

[18] https://www.vanguardngr.com/2020/10/55-commodity-associations-demand-unfettered-access-to-foreign-exchange/

S/N	Value Chain	Name of Association
25.	Honeybee Pollination Services	Federation of Beekeepers Association of Nigeria (FEBKAN)
26.	Bush Mango (Irvingia)	Irvingia Association
27.	Kenaf	Kenaf Producers, Processors and Marketers Association of Nigeria
28.	Maize	National Association of Maize Farmers
29.	Nutrition	Women in Nutrition Small Holder Farmers Association
30.	Cowpea	Cowpea and Beans Commodity Association
31.	Catfish	Catfish and Allied Farmers Association of Nigeria
32.	Fish	National Fish Association of Nigeria
33.	Fisheries	Fisheries Federation of Nigeria
34.	Cattle Breeder	Cattle Breeder and Dealers Association of Nigeria
35.	Mangoes	Mangoes Producers Association of Nigeria
36.	Banana and Plantain	National Banana and Plantain Association of Nigeria
37.	Sheep and Goat	National Sheep and Goats Association of Nigeria
38.	Cassia Tora	National Association of Cassia Tora Producers, Processors and Marketers of Nigeria
39.	Mechanization	Tractor Operators & Farmers Association of Nigeria
40.	Mechanization	Tractor Owners & Hiring Facility Association

Source: 2021 Food Systems Summit[19]

Other associations that participated in the 2021 Food Systems Summit are:

Table 8: Associations that participated in the 2021 Food Systems Summit

S/N	Name
1.	Nigeria Agro-Dealers Association
2.	Croplife Nigeria
3.	Seeds Entrepreneurs Association of Nigeria
4.	Agricultural Research Council of Nigeria
5.	National Agricultural Seed Council
6.	A-Nagropreneurs Association
7.	Small Scale Women Farmers Organisation of Nigeria
8.	All Farmers Association of Nigeria

Source: 2021 Food Systems Summit[20]

[19] https://summitdialogues.org/dialogue/20309/
[20] https://summitdialogues.org/dialogue/20309/

The number of registered and recognised commodity associations gives a vivid picture of potential demand for PUE Equipment and Appliances. The NBS baseline study on Nigeria's socio-economic activities reported that there were more than 100,000 registered Farmers Multipurpose Cooperatives with membership over 1.6 million in 2006. Unregistered farmers multipurpose cooperatives were close to 6,000 with membership over 3 million. This provides a significant market for the sale of PUE Equipment and Appliance. However, willingness to adopt, willingness to pay, amongst other factors are significant in determining how much of sales penetration can be achieved.

Table 9: Statistics of Registered and Unregistered Cooperatives in Nigeria

Type of Agric Cooperatives	Number					
	Registered		Unregistered		Membership	
	2005	2006	2005	2006	2005	2006
Farmers Multipurpose	150,719	100,444	7,337	5,853	1,695,444	3,027,781
Group Farming	91,498	12,702	1,956	1,640	326,970	308,611
Farm Settlements	25,803	4,022	23	5	61,679	22,895
Fishery	15,030	6,496	1,926	118	67,505	108,093
Livestock	29,149	14,373	151	1,086	36,838	98,218
Credit and Thrift	35,970	45,195	107	579	270,491	2,834,485
Informal Sector	26,185	23,119	358	136	87,326	113,641
Others	30,753	17,165	211	118	392,968	560,242

Source: Final Statistical Report, Volume I, NBSCBNNCC Report (2007)

4. Challenges and Opportunities

The PUE market is expected to grow exponentially with increased local production and durability of PUE equipment and appliances, increased technical competence for maintenance and repairs, of improved customer relationship, reduced import costs, finance cost and policy bureaucracies.

Allowing the private sector to massively lead market engagements while government and its agencies provide adequate enabling environment and access to resources will be a game changer for the increased adoption of PUE equipment and appliances.
The supply side financing gap remains largely due to low access to local funds, while international funds are challenged by foreign exchange fluctuations and capacity for uptake

by local firms. The interest rate on regular local finance is not suitable for an incipient sector as the PUE is where returns may be slow.

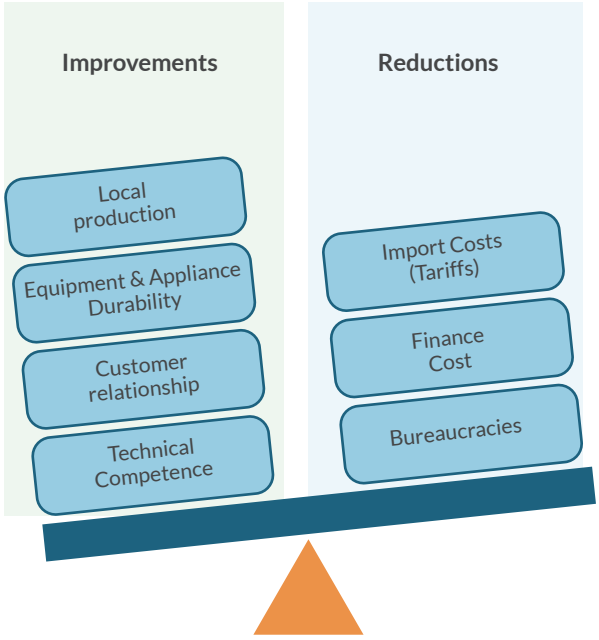


Figure 5: Proposed strategic directions

Significant challenges according to the REAN to achieving the renewable energy projections include "high tariffs and taxes of renewable technology, a relatively government-driven renewable energy market, poor sustainability check for quality and standards, poor sector liquidity to support new local investments and consumer financing for renewable energy adoption, poor support for local production and skill development, poor incentives for small local entrants, government bureaucracy,

and over 85% of the technology components imported[21]". Specifically, to address these challenges, policies, strategies, political will, funding, and targeted actions are required.

1. High tariffs and taxes of renewable technology

The Finance Act is a viable instrument to address this challenge. It would require a consolidation of lobbying as well as stakeholder engagements to achievement a reduction or waiver for the industry. It is noted that there is a level of concession, however, stakeholders especially manufacturers, assemblers, and suppliers have complained of the challenge of tariffs especially given the FOREX fluctuations.
Also, it has been argued that catalyzing local production will drastically reduce cost of production.

2. Government-driven renewable energy market

To drive the emerging market, it has been advocated that Government's role should be as an enabler, hovering around policy, regulation, market support mechanisms and instruments, rather than direct involvement in implementation.

3. Poor sustainability check for quality and standards

The Standards Organisation of Nigeria (SON) along with other agencies of Government such as the Nigeria Customs Service (NCS) have oversight of items coming to Nigeria at Ports and entry points. However, there have been complaints about substandard solar products, especially from China. Specifically, a report by SE4All "there is a proliferation of low- quality imports from China due to lack of strict regulations on quality products coming into Nigeria"[22].
More technology-enhanced monitoring and staff development would need to be done to ensure product monitoring for compliance.

4. Poor sector liquidity to support new local investments.

Funding is currently a challenge, but it is being addressed with many investors showing significant interest in entering the Nigerian renewable energy market.

5. Poor sector liquidity to support consumer financing for renewable energy adoption

Technology to support consumer financing is increasing with mobile telephony penetration at approximately 90%23 as well as growing Payment Service Bank (PSB) licensing.

6. Poor support for local production and skill development

As mentioned earlier, the work by NAPTIN and NASENI as well as other renewable energy academies is significantly increasing the capacity and competence of technical hands for manufacturing, assembling, maintenance, and repairs of solar products.

[21] Perception Survey of Local Manufacturers in the Nigerian Renewable Energy Sector
[22] SE4All (2021). Achieving Economies of Scale in the Nigerian Solar Value Chain: Opportunities and Benefits of Upstream Localization

There is need for sustained growth in this regard as well as targeted trainings to increase capable hands.

7. Poor incentives for small local entrants

Entrants into the renewable energy space are receiving little support. However, it is noted that as the sector grows with hubs springing up, the much-needed support will be available.
Technology hubs can help to minimise information asymmetry as well as fear of entry currently experienced by proposed entrants.

8. Government bureaucracy

Government bureaucracy is a hard nut to crack. However, with political will, it is possible to reduce bottlenecks and allow smooth running of Government's intervention. Government may decide to reduce its operational involvement in the industry as well.

9. Overdependence on importation of technology components

This challenge has been addressed earlier. As it stands, importation is the viable option, due to current levels of technology and capacity. With concerted efforts to increase competence, infrastructure, and an enabling environment, local production of technology can be achieved.

Some of the opportunities in the PUE market include the following:

1. Access and distribution channels

Access to market in Nigeria is significantly open. There is existing distribution infrastructure which can be leveraged at significantly reduced cost to manufacturers. Similarly, there are opportunities (resources, data, personnel etc.) to develop new distribution channels at low cost.
Currently the main distribution channels for PUE to the agro-processing sector include:

a) Indirect channels (alliances)
   This distribution channel targets formal and informal agro-allied alliances such as cooperative societies, associations, and clubs. This way the distributors or manufactures of PUE equipment relate indirectly with users through their registered associations.
b) Indirect channel (Joint venture, agency)
   This type of distribution targets already established business with significant outreach. Lumos and MTN Nigerian is a vivid example.
c) Direct channels
   Distributors or manufacturers engage users directly, promising them excellent customer service and product warranty.

2. Profit potential

It is estimated that many MSMEs are self-generating electricity and spend between highly on petrol- and/or diesel-powered generators as well as other sources. Asides the increasing cost of fuel, the cost of generator maintenance and repairs is significant. Considering the appeal of cleaner energy, research has shown that many electricity self-generating MSMEs are transitioning to solar energy.

5. Operating Models

The REA highlighted and proposed two business models: processing center model and facilitator model. Write up about the models are as presented by REA[24].

1. Processing Center Model

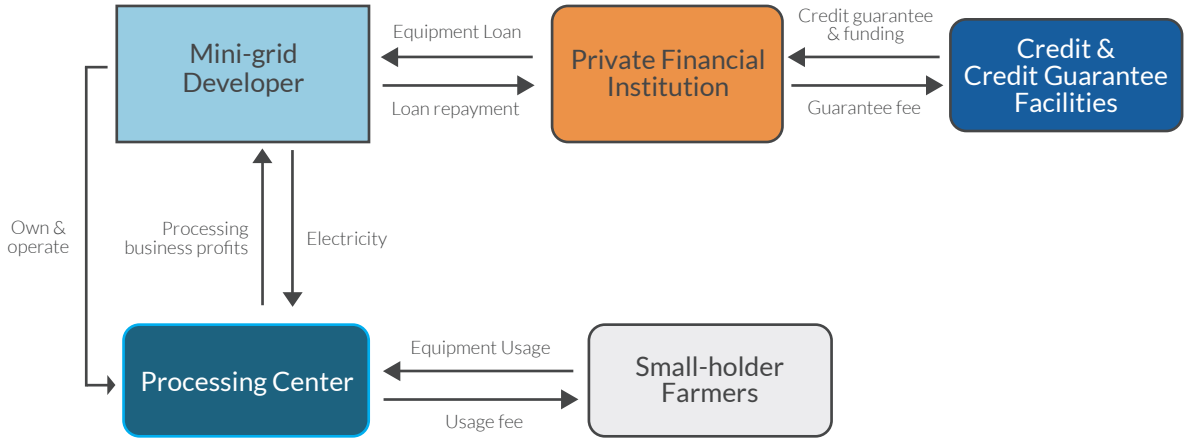


Figure 6: Processing Center Model

Source: REA[25]

The Processing Center Model relies on the mini-grid developer based in a rural community to invest in, own, and operate the productive use equipment for a new processing service that existing entrepreneurs within the community are not able to solely establish.

Below, are examples of actors in the Processing Center Model:

The mini-grid developer, who already provides reliable electricity services, will be the owner of the processing center by investing in the energy-efficient productive use appliances necessary to operate the processing center/business, and will be responsible for equipment operations and equipment loan repayment. Thus, the mini grid developer will bear the credit and operational risk of this project.

A private finance institution on-lends funding from the credit facility to the mini-grid developer. The PFI should have experience lending to the agriculture/power sector because it will have a better understanding of common risks, already have mechanisms to address these risks, and be more willing to lend for agricultural activities. Alternatively, banks that are already lending to mini-grid

[24] Perception Survey of Local Manufacturers in the Nigerian Renewable Energy Sector
[25] https://nep.rea.gov.ng/result-based-financing-for-productive-appliances-equipment/#models

companies may be more comfortable extending credit for a new credit line. The following banks are lending or have demonstrated interest in lending to mini- grid developers in Nigeria: Sterling Bank, First City Monument Bank, Access Bank, WEMA Bank Debt.

2. Facilitator Model

The Facilitator Model is led by a facilitator who enables small-scale processors to invest in equipment by serving as their education resource and connection point to finance providers.

In this model, the small-scale processor will be responsible for the credit and operational risk. The facilitator builds awareness about the investment opportunity and provides business development training to support loan applications and equipment selection, within the community.

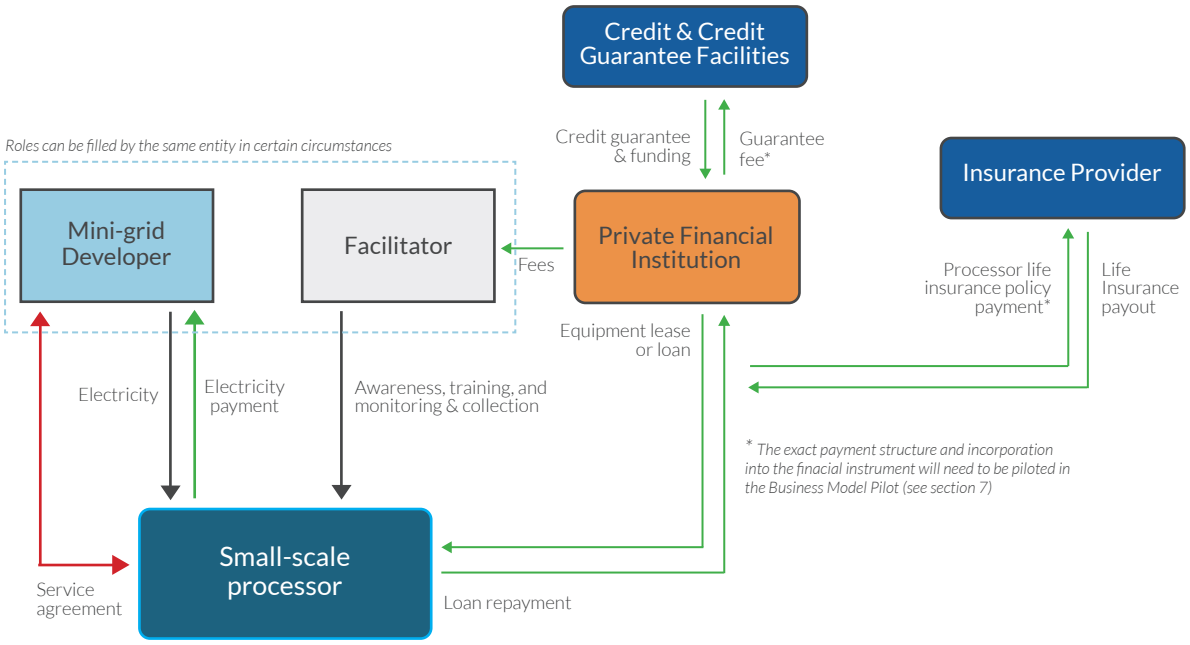


Figure 7: Facilitator Model

Source: REA[26]

Over time, once the viability of lending to small-scale processors is proven, the role of the facilitator would be phased out or reduced and the private financial institution (PFI) assumes the role of identifying and selecting would-be processors.

One major advantage of operating the Facilitator Model is that it de-risks participation by third parties to provide financing and capacity building, which enables equipment purchases and reduces the burden on the mini-grid developer.

[26] https://nep.rea.gov.ng/result-based-financing-for-productive-appliances-equipment/#models

6. Conclusions and Recommendations

6.1 Conclusions

The idea of stable, clean, noiseless, better energy at a slightly increased purchase rate can be appealing to households and businesses considering the erratic supply currently being endured as well as the fact that the instability of grid supply is mostly supplemented by alternatives such as petrol- or diesel-powered generators that create both air and noise pollution. It is also noted that solar energy has reduced maintenance cost, albeit its initial acquisition cost is still high. Furthermore, the use of disruptive technologies to manage solar energy gives much needed convenience and flexibility of use. The Nigerian Government has also shown significant interest in fostering the development and deployment of solar energy around the country. The market for PUE equipment and appliances will therefore continue to expand with increased adoption of decentralised renewable energy technologies.

6.2 Recommendations

To increase uptake of PUE equipment and appliance, the following are recommended:

1. Government support for PUE cannot be overruled, albeit increased engagement in the areas of subsidy and grants are better options for mini-grids.
2. Policy and technical support for local production of PUE equipment and appliances are likely to reduce cost of production and increase uptake by end users, ordinarily.
3. Reaching (engaging, and selling to,) the agro-processing MSMEs using their registered, recognised, and accredited associations, unions, and cooperatives will increase sales, revenue collections for especially PAYG.
4. Giving incentives to participating MSMEs in the forms of recognition for their contribution to climate change issues through cleaner, noiseless energy will boost the morale of existing subscribers and is likely to attract undecided (potential) and new subscribers.
5. Ensuring that PUE equipment and appliances are certified good by manufacturers and suppliers and giving such assurance through effective warranty policies are likely to increase their adoption.
6. Adopting a reducing balance repayment model for PUE equipment and appliance may be better for revenue collection. The reducing balance method proposes a higher repayment in the earlier period of acquisition, while lower amounts towards the later periods. The added benefit of this model is that the supplier can reduce bad debts.
7. Increasing customer relationship can foster adoption of PUE equipment and appliances.
8. Providing information on PUE equipment and appliances such as energy rating, durability, estimated useful life, dos and don'ts is likely to inspire increased adoption.

PART III

COMMERCIAL VIABILITY & FINANCIAL MECHANISMS

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List of Tables

1. Mapping of Programmes, Financiers and Financing Options for PUE MSMEs and for Energy Access Companies

1.1 Programmes

Apart from the REA NEP Energy Efficient Productive Use Appliances and Equipment grant intervention, there are various programmes promoting PUE in Africa and Nigeria. Some of them are highlighted below:

Programme	Description
Stand-Alone Solar for Productive Use (SSPU)	The Stand-Alone Solar for Productive Use (SSPU) programme of the UEF is designed to scale up electricity access to households, and small and medium enterprises (SMEs). The programme offers results-based grants to solar companies for verified end-user connections based on pre-determined standards. Companies using energy- as-a-service or lease-to-own business models are supported under the SSPU programme"[1].
Solar Power Nigeria (SPN)	The SPN plans to connect 5 million new connections as part of the Economic Sustainability Plan (ESP) and is supported by the Solar Connection Intervention Facility and is available to both upstream and downstream participants[2].
Sustainable Energy for All (SE4All)	Aims to achieve universal access to modern energy services, improve energy efficiency, and increase the share of renewable energy globally. "In September 2011, the UN Secretary General launched the Sustainable Energy for All (SE4All) initiative with the aim of achieving three goals by 2030: Ensuring universal access to modern energy services; doubling the global rate of improvement in energy efficiency; and doubling the share of renewable energy in the global mix"[3]. As part of the SE4All, the Sustainable Energy Fund for Africa (SEFA) was created with support from both the AfDB and Denmark. This fund was "to allow the AfDB to scale- up its engagement in the small to medium-sized renewable energy and energy efficiency space". Additionally, there is the SE4All Africa Hub, which "coordinate and facilitate implementation of the SE4All initiative"[4].

[1] https://www.seforall.org/SSPU
[2] https://nep.rea.gov.ng/federal-governments-5milion-solar-connections-program/
[3] https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-for-all-se4all
[4] https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-for-all-se4all

UN Sustainable Development Goals (SDGs)	There are three specific Sustainable Development Goals that are directly related to PUE for which the Nigerian Government has committed to. They are Goal 7 (Affordable and Clean Energy), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action). There are diverse programmes initiated to achieve these goals. For example, to achieve Goals 7 and 13, Global Cleantech Innovation Program (GCIP) Nigeria is "seeking to encourage young Nigerian entrepreneurs and innovators in the technology, agricultural, industrial, waste management, water resources sectors, with finance and other support schemes, geared towards wealth creation through green processes and methodologies"[5].
Global Cleantech Innovation Program (GCIP)	Nigeria supports young entrepreneurs and innovators in green sectors to promote wealth creation and sustainable practices.
Africa-EU Energy Partnership (AEEP)	The essence of the AEEP is to generate sufficient fund for the African market to undertake strategic investments in the renewable energy sector such that growth is spurred to accelerate employment, economic activities, agricultural development and national development. Specifically, the aim is to "facilitate the achievement of universal access to affordable, sustainable and modern energy services in Africa, including in rural areas, as a necessity and as a pre-requisite to generating inclusive development and jobs"[6].
Productive Use Appliance Financing Facility (PUAFF)	In late 2022, CLASP and Nithio, supported by GEAPP launched a USD $6.5 million financing facility to grow the Productive Use Appliances market across Africa, focusing on six appliance technologies – walk-in cold rooms, refrigerators, electric cookers, fans, mills, and solar water pumps.

1.2 Funding and Financing Options

- Debt Financing through MFIs and Cooperatives providing load directly to providers/suppliers, crop off-takers and/or end users e.g., include credit guarantee facility (Agriculture Credit Support Scheme ACSS), private finance institutions. Interest rates and loan repayment tenors are important considerations for both suppliers and end-users of PUE.
- Equity Financing where mini-grid developers, crop off-takers/aggregators, equipment providers, or cooperatives can raise capital to finance equipment and appliance purchase. From DFIs, Impact investors, VCs, private equity investors.
- Grant Financing from DFIs in collaboration with government entities to reduce capital cost of equipment and appliances for the supplier, off-taker and/or end user. No repayment required but verification necessary. e.g. Grants can be administered in the form of result-based financing (RBF) or upfront payments. Examples of grants that can be leveraged for solar irrigation projects are the Nigeria Electrification Project (NEP), Rural Electrification Fund (REF) and Results Based Financing for Productive Appliances and Equipment. A list of identified potential funding and financing providers is included in Annex 6.3 below.

[5] https://sunnewsonline.com/fg-unido-gef-collaborate-to-meet-sdg-7-13-reduce-carbon-emission/
[6] https://africa-eu-energy-partnership.org/

Subsidy System

All the models highlighted above can be implemented in an easier manner with the assistance of government policies, and financial instruments interventions such as CAPEX subsidies. The aim of the CAPEX subsidy is to reduce the cost for the initial investment which will in turn reduce the cost of accessing the services, to the ultimate benefit of the end users.

Ordinarily, a subsidy is discouraged for the economic system except where this is properly targeted. But one of the importance of subsidies is to ensure that economic policies can be targeted.

However, there is a need to understand how to implement it. Factors that could influence the determination of subsidy level should be gender incentives, ability to scale solutions, vulnerability index all on top a base subsidy percentage. However, a cap on the value of subsidy per category can be established.

1.3 List of Identified Financiers

Access to suitable financing solutions is crucial for the development and success of indigenous businesses in Nigeria. A thorough list of funders is necessary to assist the growth of the manufacturing industry and to encourage the adoption of useful solar equipment and appliances in off-grid communities. This collection includes commercial banks, development finance organizations (DFIs), impact investment funds, microfinance institutions (MFIs), crowdfunding platforms, and supplier financing options in an effort to give a broad picture of the many financing options accessible to local manufacturers.

Local manufacturers rely heavily on the debt financing provided by commercial banks, who provide specialized loan programmes catered to their specific requirements. These financial institutions, including First Bank of Nigeria, Guaranty Trust, United Bank for Africa, Stanbic IBTC, Fidelity, Union Bank of Nigeria, Ecobank Nigeria, and Sterling Bank, provide a range of loan alternatives, including term loans, working capital financing, and trade finance options. These banks help manufacturers by offering reasonable lending rates, adaptable repayment periods, and individualized service to help them buy equipment, expand their facilities, and manage their working capital efficiently.

DFIs, such as the Bank of Industry, Development Bank of Nigeria, and Nigerian Export-Import Bank, in addition to commercial banks, are essential in providing long-term financing and assistance to regional manufacturers. To help manufacturers access patient capital for their growth and development, they provide a variety of loan facilities, project finance choices, and specialized financing plans.

Impact investment funds like Acumen, African Capital Alliance, Verod Capital Management, Sahel Capital, and Alitheia IDF Fund offer manufacturers committed to producing positive social and environmental impact alongside financial returns not only financial support but also expertise and guidance.

MFIs, such as LAPO Microfinance Bank, AB Microfinance Bank, Accion Microfinance Bank, and Mainstreet Microfinance Bank, provide accessible and customized financing options to micro and small-scale manufacturers, assisting them in meeting their working capital and investment requirements.

Finally, alternative financing possibilities are made available via crowdfunding websites like Crop2Cash, Thrive Agric, and FarmCrowdy, enabling people and organizations to engage in debt-based crowdfunding and support regional manufacturers.

Local PUE producers looking for finance solutions to assist their initiatives for productive use appliances and equipment in off-grid communities might benefit greatly from this comprehensive list of financiers. Manufacturers can discover the right partners to fuel their growth, boost their competitiveness, and contribute to the sector's sustainable development by looking into the wide range of financing options that are accessible.

Commercial Banks

Access Bank Plc

Term loans, working capital financing, and asset financing are just a few of the several loan options that Access Bank provides. They offer manufacturers specialized solutions, including financing for machinery and equipment. Through their Business Banking Division, Access Bank also provides advice services and specialized support to help manufacturers meet their growth goals.

Zenith Bank Plc

To help local enterprises grow and expand, Zenith Bank offers loans with a manufacturing sector focus. Term loans, working capital financing, trade financing, and equipment financing are all part of their loan portfolio.

Guaranty Trust Bank Plc (GTBank)

Through its Corporate Banking business, GTBank provides manufacturers with financial options. Term loans, working capital financing, and project financing are all part of their loan portfolio.

United Bank for Africa Plc (UBA)

The industrial industry is catered to by the numerous lending options offered by UBA. They offer term loans, overdraft services, invoice discounting, and trade financing options among their loan offerings.

First Bank of Nigeria Limited

Manufacturers can get funding from First Bank through term loans, working capital financing, and trade financing.

Stanbic IBTC Bank Plc

Manufacturers have access to a variety of financing alternatives from Stanbic IBTC Bank, including term loans, trade finance options, and working capital financing. Through their Business Banking division, they offer specialized assistance to manufacturers, helping with funding for equipment purchases, business expansion plans, and working capital requirements.

Fidelity Bank Plc

The industry can take advantage of the term loans, project financing, and working capital financing that Fidelity Bank provides. They give producers financial assistance for a range of needs, including inventory management, facility expansion, and equipment purchases.

Union Bank of Nigeria Plc

Through its Business Banking business, Union Bank provides manufacturers with financing options. Term loans, working capital financing, trade financing, and equipment financing are some of their borrowing options.

Ecobank Nigeria Plc

Manufacturers can get loans from Ecobank Nigeria in the form of term loans, working capital financing, and trade finance options. They provide funds for a range of initiatives, including inventory management, facility growth, and equipment acquisition.

Sterling Bank Plc

Manufacturers can get loans from Sterling Bank in the form of term loans, working capital financing, and trade finance options. Through their Business Support Services, they offer knowledgeable advice and specialized support to manufacturers.

Microfinance Institutions

LAPO Microfinance Bank

One of the biggest microfinance institutions, LAPO Microfinance Bank offers small and microbusiness owners financial services. They provide local manufacturers with working capital financing, asset financing, and equipment loans, among other lending options.

AB Microfinance Bank

Leading microfinance institution AB Microfinance Bank provides manufacturers with financing services for their small and microbusinesses. For the purpose of assisting manufacturers with their growth and operating requirements, they offer business loans, working capital financing, and asset financing.

Accion Microfinance Bank

A respected microfinance organization, Accion Microfinance Bank, offers financial services to micro and small-scale business owners throughout Nigeria. They provide manufacturers with credit and financing options for working capital, equipment purchases, and company growth.

Mainstreet Microfinance Bank

Mainstreet Microfinance Bank is a microfinance institution focused on providing financial services to micro, small, and medium-sized enterprises (MSMEs) in Nigeria. They offer business loans, asset financing, and working capital finance to manufacturers to support their growth and development.

Development Finance Institutions (DFIs)

Bank of Industry (BOI)

The Bank of Industry is Nigeria's oldest and largest DFI, focused on providing financial assistance to various sectors, including manufacturing. BOI offers loan products such as term loans, working capital finance, and project finance to support the growth and development of local manufacturers. They have specialized financing schemes, including the Cottage Agro Processing (CAP) Fund and the Small and Medium Enterprises Development Fund (SMEDAN) Loan Scheme, tailored to specific manufacturing sub-sectors.

Development Bank of Nigeria (DBN)

The Development Bank of Nigeria was established to provide sustainable financing to micro, small, and medium-sized enterprises (MSMEs), including manufacturers. DBN offers term loans, working capital finance, and other financial products to support the growth and expansion of local manufacturers. They collaborate with Participating Financial Institutions (PFIs) to channel financing to manufacturers, ensuring broad access to funding across the country.

Impact Investment Funds Acumen

Acumen is a global impact investment fund that focuses on supporting businesses that address social and environmental challenges. Acumen provides patient capital in the form of debt financing to local manufacturers in sectors such as agriculture, energy, and healthcare. They offer customized loan products and investment structures tailored to the needs of impact- driven manufacturers. Acumen also provides business support services, mentorship, and access to networks to help manufacturers grow sustainably.

African Capital Alliance (ACA)

African Capital Alliance is a private equity and impact investment firm with a focus on West Africa. ACA provides debt financing and equity investments to local manufacturers in various sectors, including manufacturing and renewable energy. They support manufacturers through their West Africa Emerging Growth Fund, which provides growth capital and strategic guidance.

ACA's investment approach combines financial returns with measurable positive social and environmental impact.

Verod Capital Management

Verod Capital Management is a private equity firm that invests in small and medium-sized enterprises (SMEs) in West Africa, including manufacturers. They provide debt financing and equity investments to support the growth and expansion of local manufacturers. Verod Capital Management offers flexible financing structures and value-added support to help manufacturers scale their operations and achieve long-term success.

Sahel Capital Agribusiness Managers Limited

Sahel Capital is an impact-focused private equity and advisory firm focused on agribusinesses and rural development in Nigeria. They provide debt financing and equity investments to manufacturers in the agricultural and agribusiness sectors. Sahel Capital offers patient capital and works closely with manufacturers to drive growth, improve operational efficiency, and create positive social impact.

Alitheia IDF Fund

Alitheia IDF Fund is a private equity and impact investment fund that focuses on gender lens investing in Africa. They provide debt financing and equity investments to local manufacturers, with a particular emphasis on businesses that promote gender equality and empower women. Alitheia IDF Fund offers financial and technical support to manufacturers, enabling them to expand their operations and contribute to sustainable development.

Crowdfunding Platforms

Crop2Cash

Crop2Cash is a Nigerian crowdfunding platform that focuses on providing financing solutions to agricultural enterprises, including manufacturers in the agricultural sector. They offer debt- based crowdfunding where individuals or organizations can lend money to manufacturers in exchange for interest payments. Crop2Cash provides a digital platform that connects manufacturers with potential lenders, facilitating the crowdfunding.

Thrive Agric

Thrive Agric is an agricultural crowdfunding platform in Nigeria that enables individuals to invest in agricultural projects, including those related to manufacturing. They offer debt-based crowdfunding options where investors provide loans to manufacturers in return for periodic interest payments. Thrive Agric provides a transparent and easy-to-use platform, allowing manufacturers to showcase their projects and attract funding from interested individuals.

FarmCrowdy

FarmCrowdy is an agri-tech platform that combines crowdfunding and technology to support agricultural projects, including manufacturing ventures in the agricultural value chain. They provide debt-based crowdfunding options where individuals can lend money to manufacturers and earn returns on their investment. FarmCrowdy connects manufacturers with a community of lenders and provides support throughout the crowdfunding process.

Debt Financing

Potential Credit Guarantee Facilities include:

- The Nigerian Infrastructure Credit Enhancement Facility (InfraCredit) is a USD75 million NSIA- backed project aimed at providing guarantees for infrastructure projects to enable debt financing from the domestic market, including energy supply and distribution infrastructure such as mini-grids.

- The Development Bank of Nigeria (DBN) provides partial credit guarantees to financial intermediaries which aid in providing financial support to micro, small and medium scale enterprises including to Agricultural off-takers/agribusinesses.

Potential Credit Facilities include:

- The Central Bank of Nigeria acts as a credit facility provider through its Solar Connection Facility launched as part of the Economic Sustainability Plan (ESP), with a plan to roll out 5 million new solar- based connections in off-grid communities by providing long term, low-interest credit facilities to manufacturers and assemblers of solar components and off-grid energy retailers.

- SUNREF Nigeria offers a concessional loan facility of US$70 million (approx. EUR 60 million) through two Nigerian banks (Access Bank and UBA), to renewable energy companies to advance projects in renewable energy and energy efficiency technologies. Each eligible company can apply for a maximum of US$ 10 million, with a 5-year loan maturity period. Interest rates vary based on individual projects however they are capped for Power and Energy Prime Lending Rate of the bank minus 3% (as published by CBN) on naira denominated loans, and at the subsidized interest rate paid by the banks to AFD plus 4% on US dollar denominated loans.

- The Bank of Industry (BOI) through its NGN 6 billion (US$150,000,000) solar energy fund aims to provide financial support to commercial and residential end-users including smallholder farmers, in the development or acquisition of reliable solar solutions. The funds will be disbursed directly through the BOI or Deposit Money Banks (DMBs) or Microfinance Banks (MFBs). Mini-grid developers can leverage the fund for the development of mini-grids in rural communities.

- The Agricultural Credit Support Scheme (ACSS) is an initiative of the Federal Government and the Central Bank of Nigeria aimed at equipping farmers with the capacity to maximize the untapped potential of the agricultural sector. Practicing smallholder farmers and off-takers can apply for loans at 8% interest rate, through the respective state chapters of Farmers Associations and State Implementation Committees. Large-scale farmers can apply for loans at 14% interest rate, directly to the banks in accordance with the guidelines.

- All On Energy and BOI invested NGN 1 billion (US$2.4 million) in the Niger Delta Off-grid Clean Energy Fund, which aims to provide debt financing for the provision of clean energy solutions and electricity within rural communities in the Niger Delta region. The financing will be provided at a 10 percent interest rate per annum as well as a 1-year moratorium and tenor of up to 7 years.

Potential Private Financial Institutions

- LAPO Microfinance Bank offers agricultural loans between NGN50,000 to NGN500,000 (USD122 to USD1,220) to smallholder farmers over a 12 to 14 months term. The loan is a low-interest loan that requires no collateral. It is targeted at individuals and farmer groups.

- Grooming Center, through its IFDC loan, provides smallholder farmers with NGN250,000 to NGN750,000 (USD500 to USD1,500) at an interest rate of 14 percent to be repaid after 6 months. Grooming Center can receive credit facilities and loans to smallholder farmers with the loan structures already in place within the organization. The IFDC loan can be utilized together with other financing options to fund the purchase of PUE equipment and appliances. However, the repayment period is too short and needs to be longer if it is to serve the purpose.

- **The Small and Medium Enterprise Development Agency of Nigeria** (SMEDAN) in collaboration with the Bank of Agriculture (BOA) aims at improving the output of Micro and Small Enterprises (MSEs) in Nigeria.7F110It provides loans between NGN1.2 million (USD2,900) and NGN 5 million (USD12,200) at an interest rate of 9 percent per annum for a tenor of 30 months.

- Bank of Agriculture (BOA) is a development finance institution focused on providing loan credit facilities in agriculture. They accept loan applications from cooperative societies. Its mission is to stimulate agriculture, improve lives and grow communities. As part of the eligibility criteria, applicants must own or operate an existing farm. One of the BOA loans is the Direct Credit Product loan. Loan ranges from about NGN250,000 (USD609.76) to a maximum of NGN50million (USD122,000) with a loan tenor of a maximum of 5 years. There is a limit of NGN 5 million (USD12,200) to individual persons. There is an interest rate of 14 percent for agricultural production and agro-processing, and a 20 percent interest rate for commodity marketing. In order to access this loan, a deposit of 20 percent of the required loan amount must be made into the account. Securities are an acceptable form of collateral under this loan option.

- **Sterling Bank;** The bank through its non-interest banking division Sterling Alternative Finance (SAF), has promoted its clean and affordable energy solution for homes and businesses across Nigeria. The energy solution known as Altpower, has to its attachment, package of financing offering the consumers flexible and pocket-friendly options. With its accessible alternative – solar and renewable- power solutions to homes, businesses and public institutions, intending consumers can benefit from it having a monthly or instalment-payment plan. The product is designed to offer a reliable and affordable energy source to underserved homes and businesses as well as those living and doing business in communities that do not have any access to electricity.

- **First City Monument Bank;** Apart from embarking on decarbonizing its footprints, FCMB is partnering with development financial institutions to provide targeted financing to improve Nigeria's energy access through mini-grids and energy-efficient projects and pioneering green energy financing to bridge the energy deficiency gap. The partner institutions include African Development Bank, Proparco and International Finance Corporation in its Powering economy through clean energy financing. In addition, this, it also has its collaborations with the Nigerian Electrification Program (NEP) and Nigeria Energy Support Program (NESP) under the Rural Electrification Agency, Solar Naija Program and the Central Bank of Nigeria.

- **WEMA Bank;** With its support for energy transition in Nigeria and the drive to help businesses in the country to overcome the challenges of the hike in costs of petrol and diesel, the bank is offering loans to SMEs for clean and renewable energy solutions like solar panels, inverters, and batteries. This service is available in partnership with reputable renewable energy companies and service providers in Nigeria who will offer after sales services and warranty of up to 2 years while the average product has lifespan of 10 years.

- **Sterling Bank via their Non-Interest Banking business:** Sterling Bank's Alternative Banking Agriculture (SWAY AG) option commits up to NGN 20 million at 9% markup rate per annum, 5% security deposit of financed amount, and 2% cost of insurance of financed asset to provide agro businesses with stocks and equipment required for production.

- **Alitheia Capital** is a Venture Capital that has raised five (5) funds since 2018 with the most recent being $8.3M in July 2021. The focus amongst other ventures tends to support clean energy as well as Solar-based off-grid electricity providers. Similarly, Alitheia Clean Energy Fund (ACEF) was created in collaboration with Oando as a wholesale debt facility creating new markets for clean energy products for underserved areas/segments by providing distributor and consumer finance in Nigeria. ACEF funds viable commercial intermediaries that provide clean energy finance to low-income households.

Grant Financiers

- **The Nigeria Electrification Project (NEP)** is an initiative of the REA supported by the World Bank and AfDB. It seeks to provide electricity access to households, micro, small and medium enterprises in the off-grid communities across the country through the adoption of renewable energy sources. 111 The initiative provides grant facilities to private and public sector organizations which will enable the electrification of rural communities. The grant is performance-based and provides support to mini-grid developers for the deployment of mini- grids within rural communities. The electricity generated by the mini-grid can be utilized productively by farmers through the use of solar irrigation systems.

- **The Results Based Financing for Productive Appliances and Equipment**, managed by the REA, is aimed at increasing the productive use of electricity through the provision of productive use appliances (including solar irrigation equipment) to 24,500 MSMEs in Nigeria. The total fund available under this program is NGN 8.2 billion (USD20 million) targeted towards mini- grid developers with existing mini-grids in rural communities. 112 Standalone irrigation equipment providers are also eligible.

- **The Rural Electrification Fund (REF)** administered by REA provides upfront capital grants to mini-grid developers and solar home systems companies to electrify unserved and underserved rural communities and is financed through budgetary allocations from the Nigerian Government. The REF grants between USD10,000 to USD300,000, or 75 percent of the total capital costs of the project to the mini-grid developers and solar home system companies.

- **USADF Energy Challenge:** Under the U.S. government-led Power Africa initiative, USADF partners with the private sector to launch various off-grid energy challenges awarding grants of up to USD250K to African enterprises that power local economic activities and demonstrate a sustainable, scalable business model. Challenge winners have near-term solutions to power the needs of productive and commercial activities, including agriculture production and processing, off-farm businesses, and commercial enterprises.

- **RMI** together with the REA under the Energizing Agriculture Programme (EAP) launched a Call for Proposal to support a new portfolio of PUE products in 20 communities. This co- financing program aims to ensure that rural community members fully realize the benefits of electrification by connecting commercial service providers to mini-grid customers to offer services and/or electric equipment and appliances that meet their local needs.

Blended Financiers

- **The U.S. African Development Foundation** (USADF) and All On Energy Challenge in an attempt to provide funding to businesses looking to increase energy access to communities, launched the Nigerian Off-grid Energy Challenge Fund. The fund provides US$50,000 in convertible debt and US$50,000 in grant capital to businesses including mini-grid developers and can be used to provide off-grid energy to rural communities and most importantly smallholder farmers, for productive use (i.e., solar irrigation).

- **CrossBoundary Energy Access** CBEA as a separate legal entity is a blended finance facility for post-construction project finance for mini-grids using impact capital to provide long-term concessional finance for first-time grid quality power to rural Africans. Recently, CBEA secured USD60 million funding to deploy solar mini-grids in Nigeria. Given the reputation of the CrossBoundary Group, it is expected that this funding will go a long way in achieving its desired aim.

- **Access Bank;** With its first corporate issue to finance sustainable development in Africa in 2019, for NGN15B (~USD39M), Access bank has instituted its Green financing which leverages on blended finance to combine financial instruments from commercial capital sources such as institutional investors with de-risking and catalytic instruments from concessional capital sources which development partners. This It has made available to customers who intend to partner with Access bank in green bond for energy financing.

- **Norfund** is owned and funded by the Norwegian Government as the Norwegian Investment Fund for developing countries with a focus to create jobs and improve lives by investing in businesses that drive sustainable development. Norfund's approach is to invest where others will not and has been active since 1997 to support investment in Sub-Saharan Africa by providing equity capital and other risk capital.

- **Rockefeller Foundation** leads the development of large-scale, innovative partnerships, crowding-in investment, and piloting breakthrough and sustainable solutions to power the last mile. Additionally, the Rockefeller Foundation provides project financing facility for Africa with focus on accelerating the pace of electrification by leveraging the full potential of decentralized renewable energy by investing in climate-smart energy systems to empower and protect the world's poorest and most vulnerable populations.

- **DOEN Foundation** believes that it is possible to achieve a green, socially inclusive and creative society. DOEN's role is to support these pioneers in the very first phase in order to give initiatives a flying start, and thereby stimulate innovation. Where possible, DOEN subsequently transfers the initiatives to other parties to increase their impact.

- **WRI** works with large energy buyers, utilities, policymakers, development institutions and urban leaders worldwide to accelerate the transition to clean, affordable energy. Using partnerships, WRI's Energy Program collaborates with policymakers, cities, companies, utilities, regulators and development institutions to secure a clean energy future. This is done by facilitating partnerships to help cities and corporations purchase renewable power at scale to unlock economic opportunities.

- **David & Lucile Packard Foundation:** Using multisectoral partnerships, Packard focuses on proven and emerging mitigation strategies that make the biggest difference in promoting clean power alternatives that reduce reliance on coal, increase the availability of low carbon transportation options to minimize global oil consumption, increase energy efficiency across all sectors, minimize emissions from land use practices around the world by stopping deforestation and improving agricultural practices. Given a significant commitment to climate change discourse, the David & Lucile Packard Foundation commits to sponsor power projects that align with their climate change trajectory.

Equity Financiers

- Sterling Bank via their Non-Interest Banking business. Sterling Bank's Alternative Banking Agriculture (SWAY AG) option commits up to NGN20M at 9% markup rate per annum, 5% security deposit of financed amount, and 2% cost of insurance of financed asset to provide agro businesses with stocks and equipment required for production.

- Alitheia Capital, a Venture Capital that has raised five (5) funds since 2018 with the most recent being USD8.3M in July 2021. The focus amongst other ventures tends to support clean energy as well as Solar-based off-grid electricity providers. Similarly, Alitheia Clean Energy Fund (ACEF) was created in collaboration with Oando as a wholesale debt facility creating new markets for clean energy products for underserved areas/segments by providing distributor and consumer finance in Nigeria. ACEF funds viable commercial intermediaries that provide clean energy finance to low- income households.

- All On drives long-lasting impact through supporting the development and growth of commercially viable energy solutions by investing in facilities that leverage additional capital for off grid companies. Additionally, All On provides funding and technical support to early-stage energy firms. One collaboration that All On is currently driving is the African focused Off-Grid Energy Access Fund (OGEF) with a tenor of 12-60 months which empowers local capital markets with local currency equivalent of US$2-10million under a competitive lending rate that depends on transaction structure and risk profile.

- African Infrastructure Investment Managers. In 2019, AIIM's third pan-African infrastructure fund (AIIF3) of US$ 399 million targeted core and core-plus infrastructure investments in the power, transport and midstream energy sectors across sub-Saharan Africa. The fund supported Starsight in Nigeria to support a distributed solar power energy project.

- Helios Investment Partners. Founded in 2004, Helios is the largest Africa-focused private investment firm, managing funds totalling US$ 3.6 billion. As part of its support for reducing carbon emissions, Helios as a private equity firm investing exclusively in Africa.

- Metier, founded in 2003 is South Africa's largest private equity fund in terms of third-party local commitments. Metier has delivered multiple investments spanning multiple renewable energy technologies including Wind, Solar Photovoltaic, Concentrated Solar Thermal and Micro-Hydro.

- Vulcan Impact Investing (VI2) identifies and invests in market-based solutions that have the potential to transform lives through sustainable, scalable approaches to development. They are increasing their African presence and support projects and businesses which accelerate access to infrastructure and services designed to meaningfully improve quality of life.

- Tao Capital Partners. Tao Invest is the direct investment entity affiliated with Tao Capital Partners, invests in technology, alternative energy and transportation, healthcare, education, sustainable food & agriculture, consumer, and real estate businesses that have a positive impact. Tao is an active investor with the ability to support companies through various stages of their life cycle. Some of their portfolio companies in the alternative energy sector include SolarCity (SCTY), Enlighted (Siemens), Crusoe Energy, and Arcadia Power.

- AHL Venture Partners. Through investments in innovative entrepreneurship, AHL Venture Partners support entrepreneurs to drive African development forward. Since 2007, AHL Venture Partners have committed more than US$100M to 35 impact-focused businesses and funds that operate across 27 different African countries. AHL Venture Partners are willing to go the long haul with innovative financing products that respond to founder's needs, with tickets ranging from venture debt, working capital and equity investments. As a permanent capital vehicle, they are positioned to participate in subsequent funding rounds, and can be patient to optimise both return and impact.

2. Analysis of Financing Mechanisms and Schemes

2.1 Demand Side Financing

Financing schemes for demand side PUE market are largely provided by Development Finance Institutions (DFIs) and disbursed through Deposit Money Banks (DMBs) and Microfinance Banks. Governments have also been able to provide some level of subsidies and grants to cushion the high cost of adopting clean energy. With the aid of technology, other retail banking service providers can for example, leverage their presence across the country to provide revenue collection services at a fee. MTN Nigeria and Lumos is an example[7].

Basically, there are three financing modes on the demand side – Pay-As-You-Go (PAYG), Planned instalment to ownership or Lease-To-Own, and Outright Purchase. There is no overall best option and providers of demand side financing need to consider many variables before extending such services to any customer segment. For example, factors such as demography of users, economic rating, credit rating (where available), level, type, and time of energy use, as well as locality amongst others should be considered.

2.2 Supply Side Financing

On the supply side, financing schemes range from grants, subsidies, equity, and debt financing are granted and provided and granted by angel investors, Private Equity (PE), Venture Capitalists (VCs) and impact investors. For grants, impact investors as well as not-for-profit organizations may give seed or expansion grants to qualifying startups or established actors in the renewable energy sector to produce for sale or facilitate the development of solar only or hybrid grids especially in unserved or undeserved communities. These grants could also be given to facilitate the supply of PUE Equipment and Appliances.

For subsidies, Governments can grant import waivers as in the case of Nigeria[8] where there were calls by Legislators. However, with the reclassification of solar panels, import duty waivers no longer hold for solar panels imported to Nigeria[9].

Other financing schemes are equity-based and debt-based which practically target ownership and returns. Equity financiers basically look to contribute by taking some percentage of ownership with the hopes of selling out or cashing in. Debt financiers basically look out for returns on investment.

[7] https://www.gsma.com/mobilefordevelopment/resources/lumos-pay-as-you-go-solar-in-nigeria-with-mtn/
[8] https://punchng.com/reps-seek-waivers-for-imported-power-equipment/
[9] https://ng.boell.org/en/2019/07/02/solar-import-duty-and-tariffs-exempt-or-not

Again, no single scheme is best, but factors should be considered. For example, foreign investors look out for political stability, profit reparation policy, Foreign Exchange (FOREX) fluctuations and other factors that can affect their investment. Local investors mostly seek returns. Other factors to be considered when investing is technical competence of the company (developer, manufacturer, supplier), supply chain (distribution strength and reach), acceptability and public disposition/opinion concern/of the company as well as product specification. The company's revenue collection model is also significant as well as debt recovery policy and strategy.

2.3 Overview of interesting financing mechanisms and schemes for PUEs in Africa

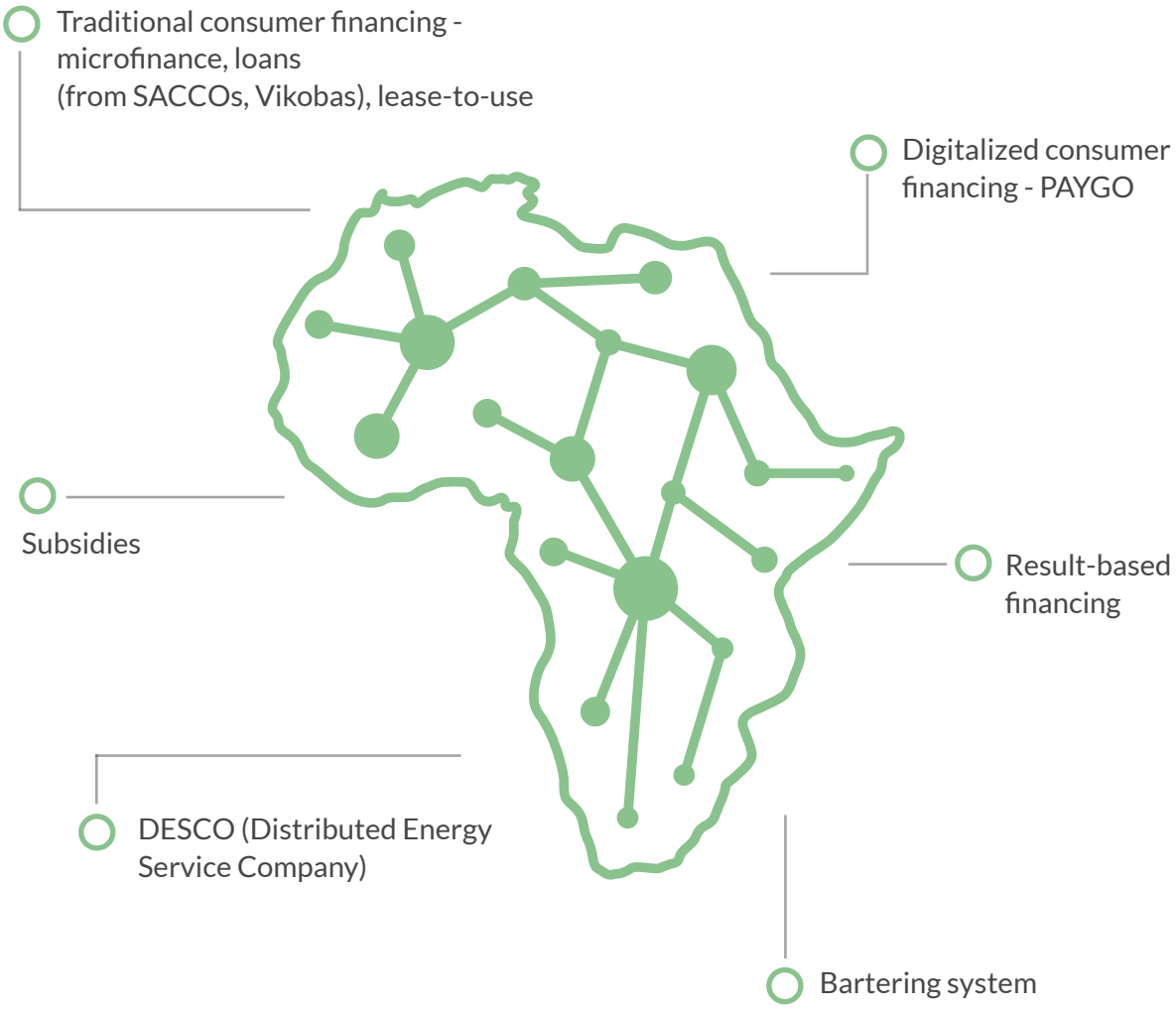

Table 1: Role of Renewable Energy Associations in promoting PUE

Category	Case	Lessons Learned
Traditional consumer financing - microfinance, loans (from SACCOs, Vikobas), lease-to- use	Small Industries Development Organization (SIDO) offers credit facilities to MSMEs for equipment with funding from the National Income Generating Programme (NIGP), the Tanzania Growth Trust (TGT), the Small Entrepreneurs Loan Fund (SELF) and East African Development Bank. (Tanzania)[10] CLASP & Nithio Launch Financing Facility for Productive Use Appliances: USD USD6.5 million financing facility to catalyze uptake of productive use appliances across Africa. (walk-in cold rooms, refrigerators, electric cookers, fans, mills, and solar water pumps) The facility will improve appliance affordability for consumers and companies. The facility will initially operate in Democratic Republic of Congo, Ethiopia, Kenya, Nigeria, Sierra Leone, and Uganda based on growth potential and market maturity.)[11]	
Digitalized consumer financing - PAYGO	PULSE Report: At present, consumer financing is not widely available in African markets. PAYGO players, who have expanded access to household systems and lighting for off-grid households, are piloting similar PAYGO models for productive use appliances. But this is still nascent and faces challenges because PULSE appliances are higher value (requiring larger loan sizes), more complex (less plug-and-play and needing more customer touchpoints), and bulkier (harder to market and distribute in rural areas).[12] Plug and play (P&P) PUE offer important entry technologies with pay-as-you-go (PAYGo) end user financing, though their smaller size limits value-addition.[13] PAYGo for PUE is further complicated by the fact that locking the customer out of the appliance for non-payment shuts off their primary path to repayment.[14]	Modifications to the PAYGo model that might benefit the customer – for example, extending a repayment grace period so that new customers have time to develop a cash flow – would require suppliers to have financial support to manage in the interim.

[10] https://www.iied.org/sites/default/files/pdfs/2021-02/16681iied.pdf
[11] https://www.clasp.ngo/updates/press-release-clasp-nithio-with-support-from-the-global-energy-alliance-for-people-and-planet-launch-financing-facility-for-productive- use-appliances/
[12] https://www.lightingglobal.org/wp-content/uploads/2022/04/PULSE-Report.pdf
[13] https://snv.org/assets/explore/download/The%20Market%20for%20Productive%20Uses%20of%20Solar%20Energy%20in%20Kenya-Status%20Report%202021_web%20%28002%29.pdf
[14] ibid

	EnDev has warned that Pay-As-You-Go sales mechanisms are unlikely to bear great success.[15] Not all PUE appliances can be adapted for PAYG (a full range of power tools, ICT, processing and packaging, beauty and textiles)[16]	
Result-Based Financing (RBF)	The Kenya Climate Innovation Center (KCIC) with funding from the Mott Foundation is implementing a Pilot Project titled, "Financing Solutions for Local Productive Use of Solar[17] Energy Entrepreneurs in East Africa's Agriculture Sector" which aims to enhance access to Productive Use of Solar Energy (PUE) in key agricultural value-chains in Kenya, Uganda and Tanzania for two years, from January 2023 to December 2024. The programme budget is USD 355,000. The programme aims to support 30 businesses to create over 160 full-time job opportunities. (Kenya) Using a results-based approach, GBE helps distribute financing for solar-based equipment for productive use, for example solar pumps. While RBF is effective for ensuring solar power entry into rural markets and for productive use, the approach places high demands on management. To support administration of financial disbursements to companies and organisations eligible for grants and financing, GBE in Côte d'Ivoire sought out Odyssey as a suitable tech partner after seeing proof of concept with GBE in Benin. Green People's Energy for Africa (BMZ/GIZ/ KFW): offers measures for financial and knowledge support of end-users and private companies to help improve adoption of decentralized renewable energy systems and productive use of energy in off-grid rural communities.[18] • Establishing guarantee funds and offer incentive payments for microfinance service providers (MFIs) • Building links between MFIs, solar companies and organized savings and loans associations or cooperatives to access funds • Putting users in touch with solar companies • Helping users purchase 'productive use of energy' technologies	RBF does little to enable access to the up-front capital required to design and raise finance around a PUE investment.[19]

[15] https://endev.info/wp-content/uploads/2021/03/EnDev_Learning_Innovation_PUE.pdf
[16] https://www.get-transform.eu/wp-content/uploads/2022/08/Productive-Use-of-Energy-2-0_GET.transform2022.pdf
[17] https://www.kenyacic.org/PUE-financing-program/#1677499666334-b7e63e1c-2e02
[18] https://gruene-buergerenergie.org/en/topics/financing/
[19] Same as 16

Subsidies	The S**olar Irrigation Rwanda (SIR)** programme has applied a three pronged strategy to address low appetite from lenders in the market: (1) combining a high level of subsidies with agronomic advice to farmers, helping to reduce the financial risk for potential lenders; (2) supporting several banks to design new loan products, allowing repayments by farmers after the harvest; (3) convincing financial institutions to accept solar irrigation equipment as collateral for their loans. Clearly, this approach requires intensive TA support targeting farmers, processors, distributors and banks. [Source: https://energy4impact.org][20]	
(Distributed Energy Service Company)	A mini-grid company or DESCO has the advantage of being able to offer PUE services to their customers under existing relationships. Several mini-grid companies are offering PUE equipment and services through existing energy agreements with households, businesses and/or institutions. Some even integrate PUE fees into the kWh electricity tariffs. Beneficial in areas wih either no or limited equipment suppliers and/or MFI branches. EnerGrow in Uganda provides productive assets (e.g. drills, fridges, sewing machines), working capital and financial literacy and business training to small businesses and households. Appliances are valued between USD50 and USD5,000, while EnerGrow's sweet spot in loan size is USD 500- 1,000. The company partners with utility UMEME, facilitating the use of data-driven credit profiling to assess the eligibility of loan requests. Having noticed increased energy demand and revenues from connections receiving asset finance from EnerGrow, UMEME is now considering establishing an off-balance sheet working capital facility. [Source: Interview Aaron Leopold (CEO of EnerGrow), 28/05/21][21]	
Bartering system	SolarWorks in Mozambique offers seasonal payment plans, while Village Infrastructure Angels (VIA) in the Indo-Pacific and Natfort Energy in Zimbabwe accept non-cash payments: "We ask customers: how much time are our products [agri-processing equipment] saving you, and can you make something with that time that we can barter? We have bought mats, handwoven baskets and jewellery from customers to sell". Some distributors such as Sosai in Nigeria have adopted service models (i.e., perpetual lease models) for PUE products like solar dryers, but these are still early- stage pilots.[22]	

[20] Same as 16
[21] Same as 16
[22] SEFORALL - https://www.seforall.org/news/five-hurdles-to-getting-productive-use-of-energy-products-to-the-last-mile

3. Renewable Energy Agencies role in PUE financing (and project collaborations)

Examples of countries and organisations that have engaged in PUE related interventions include:

Kenya: EforA in Kenya found that customers struggled to understand the various performance and sizing factors of different solar water pumps and engaged in awareness raising initiatives.

Nigeria: Energizing Agriculture Program[23]
Rural Electrification Agency (REA) partnership with the Rocky Mountain Institute and the Global Energy Alliance for People and Planet (GEAPP) launched the Energizing Agriculture Programme (EAP). The EAP aims to stimulate the productive use of minigrid electricity in agriculture by enabling market-led solutions and breaking the silos separating electrification and agricultural development programmes.

Uganda: Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA)
UNREEEA is a non-profit, non-partisan apex organisation of business associations and actors in the renewable energy and energy efficiency subsector. It engages in market building, lobbying and advocacy, capacity building, standards and quality assurance.

Ghana: Market entry in renewable energy and energy efficiency and technical education and vocational training (TVET) for the productive sector in Ghana 2018-2021
Collaboration with the German Federal Ministry for Economic Cooperation and Development (BMZ). An Energy Service Centre has been established – hosted by the Association of Ghana Industries (AGI) – to serve as a connector between RE/EE service providers and potential clients.

Get. Transform in its Energy for Rural Industrialisation Productive Use of Energy 2.0 report (2022)[24] highlighted the fact that there is a dearth in Specialist Funds, Investors and Champions of PUE.

[23] https://amp.gefundp.rea.gov.ng/energising-agriculture-programme
[24] https://www.get-transform.eu/wp-content/uploads/2022/08/Productive-Use-of-Energy-2-0_GET.transform2022.pdf

Among the financing instruments that do facilitate individual PUE investment projects as part of their overarching investment strategy, most active investors do not have a clear strategic orientation (or exclusion) towards PUE.

Examples of funds that do include PUE to some extent include the Gaia Impact Fund, SunFunder, ElectriFI, the Africa Enterprise Challenge Fund (AECF), the United Nations Capital Development Fund (UNCDF) and the Energy and Environment Partnership (EEP) trust fund.

However, there are no funds that explicitly and/or exclusively support PUE; those that are active make their investments in PUE alongside other opportunities and usually prefer other investments that are considered more scalable, lucrative, or safe. The absence of PUE as a core part of a rural electrification fund creates a situation where there is no clear champion for scaling PUE.

Installed solar panels. Source: Unsplash

4. Analysis of MSME's Commercial Viability to Absorb the Financing Schemes

In 2022, the Federal Government launched the Nigeria Energy Transition Plan to achieve net- zero emissions by 2060[25]. This is a booster to MSMEs to tap into Government's commitment as well as other viable options to forge the transition to cleaner energy.

Nigerian households and businesses have been meeting electricity needs by powering petrol and/or diesel generators including other traditional sources at a high cost. In 2020, it was estimated[26] that Nigerians spent USD 14billion on energy. Given that MSMEs make up most businesses in Nigeria[27], which have been meeting their electricity needs using other sources, their ability to transition to solar energy cushioned with a good financing model is therefore not in doubt.

Considerably, there is little to no data on the financials of Nigerian MSMEs because they mostly do not have public accountability and are mostly considered informal, especially micro enterprises. However, it was estimated[28] that MSMEs contribute 48% to Nigeria's GDP. Additionally, more than 95% of Nigerian businesses are MSMEs and support the employment drive with more than 80%. SMEDAN and NBS agree in their National Survey of Micro Small & Medium Enterprises (MSMEs) 2017 report that MSMEs are significant to the Nigerian economy. Despite these levels of significant contributions to the national economy, their individual financial capacity for adoption of PUE may not be strong. It is mostly left out that micro enterprises with less than ten (10) employees and asset (excluding land and buildings) of less than NGN10 million[29] make up the largest percentage of MSMEs as shown in Table below. With this figure, only a few of them can afford a transition to solar energy without adequate, planned, targeted financing options. SMEs are more able to take up financing for PUE Equipment and Appliances.

Table 2: Statistics of MSMEs

Enterprises	Numbers	Percentage
Micro enterprises	41,469,947	99.82%
Small enterprises	71,288	0.17%
Medium enterprises	1,793	0.00%
Total	**41,543,028**	**100.00%**

Source: NBS-SMEDAN National Survey of Micro Small and Medium Enterprises (MSMEs), 2017

[25] https://www.seforall.org/events/launch-of-nigerias-energy-transition-plan
[26] Nairametrics (2020). Nigerians spend USD14 billion on generators, fuel.
[27] https://www.thisdaylive.com/index.php/2022/11/27/msmes-contribute-48-of-nigerias-gdp-says-ilo/#:~:text=ILO%2C%20a%20specialised%20agency%20of,of%20employment%20in%20the%20country.
[28] Same as 13
[29] SMEDAN National Policy on MSMEs, 2015

With the stimulation of growth in the MSMEs sector by the establishment of the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) as well as the Small and Medium Enterprises Credit Guarantee Scheme for MSMEs, the capacity of MSMEs to grow and survive has increased. Similarly on the government side, many efforts are being made to stimulate growth and contributions of Nigerian MSMEs. Some of these efforts as documented in the 2017 NBS-SMEDAN report include:

1. Establishment of a National Collateral Registry for MSMEs

   With support of the IFC, the Central Bank of Nigeria (CBN) established the National Collateral Registry[30] (NCR) to improve access to finance particularly for (MSMEs). The registry is the actioned "Part III of the Central Bank of Nigeria's Regulations on Registration of Security Interests in Movable Property by Banks and other Financial Institutions (Regulations No, 1, 2015)."[31] Deploying technology, the registry, which is a web-based system allows "lenders to determine any prior security interests, as well as to register their security interests over movable assets provided as collateral."[32] News from traditional media organizations concerning the NCR has been largely positive such as improving MSMEs access to credit[33,34,35,36]. The NCR therefore has the capacity to ensure that PUE Equipment and Appliances can be used as collateral which is secured. Given this initiative, the ability of MSMEs to absorb financing schemes for PUE should not be in doubt.

2. Development Bank of Nigeria (DBN)

   The DBN which commenced operations in 2017 "was conceived by the Federal Government of Nigeria (FGN) in collaboration with global development partners to address the major financing challenges facing Micro, Small and Medium Scale Enterprises (MSMEs) in Nigeria."[37] DBN's objective "to alleviate financing constraints faced by MSMEs … through the provision of financing and partial credit guarantees to eligible financial intermediaries on a market-conforming and fully financially sustainable basis" is a significant financing vehicle for MSMEs to adopt and/or transition to PUE Equipment and Appliances. The DBN has been enhancing and financing access to credit as well as fostering partnerships with other Development Finance Institutions to improve the Nigerian MSMEs funding access.

[30] https://www.ncr.gov.ng/Home/About
[31] Same as 5
[32] Same as 5
[33] https://www.vanguardngr.com/2019/02/national-collateral-registry-facilitates-n1-2trn-loan-to-155000- smes/
[34] https://punchng.com/fg-disburses-n17tn-to-smes-registers-650000-businesses/
[35] https://sunnewsonline.com/good-news-as-cbn-sets-up-ncr-to-assist-msmes-access-business-loans/
[36] https://www.thisdaylive.com/index.php/2022/11/30/enhancing-access-to-credit/
[37] https://www.devbankng.com/who-we-are

3. CBN/Bankers' Committee AGSMEIS (Agri-Business/Small and Medium Enterprises Investment Scheme)

To support the agricultural sector, the Bankers' Committee set up the scheme to facilitate access to finance in the agricultural sector as well as for SMEs. The AGSMEIS commenced disbursement in 2018[38] with focus on making equipment available to especially those in the agricultural business. The AGSMEIS has been able to support youth entrepreneurship in Nigeria.[39]

Given the private sector led imitative, backed by Government (CBN), its potential to foster enhanced financing for MSMEs to transition and adopt PUE Equipment and Appliances is significant.

4. Establishment of a MSMEs Rating Agency

A rating agency specifically for Nigerian MSMEs is a significant step to measure credit uptake of MSMEs. This also largely defines their ability to take up financing options available, minimize risk, and improve market activity. SMEDAN in collaboration with Bank of Industry (Bol), Nigeria Export and Import Bank (NEXIM) and Dun & Bradstreet Nigeria Limited set up the rating agency. In 2021, Government disclosed a syndicated loan of USD1 billion where the rating agency – Small and Medium Enterprises Rating Agency (SMERAN) will play a significant role of providing empirical data.[40]

5. Tradermoni Scheme

Although TraderMoni is a loan project, the value of between NGN10,000 and NGN100,000 may not be sufficient to acquire heavy duty PUE Equipment and Appliances. TraderMoni is part of the Government Enterprise and Empowerment Programme (GEEP) executed by the Bank of Industry (BOI).

6. Ease of Doing Business/PEBEC (Presidential Enabling Business Environment Council)

To make business formation easier and attract inflows, the Federal Government initiated the PEBEC to ensure steady reforms to Nigeria's business environment. The work of the PEBEC has improved the capacity of Nigerian businesses hence they are more likely able to absorb financing. Nigeria has also improved on its ease of doing business ranking. The increased capacity of MSMEs points to their ability to take up financing opportunities and transition/adopt solar energy as well as other alternative energy sources that can be used to forge PUE Equipment and Appliances.

[38] https://www.vanguardngr.com/2018/04/cbn-begins-disbursement-n26bn-agribusiness-fund-msmes/
[39] Okolo-obasi, N. E. & Uduji, J. I. (2021). Does agri-business/small and medium enterprise investment scheme (AGSMEIS) impact on youth entrepreneurship development in sub-Saharan Africa? Evidence from Nigeria, Journal of Economic and Administrative Sciences. https://doi.org/10.1108/JEAS-05-2021-0094
[40] https://mediatracnet.com/nigerian-govt-to-support-msmes-with-1bn-syndicated-loan-trade-minister/

7. Anchor Borrowers Programme
With agroprocessors as a major stakeholder of the Anchor Borrowers' Programme (ABP) which kicked off in 2015, funding was able to benefit both farmers and processors. The ABP has been rated to be largely successful.[41,42]

8. Conditional Grant Scheme (CGS)
The SMEDAN through the CGS is doing its bit to increase the financial capacity of especially micro enterprises. With this support, it is easier for business owners and managers to redirect financing options to adoption of PUE Equipment and Appliances. It is reported[43] that the CGS has enhanced the financial viability of especially micro enterprises. However, the level of financial stability that the CGS has created is unknown.

9. One Local Government One Product Programme (OLOP)
The SMEDAN using the OLOP supports MSMEs associations such as cooperatives, trade unions and other registered entities with machinery/financial grants, capacity building, advisory and monitoring services. It is reported that "about 109 projects have been delivered annually". OLOP success stories[44,45] abound. The capacity of beneficiaries have improved and they are able to absorb other financing options to transition to PUE Equipment and Appliances.

10. Incentivizing Business Registration
Despite the high number of MSMEs in Nigeria, the number of registered MSMEs is rather low. The Federal Government asides from cutting registration fees by 50%[46] also provided for free business registration[47] and it has been reported that many businesses have benefitted from the free registration[48], thereby increasing their value and ability to carry on business on a larger scale.

11. Growth and Employment Mobility in States (GEMS - 1, 2 & 3).
Growth and Employment Mobility in States (GEMS) although an employment-based project has impacted on some businesses and despite the timeframe which has lapsed, its continued impact on businesses is undoubted. For example, a 2015

[41] https://www.premiumtimesng.com/news/506666-anchor-borrowers-programme-over-4-8-million-farmers- financed-buhari.html?tztc=1
[42] https://guardian.ng/news/four-million-farmers-received-n800b-under-cbn-anchor-borrowers-programme- says-osinbajo/
[43] https://thenationonlineng.net/how-well-has-smedan-managed-conditional-grant-scheme/
[44] https://www.vanguardngr.com/2017/10/msmes-development-smedan-moves-execute-one-local- government-one-product-programme/
[45] https://nnn.ng/tag/local-government-product-olop/
[46] https://www.premiumtimesng.com/business/business-news/304223-corporate-affairs-commission- reduces-business-registration-fee-to-n5000.html?tztc=1
[47] https://www.cac.gov.ng/free-250000-fg-cac-business-names-registration-for-msmes/
[48] https://www.thecable.ng/fg-100000-businesses-have-benefitted-from-free-cac-registration

review report[49] showed that GEMS 1, 3, and 4 were largely successful albeit it was reported[50] that the DFID-funded GEM 2 was not so succesful. It is therefore believed that the beneficiary businesses and pathways have created more value in the selected core areas to enhance further financing value.

12. Conversion of Twenty-Three (23) Industrial Development Centres (IDCs) to Industrial Parks and Clusters

The conversion was reported[51] to potentially increase the value of MSMEs with investment from government of about N92bn[52]. According to the 2017 SMEDAN report, "the facility is projected to improve the global competitiveness of MSMEs, by reducing overhead costs and enjoying economies of scale as is usually the case with clusters". However, it is argued[53] that without concrete policies and political will, the project will end up a failure. News report from the Parks and Clusters are however not encouraging such as one that reported that the Parks and Clusters are suffering from access to funding, access to market, and poor infrastructure.[54]

With the base already established, expansion work is easier to ensure that the industrial park and clusters can absorb financing options to develop and be sustainable. However, relevant policies need to be in place and implemented appropriately.

With these programs run largely successfully, it can be inferred that Nigerian MSMEs have the capacity to absorb financing options. What is in doubt is the sincerity of the financiers. Due to instability, financiers have been known to change the goal post in the middle of the game by requiring businesses to pay more than they bargained for using inflation as a cover or hidden charges on loan. As shown in **Table 2.1**, funding is available for the Nigerian PUE market hence, finance is no longer an issue to Nigerian MSMEs but access to finance, which is multidimensional. Access to finance is impacted by the following:

2. Information access

Many MSMEs are not even aware that there are financing schemes they could enjoy acquiring PUE Equipment and Appliances.

3. Social capital access

The networks required to increase the net worth of many MSMEs is largely missing as only a few can tap value from the ecosystem[55].

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[49] Abalu, G., Adegbe, E., Bayaz, G., Pettigrew, S., & Wilkinson, M. N. (2015). The Independent Monitoring and Evaluation Project for the State Level Programmes (IMEP) GEMS Lesson Learning Review.
[50] The World Bank Implementation Completion and Results Report (No. 4882-NG). Report No: ICR00004862
[51] https://businessday.ng/breaking-news/article/fg-begins-conversion-of-23-idcs-to-msme-clusters/
[52] https://punchng.com/govts-investment-in-industrial-clusters-to-hit-n92bn/
[53] Iwuagwu, O. (2011). The Cluster Concept: Will Nigeria's New Industrial Development Strategy Jumpstart The Country's Industrial Takeoff? *Afro Asian Journal of Social Sciences* 2(2.4). 1–24
[54] https://businessday.ng/business-economy/article/why-nigerias-industrial-clusters-are-losing-traction/
[55] Oladele, S., Laosebikan, J., Oladele, F., Adigun, O. and Ogunlusi, C. (2022). How strong is your social capital? Interactions in a non-transparent entrepreneurial ecosystem. *Journal of Entrepreneurship in Emerging Economies*. https://doi.org/10.1108/JEEE-05-2022-0151

4. Collateral access

Some financing schemes also require equity contribution or collateral, which many MSMEs do not have thereby drawing back their ability to access funding.

5. Phobia and trust deficit

Trust deficit manifest on both supply and demand sides. Many investors are skeptical of entering the OGS market with deposit money banks only recently embracing the vision and fully supporting OGS projects with funding. Similarly, consumers are skeptical concerning the productivity of OGS. Due to the level of research and development in the sector, large scale PUE Equipment and Appliances are largely expensive, and their durability has not been widely tested. Some Founders of renewable energy solutions have also complained of investors' desire to recoup investment within a short time, which is largely difficult in a growing sector.

5. Sustainability Plan for the PUE Market in Nigeria

The Nigerian Economic Sustainability Plan (NESP)[56] is captured as ten (10) projects with one being a significant commitment to agriculture and two having direct impact in the energy sector. They include the promotion of the "installation of Solar Home Systems with a commitment of USD619 million to reach 5 million households, serving about 25 million individuals, especially those who are not currently connected to the national grid. Another is the promotion of the use of domestic Gas utilization with a commitment of NGN113 billion to promote the use of gas (CNG and LPG). With these commitments from the Government as well as political will, the Nigerian PUE market sees a potential in growth and expansion.

Similarly, considering international commitment to cleaner energy in line with climate change campaigns, the transition to solar and other cleaner sources of energy will continue to soar, fostering sustainability in the industry. Figure 4.1 shows the concept of sustainability to include economic, environmental, and social paradigms. Hence, in this light, the triple bottom line components are highlighted in a little more detail.

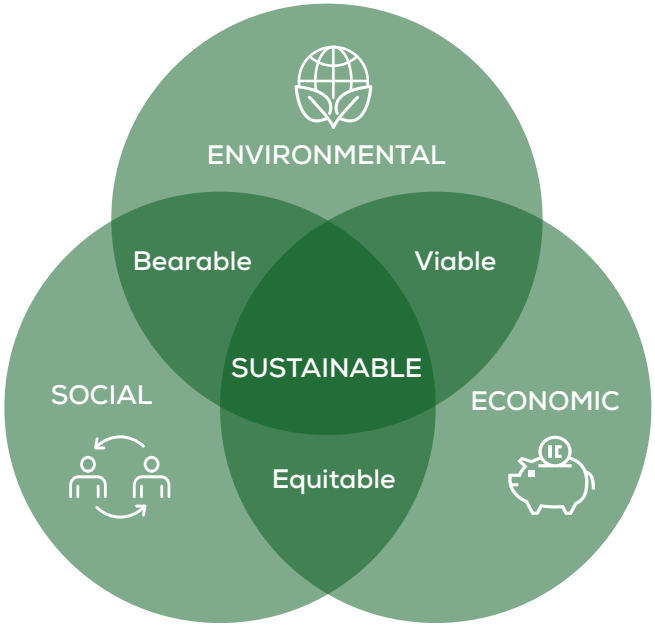

Figure 1: Sustainability Model

Source: [57]

[56] https://www.iea.org/policies/13924-nigerian-economic-sustainability-plan
[57] https://careers.snclavalin.com/blogs/2022-3/three-pillars-of-sustainability-and-the-built-environment

5.1 Economic Sustainability

The potential economic viability of the Nigerian PUE market is not in doubt, however, it is noted that certain factors and actors should be in place and active to ensure value optimization from the industry.

1. Revenue collection has been identified as a significant issue for both grid and off-grid solutions. Increasing metering access is one significant step to optimize value for revenue collection in the grid industry, while metering may be less economical in some off-grid locations. However, it cannot be undermined that data, especially real-time data on energy use and consumption is significant for building workable models and solutions as well extending financing options and models.

2. Similarly, local financing options must take note of the long-term sustainability especially of OGS projects. This can be achieved by extending moratorium, lowering interest rates, and forging industrial adoption of OGS.

3. The productivity of PUE Equipment and Appliances from the technical aspect should be addressed. There is a concern that solar-powered equipment and appliances have less throughput compared with diesel-generator powered machines. The preference for the latter machines portends a significant risk for adoption of PUE Equipment and Appliances. To increase adoption of PUE Equipment and Appliances, the research and development as well as design, modelling, and production aspects of the value chain should be structured to provide equipment and appliances that can rival their grid-powered competition.

Conclusively, insights can be drawn from the model used to drive the adoption of LPG to replace the use of fossil fuel for domestic use especially cooking and transition to white bulbs (low energy emitting bulbs) instead of yellow bulbs in the Nigerian market. This should accommodate a combination of policy, regulation, stakeholder engagement, orientation, and market shift. With these strategies in place, fostering an economically vibrant PUE market in Nigeria is attainable even in the short-term.

5.2 Environmental Sustainability

Noise, water, and air pollution are significant effects of the use of fossil fuels. Health practitioners have been inundating us on the dangers of fossil fuel to public health. The adoption of alternative energy sources has been touted as one sure model to mitigate the dangers of the use of fossil fuels and other traditional energy sources. With this steady drive from governments, advocacy groups, health practitioners and significant others, the adoption of alternative energy sources especially solar in Nigeria will continue to increase requiring the adoption of PUE Equipment and Appliances. This should also drive local material sourcing and production thereby minimizing the environmental impact of traditional and harmful energy generation.

Similarly, with increased adoption of alternative energy sources, demand for a shift to mandatory reporting and disclosure requirement for environmental impact in Nigeria by businesses (especially companies with public accountability) will increase. Nigerian companies will have no choice but to commit to being environmentally responsible in their actions, operations, and activities. This will in a way facilitate the attainment of some of the SDGs.

5.3 Social Sustainability

Inclusivity is engendered by a transition to alternative energy sources, and there is empirical evidence in Africa[58,59]. For example, the SPN Project as well as other NEP and REA projects are helping to reach many underserved and unserved communities with electricity which is opening access to communications that foster social interactions, increase exposure, improve education, facilitate knowledge creation, sharing, and transfer as well as opening doors for business development.

These opportunities have the potential to close the class gap considerably and help maintain a healthy spread between urban and rural settlements.

5.4 Commitment to the SDGs

Nigeria's commitment to the Sustainable Development Goals is unmistakable[60] demonstrated also by significant financial commitment of about USD100bn[61]. Sub-national governments have also pledged support for the attainment of the goals[62] although there are concerns that the 2030 timeline is unattainable[63,64].

Sustainable Development Goals 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities), and 13 (Climate Action) are three goals that have direct impact on the sustainability of the Nigerian PUE market. With Government's commitment to goal 7, the need for PUE Equipment and Appliances should increase fostering economic activities, increasing access to electricity, engendering social change, and improving environmental impact. A commitment to SDG 11 as well will enhance the use of PUE Equipment and Appliances since sustainable cities are largely built with alternative energy sources.

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[58] Benjamin, A. A. (2022). Renewable energy consumption and Inclusive Growth: Evidence from 20 African countries. Annals Environmental Science and Toxicology, 6(1). 97–104. https://doi.org/10.17352/aest.000060
[59] Surie G. (2020). Fostering Sustainability through Ecosystems for Renewable Energy in India. Journal of Sustainability Research, 2(1):e200010. https://doi.org/10.20900/jsr20200010
[60] https://www.undp.org/nigeria/press-releases/government-nigeria-launches-nigeria-sdgs-implementation- plan-2020-2030-support-undp
[61] https://punchng.com/fg-eyes-100bn-for-sdgs-pledges-business-reforms/
[62] https://guardian.ng/news/diri-pledges-to-implement-sdgs-in-bayelsa-state/
[63] https://www.dataphyte.com/latest-reports/sdgs/can-sdgs-be-achieved-in-nigeria-before-2030-according- to-data-not-likely/
[64] https://humanglemedia.com/nigeria-lagging-behind-sustainable-development-goals-code/

5.5 Proposed Sustainability Plan for PUE in Nigeria

To maintain Nigeria's PUE market ability to thrive and survive, some of the followings are proposed.

1. Consider and review relevant indicators

Indicators point to facts, figures, and effect. Some indicators represent causal effects while others are correlational. Understanding the interplay of economic and demographic indicators among other significant indicators is significant for identifying market focus and deploying necessary resources to meet market needs. For example, insight into gendered economic status provides business level intelligence when deploying PUE Equipment and Appliances.

2. Develop policies

Policies are important and help to escape reliance on precedence. One downside to overreliance on precedence, especially those not founded on sound principles, is that the wrong thing can become norm and change management is highly resisted overtime hence delaying transformational growth and development. It is therefore recommended that policies from the strategic level, tactical level, and operational levels are in place and available for reviews continuously to ensure that value relevance is represented in them.

It is also not enough to have policies in place, there must be a commitment to adhere to their stipulations. While adhering to policy stipulations, it is important to note that when emergency situations arise, there should be proper mitigation processes clearly stated. Finally, orientation should be done to ensure that all significant parties (stakeholders) are aware of the policies, understand them, and can action them appropriately.

3. Recalibrate models

Existing models may not be able to engender sustainability of the PUE market. Hence three models are proposed for recalibration. The current business model of importation is not exactly sustainable – local production should be encouraged. Similarly, the business environment should favor easy entry to ensure that those with interest and resources are easily able to commit to the market. Product development needs to be recalibrated as well. Most solar products are built for household use. There is a need to emphasize the PUE Equipment and Appliances and align them with solar energy supply. This should trigger a willingness to adopt PUE with the potential to expand the market.

The current financing model of PUE in Nigeria is still sub-optimal. There is significant growth in financing options available to players in the industry, but many have complained that the conditions are not exactly favorable.

4. Optimize value offering and proposition.

Business value proposition amongst other factors is highly responsible for their sustenance. Two areas of after-sale service as well as follow-up customer services are significant to expand the Nigerian PUE market. Complaints abound concerning customer relations with respect to feedback as well as repairs and maintenance. For businesses to thrive in this burgeoning market, there must be concerted commitment to ensure a highly defined customer focused identity that guarantees customers the safety of being able to access suppliers and producer services such as provided for in warranty agreements.

5. Improve processes

The environment continues to be impacted by the way and manner that waste is treated. Proper waste management practices are required to ensure that waste from PUE Equipment and Appliances is properly managed to reduce their impact on the environment. Similarly, there is a significant need for the adoption of global best practices for recycling. The reuse of equipment and appliances that may have reached their defined end of life will potentially minimize environmental degradation as well as other toxic materials that can negatively affect human existence.

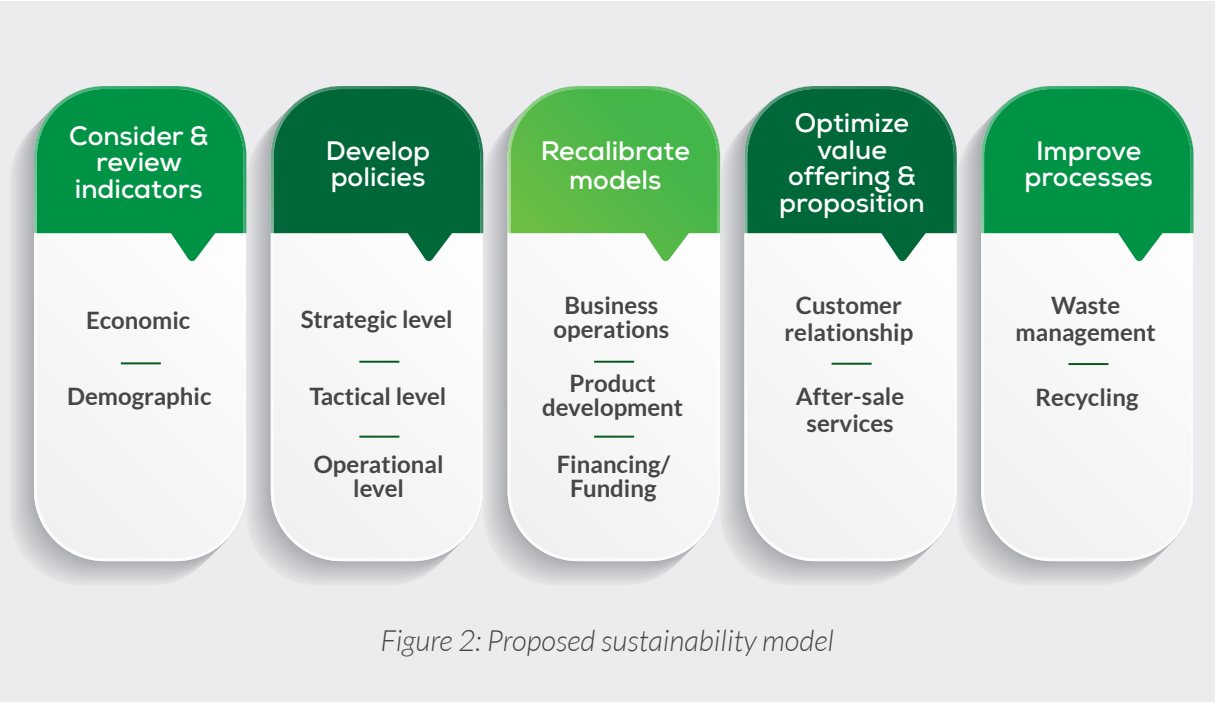

Figure 2: Proposed sustainability model

6. Conclusions and Recommendations

6.1 Conclusions

The PUE Market actors and factors are significant in their ecosystem and sustained diverse interactions are required to ensure that they continue to go through a circle of successful implementation for impact and social good. This does not in any way divorce the need for economic prosperity, which is required to hold the tripod of sustainability.

The Nigerian market led by MSMEs have both the technical and financial capacities to absorb financing model, but investors should tread with caution as the Nigerian market is still volatile. Additionally, the sustainability plan for the Nigerian market is achievable with principal support from Government with respect to forging policy development and providing regulatory oversight. There are potentials for the Nigerian PUE market spanning product design, supply chain, marketing, data governance, productivity check and so many areas of service support.

6.2 Recommendations

The focus of this chapter is the drive for sustainability, hence, to attain sustainability, the following recommendations are made:

1. Increased local content.
Product development should be significantly local based to ensure learning curve benefits opportunity to scale. Significantly as well, local production proximity potentially reduces costs, thereby increasing demand and ensuring benefits of scale. Even financing models should take cognizance of local peculiarities. Foreign financing options can be adapted to local situations to ensure relevance.

2. Review of business model
The current model for running MSMEs in Nigeria may not be sustainable. There should be concerted effort on government's part to correct the perception of "for tax" purposes documentation. Many MSMEs believe that any effort by the Government to register them or request information is for tax purposes. There is also the concern that the taxes are not judiciously utilized such that many businesses still have to provide for their peculiar business needs by and for themselves including electricity, network, eater and the likes.

3. Increased collaboration and service-sharing
MSMEs are encouraged to collaborate more to maximize economies of scale and grow together. Some services can also be shared to spread expenditure and risk.

4. On Government's part, fostering political stability will engender significant inflows of resources to grow the Nigerian PUE market. Investors both local and foreign have shown significant interest in investing in Nigeria and Africa, however, there is a concern that their investment can be impacted by the political climate. With assurance and visible actions from Government on political stability, these investments will ordinarily flow and increase productivity and sustainability.