ALTERNATIVE CASES TO DIRTY POLLUTING AGRIBUSINESS AND ENERGY PROJECTS AND THEIR ECOSYSTEM IN NIGERIA.

SUMMARY

Smallholder farmers, especially in rural Nigeria communities, generate close to 80 per cent of organic wastes such as manure, tree trimmings, grass clippings, and crop residues such as rice husk, rice straws, maize stalk, maize husk, maize cobs, cassava peels and stalk, groundnut shells and straws, soybeans pods, sugarcane bagasse and leaves, and cotton stalk, palm kernel shells and oil sludge, etc. Over 40 per cent of agricultural production is already wasted in Nigeria, as the sector contributes over 25 per cent of CO2 emissions. The waste in rural agricultural processes can be attributed to the vast energy deficit in the country. Over 45% of the Nigerian population mostly in rural communities lack access to grid electricity. The fraction of the population connected to the national electricity grid has to augment the poor grid supply with expensive, dirty polluting fossil generators. Over 20 million fossil generators are used in Nigeria mostly by small and medium-scale enterprises, many of which operate as agro-processors in rural areas.

Despite having a National Agricultural Technology and Innovation Policy (NATIP) 2022-2027, and the expansion of decentralised renewable energy projects and programs in Nigeria, small-scale agro-processing in the country continues to be neglected and unconnected.

As part of the Strategic Partnership Agreement II (SPA II) that aims at transforming societies to become more just, feminist, green, and resilient, ActionAid International is implementing a Global Climate Justice Programme. The project aims at developing, promoting, and shifting resources towards viable local alternatives led by women and youths in affected communities that reduce emissions while promoting resilience and providing inspiring examples of what the just transition looks like. Under the auspices of SPA II, ActionAid Nigeria has partnered with the Global Climate Justice Programme on the alternative track to identify, promote and potentially strengthen and scale progressive solutions to the climate crisis. The goal of the alternative track is to scope the potential for alternatives and promote investment in alternatives through different measures such as public investments, not-for-profit or private/impact investors.

In light of the SPA II program, the study is commissioned to ensure a sustainable transition to clean, reliable agro-processing and better off-grid electricity for rural communities and small businesses. It identifies and documents twenty-six (26) cases of dirty, unhygienic, and polluting agricultural processes or businesses along various crop value chains and businesses in Nigeria. The study also presents ten (10) viable clean alternative cases to the identified dirty cases.

The study recommends the following five (5) clean cases to be included in the alternatives database under the Global Programme on Climate Justice, based on the following reasons/criteria:

1. **Case 4: Quintas Energy – Biomass for Agro-processing value chain & electrification.** The solution covers a wide variety of crops, (i.e. cassava, palm oil, yam, plantain). Unlike the other solution, it promotes a circular farm system with zero waste. The biomass machines use up the generated waste from the crops. The technology also produces heat, steam, and electricity. These are all that is needed in the processing of food; either for drying, boiling or electricity for cooling and lighting. The solution is also very affordable and is based on local fabrication technology using local materials. The latter ensures local technological transfer and development.

2. **Case 9: Creeds Energy LiteDey-Mesh Grids for Rural Cluster Communities.** The idea of electricity sharing in cluster communities in rural areas is not only novel but brilliant. The business model of electricity as a service; where the customer/connected household need not own the electricity assets, but pay only for the electricity supply, reduces the business risk drastically and makes electricity more affordable. The technical viability of electricity sharing between households and processing centres and public utilities (i.e. PHCs and Schools, etc.) improved electricity utilization capacities. The solution makes it easy for mesh-connected communities to purchase PUE for their small-scale agro-processing such as solar dryers, small milling machines, etc.

3. **Case 2 and 8: DARE Solar Bubble Dryers and Parboiler.** D.A.R.E-produced parboilers and solar bubble dryers are perfect to address food wastage and the popular practice of open sun drying in northern Nigeria. Considering the massive grain production in northern Nigeria and the massive use of firewood for parboiling (and the subsequent deforestation and scarcity of scrubs), the energy-efficient parboilers are a perfect solution for the region. The solution provider also has rich use of local content, vast sustainable training elements that target youths, and good feet in local communities in the region.

4. **Case 3: Roshan Renewable Happy Clean Stoves to Reduce Firewood for Cooking & Industries.** Roshan clean stove solutions are practical and reliable. The efficient cook stoves provide the gradual shift needed from traditional open-fire cooking to 100% clean cooking. A lot of renewable energy developers and LGP promoters have executed a lot of campaigns and projects on LGP cooking and processing in rural areas. Too many of these LPG projects are in rural areas all right after the gas cylinders go empty, as the communities lack both will, financing, and proximity to LPG filing locations. The Roshan clean stoves for homes and industrial use. i.e. boilers ensure efficient and reduced use of firewood and are now promoting the use of briquettes. The intervention has received lots of acceptability in communities where it has been implemented. The flexible payment models also make the solution viable.

5. **Case 10: Consistent Energy: Solar for Small Business – Pay Small Small.** The only case that shows the largest potential of displacing the use of fossil generators by small and medium scale businesses, especially in the trade and services such as barbershops, salons, frozen food vendors, kiosks, community viewing centres, etc., is the Consistent Energy's solar instalment payments. The business models where target energy user pays monthly fees equivalent to the cost of fuelling their generators or kerosene lanterns have proven to work perfectly well. This is evidenced in the number of their connected customers. The tripartite arrangement among Consistent Energy (energy provider), the local trade association/microfinance banks, and the customer default in the agreement rates very low.

On the lesson learnt, energizing agricultural processes must be a deliberate one, a primary objective, not an afterthought interventional to increase the economic viability and bankability of already installed solar mini-grids, or show of large agricultural tractors and machinery that are too big to work. Since over 70 per cent of agricultural products and processes are done by small-scaleholder farmers, most of whom are women, mechanisation projects, programs and schemes need to be tailor-fit solutions that meet the needs of the sector demography and realities.

Energy transition proposals need to allow for the gradual shift away from traditionally-manual processes, to energy-efficient use of fossils, and then 100% clean energy use. Transition to clean energy solutions cannot be rushed or coerced, without first ensuring local acceptability (measured by the community's understanding of the technology, their ability to pay, willingness to pay and actual payments).

Locals will hardly adopt or take up any efficient, clean energy solution, if the cost of operating in dirty businesses and/or agricultural practices is free and has no direct economic cost, consequences or sanction to the user. In other words, for alternative clean solutions to thrive, a multi-stakeholder approach is needed to promote clean hygienic solutions and stress the direct consequences of dirty polluting practices.

ALTERNATIVE CASES TO DIRTY POLLUTING AGRIBUSINESS AND ENERGY PROJECTS AND THEIR ECOSYSTEM IN NIGERIA.

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List of Abbreviations

ABP	Anchor Borrowers Program
AECF	Africa Enterprise Challenge Fund
AFOLU	Agriculture, Forestry, and Other Land Use
AIF	Agro Integrated Facility
APP	Agricultural Policy Programme
BOF	Bank of Agriculture
CBN	Central Bank of Nigeria
CO2	Carbon Dioxide
DRE	Decentralized Renewable Energy
EAP	Energizing Agriculture Programme
EE	Energy Efficiency
ETP	Energy Transition Plan
FAO	Food and Agricultural Organization
FIT	Feed In Tariffs
FMARD	Federal Ministry of Agriculture and Rural Development
GEAPP	Global Energy Alliance for People and Planet
GEF	Global Energy Fund
GHG	Green House Gas
GOGLA	Global Off-Grid Lighting Association
IMF	International Monetary Fund
IPPU	Industrial Processes and Other Product Use
LFP	Lithium Ferrous Phosphate or lithium iron phosphate
LPG	Liquefied Petroleum Gas
MDAs	Ministries, Departments and Agencies
MSMEs	Medium Small and Micro Enterprises
NAIC	Nigerian Agricultural Insurance Corporation
NATIP	National Agricultural Technology and Innovation Policy
NCAM	National Centre for Agricultural Mechanization
NDP	National Development Plan
NEP	Nigeria Electrification Project
NGOs	Non-governmental organizations
NoMAP	Nigeria Off-grid Market Acceleration Program
PFI	Private Financial Institution
PPAs	Purchasing Power Agreements
PSPAs	Policy Support Programmes and actions
PUE	Productive Use Equipment
RE	Renewable Energy
REA	Rural Electrification Agency
RMI	Rocky Mountain Institute
SAPZs	Special Agro-industrial Processing Zones
SAS	Stand Alone Systems
SEC	Security Exchange Commission -SEC
SHS	Solar Home Systems
SPA II	Strategic Partnership Agreement II
UKAID	UK Aid
UNDP	United Nations Development Program
USTDA	United States Trade and Development Agency

ALTERNATIVE CASES TO DIRTY POLLUTING AGRIBUSINESS AND ENERGY PROJECTS AND THEIR ECOSYSTEM IN NIGERIA.

Background: Energy, Climate Change and Poverty

By 2050, Nigeria is projected by the World Bank to become the third most populous country globally, surpassing 400 million people. Being highly susceptible to the consequences of climate change while also being one of Africa's primary sources of greenhouse gas (GHG) emissions, Nigeria's estimated total GHG emissions ranged from 247 million tonnes of CO2-equivalent (MtCO2e) in 2010 to 347 MtCO2e in 2018.

The energy sector accounted for the largest share of GHG emissions, contributing 209 MtCO2e in 2018 (60% of the total emissions). Among energy sector emissions, oil and gas, make up 36% of the total energy sector emissions, followed by emissions from transportation, electricity generation and residential and industrial energy consumption. The second-largest contributor to Nigeria's overall GHG emissions is Agriculture, Forestry, and Other Land Use (AFOLU), which contributed approximately 25% of national GHG emissions. Waste accounted for 9% of emissions, while Industrial Processes and Other Product Use (IPPU) contributed 5%.[1]

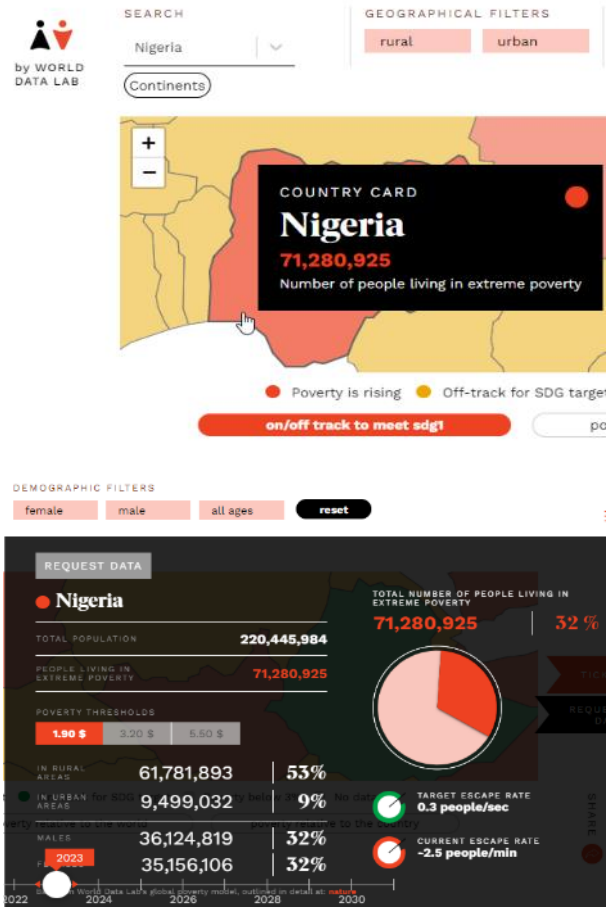
Access to reliable and affordable energy is essential for human development, economic growth, and the reduction of poverty. Energy access, poverty, and climate change are interconnected issues that influence and impact one another. Nigeria faces significant energy poverty, particularly in rural areas where a large proportion of the population resides. Limited access to electricity and modern energy services hinders economic activities, healthcare, education, and overall quality of life.

In Nigeria, the correlation between energy access, poverty, and climate change is particularly pronounced, with women bearing a disproportionate burden of these challenges. Women in Nigeria often face greater challenges in accessing energy services compared to men. They are most often responsible for household chores, including cooking and childcare, which are

[1] Federal Government of Nigeria 2021 NDC update. https://climatechange.gov.ng/wp-content/uploads/2021/08/NDC_File-Amended-_11222.pdf

heavily reliant on traditional and inefficient energy sources. The lack of clean and affordable energy options exacerbates their workload, limits income-generating opportunities, and perpetuates the cycle of poverty.

Improving energy access for women in Nigeria is crucial for their empowerment and poverty alleviation. By providing clean and affordable energy options, such as off-grid renewable energy solutions, clean stoves, improved agro-processing devices, etc., women can enhance their agricultural productivity, engage in income-generating activities, and contribute to sustainable development. Promoting climate-resilient practices and technologies, such as clean agro-processing machines, drought-resistant crops, efficient irrigation systems, and climate-smart agriculture, can enhance the resilience of women farmers and their communities- taking them out of poverty.



According to the World Poverty Clock, over 32% of Nigerians live below 1.90$ a day. 53% of these people live in rural areas. The World Bank reports that over 45% of Nigeria who live mostly in rural areas, do not have access to grid electricity – unserved Nigerians. The 55% connected to the national electricity grid are largely underserved with an average of 6 hours of electricity. Most of these connected consumers are in urban and semi-urban areas; augmenting the poor power supply with noisy dirty fossil generators. Nigeria's economy depends heavily on small gasoline generators; their collective capacity is eight times more than Nigeria's entire national grid.[2]

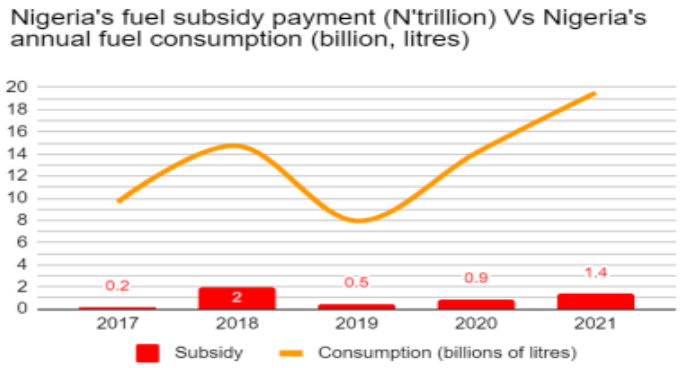
Given the poor grid access in Nigeria, at least 22 million small gasoline generators are being used to power households and small businesses. Nigerians spend $14 billion each year on buying and operating small gasoline generators[3]. With the pump price of gasoline (petrol) increasing by over 250% as a result of the fuel subsidy removal on May 29 2023[4], the cost spent per unit of fuelling these fossil generators will also increase drastically, accelerating more energy deficit and poverty. The prolific use of small gasoline generators has wide-ranging negative impacts on the environment,

2 2023 The World Bank Group. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=NG

3 The June 2022 report by Stears and Sterling, titled, "Nigeria's State of Power: Electrifying the Nation's Economy. https://punchng.com/40-nigerian-households-use-generators-spend-14bn-on-fuel-report/

4 PWC (May 2023): Fuel Subidy in Nigeria – Issues, challenges and the way forward. https://www.pwc.com/ng/en/assets/pdf/fuel-subsidy-in-nigeria-issues-challenges-and-the-way-forward.pdf

public health, and government budgets. Aside from the economic cost of these fossil generators, they are harmful to the health of users. Approximately 1,500 deaths per year come from inhaling generator smoke - carbon monoxide. More than 2/3 of users of fossil generators report impaired hearing[5]. Given that approximately 45% of Nigerians are not connected to the grid, and those who face unreliable electricity access are in their hundreds of millions, many people have no choice but to use small gasoline generators and other dirty traditional energy sources.

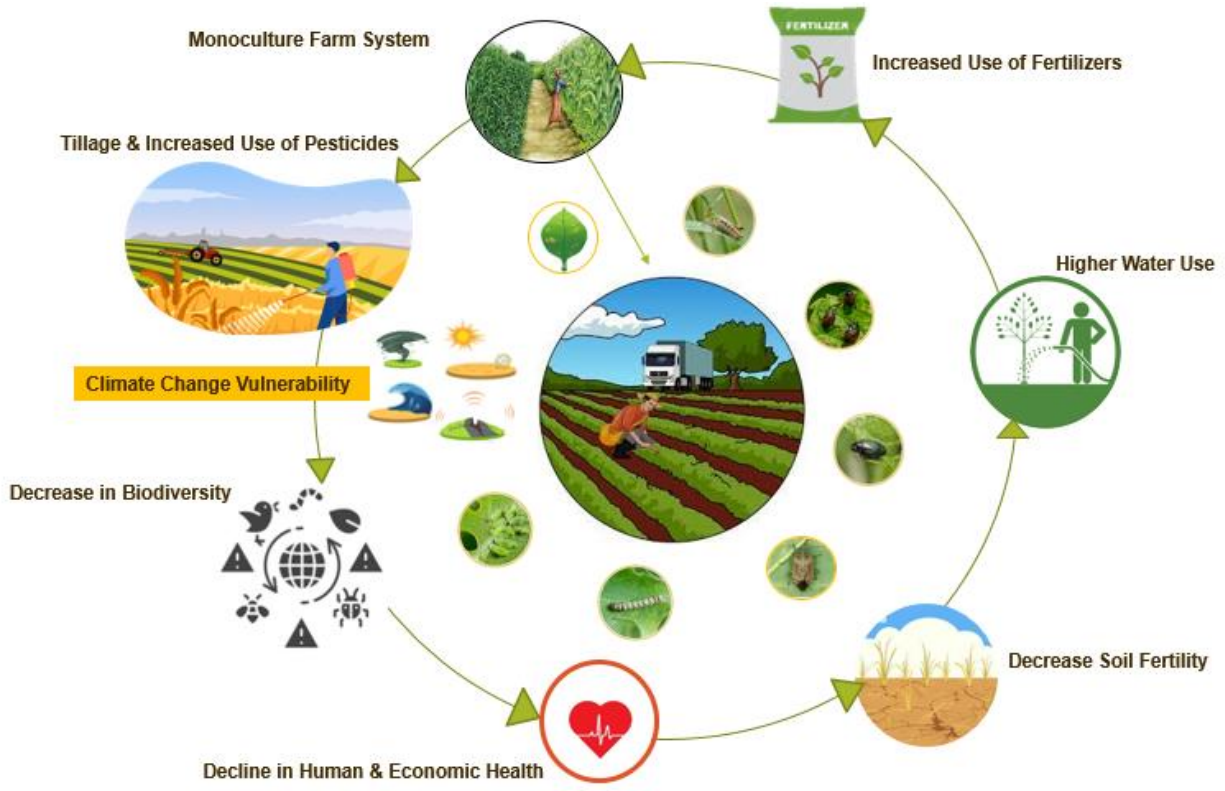


Eliminating Nigeria's 22 million gasoline generators could make a substantial contribution to the country's commitment to cut carbon emissions in the energy sector. An effective substitute for small gasoline generators, such as solar systems and biomass, can tap into the $ 12 billion-a-year generator market in Nigeria. Solar alternatives to gasoline generators exist in Nigeria but are currently 15-20 times more expensive. And given that gasoline generators typically run far below 100% load, they can be replaced by relatively smaller solar systems. However, they are currently a lot more expensive, even with the recent fuel pump price increase of over 200%. These solar systems are not available at scale to a vast majority of the citizens who live in poverty; as effective demand in the hands of the people, cannot meet up with the upfront cost of renewable energy solutions like solar rooftop systems. Accelerating the switch to solar systems requires improved affordability, concessional financing for emergent players, and an enabling policy and regulatory environment for renewable energy.

Access to clean, reliable, and affordable energy can transform the lives of women and youths by empowering them economically, improving their health and well-being, and enabling them to pursue education and entrepreneurship. Renewable energy solutions, such as solar power and clean cookstoves, offer great promise in bridging the energy gap and providing women with sustainable energy alternatives that reduce harmful emissions and protect the environment.

[5] Dalberg (June 2019): A2I's Putting an end to Nigeria's Generator Crisis: The Path Forward. https://a2ei.org/resources/uploads/2019/06/A2EI_Dalberg_Putting_an_End_to_Nigeria%E2%80%99s_Generator-Crisis_The_Path_Forward.pdf. See also: Punch Newspaper (1 April 2023): Killer generator fumes fuel deaths, climate change as power supply worsens. https://punchng.com/killer-generator-fumes-fuel-deaths-climate-change-as-power-supply-worsens/

Nigeria’s Agricultural Processes: Pollution, Waste and Emissions



Unfortunately, even when climate change adaptation and mitigation strategies are designed and implemented either by the government or development partners in Nigeria, these solutions especially for women are not economically viable, environmentally friendly, and socially inclusive nor are they sustainable. For instance, according to a report by Rocky Mountain Institute (RMI), diesel-powered milling and grating are common in Nigeria's mini-grid communities, however, most entrepreneurs do not electrify their processing equipment even after receiving reliable power in their communities[6]; either because most of the solar mini-grid projects are either not designed to carry productive machines, or the tariffs are not affordable.

[6] Rocky Mountain Institute (2023): Energizing Agriculture Program Innovation Accelerator May, 2023. Presentation by Suleiman Babamanu, Program Director, RMI.

Figure 1: Diesel-powered palm oil pressing machine in Owerri-Imo state.

Figure 2: 8-horse power diesel engine cassava girding machine in Ajegunle, Oyo East, Ibadan.

Local processors predominantly rely on inefficient and expensive diesel-powered mills, open-fire parboiling and sun drying, which give low-quality output. These processes also produce tonnes of waste that releases toxic chemicals to the environment. For instance, Nigeria generates 4.34 million tonnes of rice straw and appropriately 1.1 million metric tonnes of rice husk annually[7], thus generating millions of tonnes of carbon dioxide into the atmosphere from burning.

Figure 3: Rice husk mounds at Abakiliki Rice Mill Cluster in Ebonyi State

Figure 4: Traditional Rice parboiling and drying in Kaduna State.

[7] Businessamlive (October 31, 2022): Nigeria's agro-waste challenge offers wealth potential https://www.businessamlive.com/nigerias-agro-waste-challenge-offers-wealth-potential/

Similarly, smallholder farmers mainly in the southern part of Nigeria, contribute 80% of Nigeria's palm oil production yet they suffer from low oil yield and low quality due to a reliance on manual and traditional processing techniques –this makes farmers poorer[8]. Nigeria's palm oil production industry alone generated over 90 million tonnes of effluent (liquid waste) annually. Waste from animals also poses a big challenge to the sector and the environment.[9]

Figure 5: Palm oil processing in South East Nigeria - Abia State

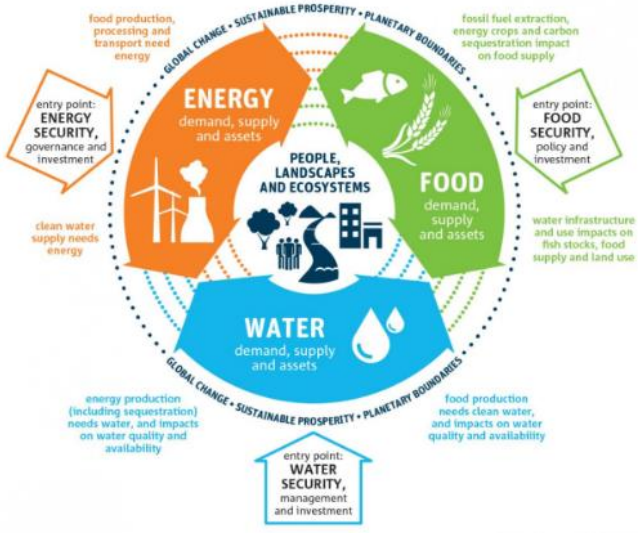
Figure 6a: Palm oil production in South West - use of feet for grinding and peeling and lots of water and open surface disposal of effluent. Ebun Akintola Village –Oni Gambari, Ibadan Oyo State.

8 Rocky Mountain Institute (May 2023): Energizing Agriculture Program Innovation Accelerator May, 2023. Presentation by Suleiman Babamanu, Program Director, RMI.

9 Businessamlive (October 31, 2022): Nigeria's agro-waste challenge offers wealth potential https://www.businessamlive.com/nigerias-agro-waste-challenge-offers-wealth-potential/

Figure 6b: Palm oil production in South West - lots of tree felling for open firewood burning for boiling. Ebun Akintola Village –Oni Gambari, Ibadan Oyo State.

Overall, Nigeria loses an estimated 40% of annual food production to postharvest losses every year, in part due to poor storage facilities with unreliable electricity[10]. Only 20% of staple crop like maize is canned and processed in Nigeria, the remaining 80% is wasted[11]. According to estimates made throughout the years by the Food and Agriculture Organization (FAO), Nigeria loses $9 billion (or about N3.5 trillion) annually due to post-harvest waste. Nearly a quarter of the nation's annual budget is wasted. This loss accounts for 31 per cent of the country's total land use and accounts for 5 per cent of its greenhouse gas emissions[12]. Tomatoes, oranges, cashews, onions, beans, wheat, cassava, and even yam are some of the grains, vegetables, tubers, and fruits that are largely wasted. This increase in agro-waste is evident across Nigeria and very evident in agricultural markets and popular markets across the city – where food waste accumulates.



To curb agro-processing waste and promote renewable clean technology solutions, several options and programs have been introduced globally

[10] CBI Ministry of Foreign Affairs (2021): Food Loss in Nigeria: Value Chain Analysis (VCA) of Tomato, Onion, Chilli value chains. SureChain January 2021. https://www.rvo.nl/sites/default/files/2021/02/Report-Food-Loss-in-Nigeria.pdf

[11] Obi, F., Ugwuishiwu, B., & Nwakaire, J. (2016). Agricultural Waste Concept, Generation, Utilization and Management. Nigerian Journal of Technology, 35(4), 957. https://doi.org/10.4314/njt.v35i4.34

[12] Nigeria Health Watch (2023): Serving Freshness: How Coldhubs is Tackling Food Waste in Nigeria. https://articles.nigeriahealthwatch.com/serving-freshness-how-coldhubs-is-tackling-food-waste-in-nigeria/

to improve the economies of community women through the integration of clean energy alternatives in agro-processing and domestic energy access.

Table 1: Renewable Energy for Agro-processing and Lighting

Energy need		Type of productive use		Type of business	Renewable energy technology
		Improvement to existing activity	New productive use activity		
Electrification	Information & communication		Provision of services such as mobile charging stations & internet	Shops	Solar PV, micro-hydropower, small wind
	Services		Provision of services using electric appliances e.g. television, sewing, solar refrigerator, battery charging	Shops	Solar PV, micro-hydro
Food issues	Drying	Improved quality of the existing product (e.g. compared to open sun drying)	Preservation, storage, selling products off-season or in higher value markets	Communities cooperative Farm gate process cluster Shops/Market	Solar dryers, biogas-powered dryers, biomass power plants
	Smoking	More efficient smoking e.g. fish	Creation of value-added products that can be sold locally	Shops Markets Farm gate process cluster Communities cooperative	Improve biomass stoves, biomass, efficient ovens
	Cooking & baking	Increase efficiency of food businesses	Creation of value-added products that can be sold locally	Food vendors, bakeries, restaurants, home-based businesses	Solar Cold storage, Biogas-powered ovens, solar ovens, biomass ovens, clean efficient stoves
Agriculture	Irrigation	Increase in yields, higher sales/availability	Cultivation of new crops with higher value/previously unavailable	Farmer	Water pumps, Micro-hydro power, biofuel-powered pumps, wind pumps, solar pumps
	Post-harvest processing	Higher productivity, higher quality production, less labour-intensive	Creation of value-added agricultural products Provision of processing services	Farmers, millers, New processing businesses	Grinding mills, threshing and husk machines, biofuel-powered motors and dryers, small wind turbines, biogas to electricity, solar PV dryers, micro-hydro, biomass-efficient stoves, electric peeling and shredding machines
	Livestock and Poultry	Higher and improved productivity, waste management	Provision of processing services	Poultry, shops, abattoir	Egg incubators, milk chillers, fodder preparation (i.e. chaff cutters), biogas plant
Cooling		Preservation of products (e.g. food products, medicine) Reduction of cooling costs (e.g. mill chilling)	Preservation, storage, and selling of products at higher value markets (e.g. fish, vegetables, beef, etc.) Provision of cooled products (e.g. cooled beverages)	Farmers, fishermen, butchers, shops, markets	Biogas to electricity, solar cold storage, etc.
Lighting		Extended operating hours	New home-based productive activities	Shops, home-based businesses, markets	Solar PV, solar lamps, small wind turbines
		Improved practices e.g. night time fishing		Fishermen, Suya (meat barbecue, steak or Tsire)	Solar PV, Solar lamps
Mobility		Preservation of products, vehicle conversion from fuel and diesel to CNG and e-vehicle	Reduce travel distance, haulage, increase market access	Vehicle owners, cooperatives, shops, government	Electronic cargo bikes, CNG conversion technology for cars and generators

Source: Authors compilation based on available technologies in Nigeria

Renewable energy agro-processing technologies like solar-powered milling machines can be used for processing grains such as groundnut, maize, wheat, or rice. They utilize solar panels to generate electricity and can be particularly beneficial in regions with abundant sunlight like northern Nigeria.

Biogas digesters can be used to generate biogas from animal manure and food waste in markets. Fish guts, water hyacinth and other local organic waste can be used to produce biogas, which will then fuel generators for productive use. Waste to energy like Biogas is used in countries like Nepal, Bangladesh, Kenya, and even Nigeria. The popular Ikorodu Mini Abattior in Ikorodu in Lagos State Nigeria is powered by an efficient biogas plant – producing up to six hours of electricity every day. The plant is capable of converting organic waste through the installation of four 5,000-litre digester tanks and fed with digestible organic waste and concentrated wastewater from the abattoir. Part of the by-product of the plant is an organic fertilizer that can be used to grow food sustainably[13].

Biomass briquette machines use agricultural residues such as crop stalks, sawdust, or rice husks to produce biomass briquettes. The briquettes can be used as fuel for cooking or heating, reducing reliance on traditional biomass fuels. Solar or wind-powered water pumps can be used to power water pumps for irrigation purposes on farms. Small-scale biodiesel processors can convert vegetable oils or animal fats into biodiesel, which can be used as fuel for agricultural machinery.

Many of these technologies are not designed or implemented to meet the needs of the local communities/users and lack scalable potential.

Justification

Various initiatives are being implemented in Nigeria to address the climate crisis particularly those that affect youths and women. However, these initiatives aside from being implemented in silos, hardly pass the accessibility, sustainability and inclusiveness test over time. For instance, although many climate-smart solar mini-grids are connecting rural communities in Nigeria with electricity, they are not translating or contributing significantly to increased production and/or quality in agricultural practices and processes. There is, therefore, a need to identify dirty agricultural processes that need urgent transformation for improvement efficiency and higher user investment returns, while at the same time addressing the lingering climate change impact and pollution problem caused by these practices and energy poverty. Without such bold, realistic and detailed mapping of dirty agro-processes and a presentation of viable clean alternative solutions, meeting Nigeria's climate commitment and economic development goals, will be another mirage.

As part of the Strategic Partnership Agreement II (SPA II) that aims at transforming societies to become more just, feminist, green, and resilient, ActionAid International is implementing a Global Climate Justice Programme. The project aims at developing, promoting, and shifting resources towards viable local alternatives led by women and youths in affected communities that reduce emissions while promoting resilience and providing inspiring examples of what the just transition looks like. Under the auspices of SPA II, ActionAid Nigeria has partnered with the Global Climate Justice Programme on the alternative track to identify, promote and potentially strengthen and scale progressive solutions to the climate crisis. The goal of the alternative track is to scope the potential

[13] Ecogreen News(September 2, 2019): FOTE, IHS deliver Ikorodu biogas plant. http://www.ecogreennews.com/fote-his-deliver-ikorodu-biogas-plant/

for alternatives and promote investment in alternatives through different measures such as public investments, not-for-profit or private/impact investors.

In light of the SPA II program, the study is commissioned to ensure a sustainable transition to clean, reliable agro-processing and better off-grid electricity for rural communities and small businesses. It identifies and documents twenty-six (26) cases of dirty, unhygienic, and polluting agricultural processes or businesses along various crop value chains and businesses in Nigeria. The study also presents ten (10) viable clean alternative cases to the identified dirty cases.

Objective

This exercise seeks to identify, and document 20-25 cases of polluting agriculture and energy technologies in Nigeria and present matching clean alternative cases. Specifically, the study seeks to present:

1. Systems for renewable energy production and consumption that lower greenhouse gas emissions, improve resilience and benefit the victims of climate change.
    - These alternative models can be for producing, processing, and distributing food that reduces greenhouse gas emissions, enhance (bio) diversity, respect traditions, and improves equity and/or working practices for re-claiming and managing natural resources.
2. Identify the ecosystem (donor/funders/development agencies supporting or funding alternatives in agriculture and energy sectors), funding available, barriers faced by the alternative cases implemented, existing gaps (financial, technical assistance or capacity building), opportunities and what key lessons can be learned by ActionAid Nigeria.
3. Showcase 10 – 15 good alternative processing solutions, using a developed case tool that clearly articulates the identified alternative cases in agriculture and energy, and
4. Recommend 3-5 cases to be considered for the alternatives database under the Global Programme on Climate Justice and the criteria used to select them.

Methodology and Scope of Study

The methodology employed for this study involves a comprehensive and systematic approach to identify and document alternative cases to polluting agriculture and energy practices in Nigeria. The following steps were undertaken:

1. Extensive Literature Review: A thorough review of relevant literature, reports, websites, academic journals, research papers, and case studies was conducted to gather existing knowledge and insights on renewable energy projects, programs, interventions, sustainable agriculture, community practices, and ownership models in Nigeria.

5. Stakeholder Interviews: Key stakeholders, including renewable energy developers, fabricators and inventors, NGOs, members of farmers' associations, community-based organizations, women and youth groups, farmers, and experts in the field, were interviewed to obtain first-hand information and perspectives on dirty agricultural practices, clean alternative models, and technologies in use. These interviews provided valuable insights into the feasibility, impact, and challenges associated with implementing sustainable approaches.

6. Field Visits and Case Studies: Visits to communities, markets, farms, and energy projects were undertaken to observe and document the implementation of alternative models. In-depth case studies were conducted, collecting both quantitative data and qualitative observations to assess the greenhouse gas emission reduction potential, resilience, and community benefits achieved through these approaches.

7. Documentation and Reporting: To systematically capture all the dirty agricultural dirty business cases, this study employs a specific crop value chain approach; identifying the dirty cases in each of the processing stages of these crops and their by-products. Through this process, the traditional and manual technique used is better highlighted and then tagged dirty, clean or neutral. Each crop value chain is immediately closed with recommended clean energy alternative technology. The report identified alternative clean technological solutions to addressing the dirty agro-processes and energy use. The clean alternative solutions were selected based on criteria such as; community-based initiatives with local collaborations, use of local content materials, customer-tailored solutions or location-specific, value chain comprehensiveness (promoted circular economy), targets rural economies, female dominant productive activities, and elements of ease of energy transition. The study presents relevant data, case studies, stakeholder insights, and other relevant information in a clear and organized manner to effectively communicate the results of the study.

8. Recommendations: Based on the analysis and findings, recommendations were provided; with 3-5 cases to be considered for the alternatives database under the Global Programme on Climate Justice and the criteria used to select them.

This exercise limits itself to policies, programs, projects and works of literature that span between 2018 till date. It also makes a good effort to select projects and programs that relate to energizing agricultural processes in Nigeria.

In the selection of solutions, the consultant and his team were very deliberate in selecting experts with vast and in-depth on-the-ground experience in energizing agriculture and small businesses. They seek experts, that do not only technically competent, but have a community base approach to designing solutions; possess a history of working with community people (women and youths), and prioritise, the design of tailor-fit solutions using a good percentage of local raw materials, and manpower.

Review of Literature

Agriculture-Energy Nexus Programs, the Ecosystem, and Lessons

This section presents a review of the most recent sector policies, plans and programs in Nigeria that focus on improving agricultural processes and energy access for rural communities in Nigeria. The section also embeds the funding gap for energy access at the national level. It ends with a mapping of relevant stakeholders working on improving agro-processing and energy access in Nigeria.

The National Agricultural Technology and Innovation Policy (NATIP)

The Federal Ministry of Agriculture and Rural Development (FMARD) adopted a multi-stakeholder approach to develop the National Agricultural Technology and Innovation Policy (NATIP). The Policy adopted a mix of short-term and medium-term multi-stakeholder approaches towards ensuring resilience, recovery and growth and, at the same time, achieving a shift from subsistence farming to modern agriculture capable of ensuring national food security and contributing significantly to the national economic diversification drive and creating at least 12 million jobs. NATIP has a 6-year (2022 – 2027) time frame to generate thrust, capabilities and massive public and private sector investments for successful implementation.

Purpose of the National Agricultural Technology and Innovation Policy (NATIP)

NATIP is conceived to address critical challenges of Nigerian agriculture and lay a solid foundation for modernizing the sector in line with the changing global food systems and supply chains. NATIP will also operate with other policies and strategies of relevant MDAs. The Policy is expected to leverage the quick wins of the COVID-19 pandemic by building on agricultural gains that sustained food supply and nutrition for about 200 million Nigerians during the lockdown period. Drawing from the National Development Plan (NDP, 2021-2025), SDGs and other global and continental frameworks guiding the future development of agriculture, NATIP adopted a 6-year time frame to generate thrust and capabilities as well as massive public and private sector investments for successful implementation.

NATIP is built around 10 intervention pillars. As regards improving agricultural processes and improving the product value chain, the related two pillars are;

1. **Rapid Mechanization:** As local technologies evolve, 600 private sector-driven service centres, equipped with tractors, assorted farming implements, automation of livestock, fisheries and poultry production processes, storage and IT facilities would be facilitated to attain at least 27 tractors per 100 sq km and increase livestock and fisheries production by 50% in the country. This will massively reduce production and post-harvest losses, and will further stimulate the direct and indirect creation of 2 million jobs in the country.

2. **Strengthening Value-Chains for Priority Crops:** Attention would be given to the value-chain development of maize, sorghum, rice, wheat, cassava, sesame, tomatoes, yam, cowpea, soybeans, cocoa, palm oil, hibiscus, cashew, potatoes, cotton, ginger, groundnuts and sugar cane. Key constraints facing these value chains would be reduced with the active participation of states and local governments, smallholder farmers and private investors. The establishment of over 100 processing centres in rural communities across the country, under the Green Imperatives Plan, would be supported. Furthermore, the development of clusters, rural nodal

centres, rural cottage industries and the establishment of at least six Special Agro-industrial Processing Zones (SAPZs), would be pursued. All these would assist in linking the agricultural sector with the industrial/processing sector, thereby boosting industrialization and creating at least 1 million jobs in the country.

According to NATIP, the agricultural mechanization level in Nigeria is one of the lowest in the World. FMARD indicated that Nigeria's mechanisation is at 0.027 hp/hectare which is far from the FAO's recommendation of 1.5 hp/hectare. This explained the prevailing limited access to technology for Nigerian farmers. The Agricultural Mechanization roadmap as enshrined in the Agricultural Policy Programme (APP) or the Green Alternative document had adequately addressed the role of mechanization in crops, livestock and fisheries subsectors development.

Inadequate technological inputs, particularly in production and farm-level processing equipment such as tractors, power tillers, harvesters, threshers, crushers, choppers, hay balers and milkers have reduced the amount of land area under cultivation and contributed to low crop and livestock productivity, and high post-harvest losses in the country. Thus, the promotion and deployment of appropriate technologies for crops, livestock and fisheries production, processing and marketing will enhance the productivity and competitiveness of the sector. The envisaged increased public and private sector investments, as well as development supports, are expected to generate about 2 million jobs.

Recommended Policy Support Programmes and actions (PSPAs) to Support the Deliverables include;

I. Fast-tracking the implementation of the Green Imperative with significant private sector involvement to increase the density of tractors in the country.

II. Increasing access to rural electricity and renewable energy to permit technology utilization.

III. Supporting local fabricators of small- and medium-scale agricultural equipment

IV. Establishing agriculture-based technology incubation centres for training of women, youths and people with special needs.

V. Promoting motorized farm machinery and equipment for deployment in areas where land fragmentation is a key constraint to allow the use of sophisticated machinery.

VI. Promoting the use of on-farm processing equipment and encouraging value-addition technologies across value chains.

No evaluation has been done on the implementation and performance of NATIP as the policy is relatively new. However, lessons can be drawn from implemented projects and programs that draw inspiration or build on the NATIP. For instance,

The Agricultural Mechanization Program (Tractorization Programme)

The status of Agricultural Mechanization in Nigeria is very low estimated at 0. 027hp/ha as against the United Nations Food and Agricultural Organization (FAO) recommendation of 1.5hp/ha. To this effect, the Federal Ministry of Agriculture and Rural Development, in partnership with the Bank of Agriculture (BOA) and other relevant partners, launched the Tractorization Programme in February 2023 to speed up tractor deployment in the agricultural sector. The program's goals are to promote mechanized farming, improve food and nutrition security, and expand job opportunities for young

people in Nigeria, by making tractors and other machines available to farmers at concessionary deferred payment terms.

Farmers were expected to make a 40% per cent down payment while the balance of 60% per cent would spread over three years.

The ministry would acquire 10,000 units of Tractors with Implements and 50,000 units of assorted equipment to kick start the programme.

Bank of Agriculture (BOA) Mechanization Program: The Bank of Agriculture in Nigeria has established a mechanization program to support farmers. Through this program, the bank provides loans and grants to farmers to purchase or lease mechanized equipment such as tractors, harvesters, and irrigation systems. The aim is to improve farm efficiency and productivity.

Tractor Hiring Services: Various private organizations and cooperatives in Nigeria offer tractor-hiring services to farmers. These services enable small-scale farmers to access mechanized equipment on a rental basis, reducing the initial investment required to own such machinery.

Lessons Learnt:

- Like the N500 billion farmers Anchor Borrowers Program (ABP) launched in November 2015, these mechanisation programs more than often have very high credit default rates. The ABP though designed to provide farm inputs (in kind and cash) to SHFs to boost production of the key commodities, stabilise input supply to agro-processors and address Nigeria's negative balance of payments on food, saw increased production yields, but recorded a high number in loan default. According to the International Monetary Fund (IMF), only 24 per cent of loans collected by farmers under the anchor borrowers' programme (ABP) of the Central Bank of Nigeria (CBN) have been repaid as of 12 January 2023.
- The program proposed big heavy tractors owned and managed by private companies that operate far away from the farmers and their communities. In some instances, the tractors were coming from Abuja to farm locations in Benue and Kaduna, under long schedules and bureaucratic hurdles before the tractors were dispatched to the farm. Reports from a few interviewed farmers suggest that the tractors are hardly used as farmers organise themselves and take turns to do the farm clearing before the tractors arrive. The feedback from some staff of the Tractor companies is that – farmers most times organise themselves to clear the farms even before the tractors arrive on sight. On arrival at the cleared farm, the farmers request cuts from the supposed tractor service that would have been rendered by the tractor service, or else the company would not be able to make claims from the government that the service was rendered.
- *Big machines do not work. If it's big machines; it's meant for big farms and designed for men to handle* – voices of smallholder woman farmers. There is a gender imbalance in mechanisation programs that prioritize big machines, like tractors and large-scale processing plants. First of all, the machines are too big to physically access the farm location, and operate in small sizes. Secondly, there is a gender attribution of big machines to men. Most of the sampled women farmers are reluctant to learn and handle big machines as they assume they can be too sophisticated to handle and require more masculine strength to maintain and run.

- The agricultural mechanisation programs in the ministry are not climate-conscious, as they promote the use of heavy diesel-powered machines – facilitating and sending the signal for a more conventional farm system; promoting tillage and more use of fossil, not innovative.

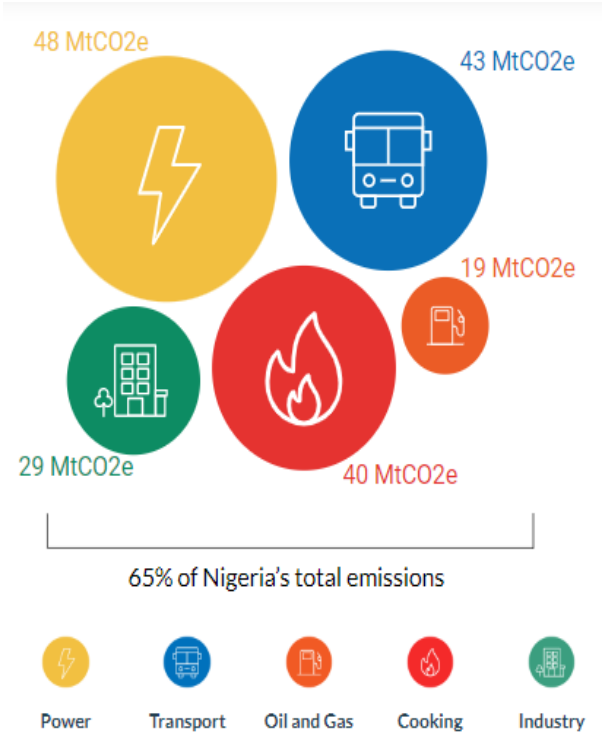
Unfortunately, most of the mechanisation programs of the Ministry (FMARD) and Central Bank of Nigeria (CBN) are too big to be affordable, accessible, male-centric and dirty. They do not meet the needs, specifications and design required by the over 70% of smallholder women farmers that produce most food and occupy most of the agro-processing value chain.

Nigerian Agricultural Insurance Corporation (NAIC) Mechanization Program: The NAIC has introduced a mechanization program to support farmers by providing insurance coverage for agricultural equipment. This initiative helps to mitigate the financial risks associated with equipment breakdown or damage, encouraging farmers to adopt mechanization technologies. However, the enrolment of farmers in agricultural mechanisation insurance is relatively low from private enrolees, except via the farmer anchor borrow program where the vendors of machines have insurance policies integrated in the premium credit.

National Centre for Agricultural Mechanization (NCAM): The NCAM is a research and development institute focused on agricultural mechanization. It conducts research, designs, and develops appropriate machinery and equipment suitable for Nigerian agricultural conditions. The centre also provides training and capacity-building programs for farmers and technicians.

The Nigeria Energy Transition Plan (ETP) 2023 - 2060

Nigeria's goal to reach net-zero emissions by 2060 was stated by the Past President Muhammadu Buhari in November 2021 at the United Nations climate change conference (COP26) held in Glasgow[14]. After that, on August 24, 2022, the then Vice President Prof. Yemi Osinbajo unveiled Nigeria's Energy Transition Plan (ETP), which outlined the nation's plan to achieve a net-zero emissions energy system by the year 2060. The energy sector accounts for 65% of all greenhouse gas emissions in Nigeria with 48Mt of CO2, with cooking accounting for 40Mt of CO2. Aside from transportation, these are the two other major contributors.



Key ETP objectives

At the core of the plan are the following imperatives:

- ✓ Lifting 100 million Nigerians out of poverty and driving economic growth
- ✓ Bringing modern energy services to the full population

[14] Bloomberg (02.11.2021): Nigeria Pledges to Reach Net-Zero Emissions by 2060, Buhari Says. https://www.bloomberg.com/news/articles/2021-11-02/nigeria-targets-to-reach-net-zero-emissions-by-2060-buhari-says#xj4y7vzkg

- ✓ Managing the expected long-term job loss in the oil sector due to the reduced global fossil-fuel demand
- ✓ Playing a leadership role for Africa by promoting a fair, inclusive and equitable energy transition in Africa that will include Gas as a "transitionary fuel"
- ✓ Streamlining existing and new government-related energy transition initiatives

The Funding Gap: $1.9 trillion is said to be required to get to Net Zero by 2060, including $410 billion above projected usual spending. This additional cost translates to about $10 billion annually.

Of the $410 trillion, decentralised electricity is estimated to be approximately $82 billion made up of ≅ $35 billion for solar microgrids and ≅ $12 billion for SHS in rural homes; and ≅ $16.5 billion for rooftop PV in urban homes and $6.6 billion for grid connections. For clean cooking, at least $79 billion is needed to transfer fossil-based energy to the use of LGP and electric cooking.

Nigeria has already secured a $1.5 billion pledge from the World Bank and is in talks with the US Export-Import Bank for an additional $1.5 billion.

The Federal Government of Nigeria (FGN) has also implemented several sector reforms, put in place enabling policies/incentives, launched ambitious programmes and made investment-grade data publicly available to demonstrate its investment readiness:

- The Federal government has put in place aggressive reforms that have led to reaching cost-reflective grid-based electricity tariffs for the first time since privatization and a 75% increase in collections.
- FGN passed the Climate Change Bill in 2021 with provisions for the establishment of a climate change council and a carbon market.
- The Nigerian government also submitted an ambitious Energy Compact to the United Nations (UN) as part of the United Nations High-Level Dialogue on Energy.
- The Nigerian Government submitted its updated NDCs in 2021. The Federal Ministry of Environment is harmonizing Nigeria's NDCs with its energy transition pathway and other climate change efforts
- Pioneer status is available to companies involved in independent power generation, the legislation provides a tax holiday of an initial three-year period, renewable for an additional two-year period.
- A Liquefied Petroleum Gas (LPG) Cylinder Manufacturing company has also been approved for the 'Pioneer Status' incentive.
- FGN introduced feed-in tariffs (FIT) as a tariff regulatory mechanism to accelerate investment in renewable energy sources. The FIT regime guarantees a stable price for electricity generated from renewables for a fixed duration, thereby securing adequate returns on Investment.
- FGN has embarked on extensive solar mini-grids and off-grid programmes such as the Nigeria Electrification Project, the Energizing Economies Initiative, the Energizing Agriculture

Project, the Energizing Education Programme, and the Interconnected Mini-Grid Acceleration Scheme via The Rural Electrification Agency (REA)

- The government has also shown leadership in Decentralized Renewable Energy (DRE) by deploying solar + storage solutions to government buildings, universities and health facilities.

Through commendable –ETP, Nigeria has previously attempted to increase the sustainability of its energy system, but efforts like the Nigerian Renewable Energy Master Plan have mostly failed to achieve their goals. A reality check suggests that Nigeria will have a difficult time realizing the key objectives of the ETP for the same reasons. The ETP fails to prioritize economic development coupled with poor planning, and weak institutional and fiscal frameworks.[15]

Because decarbonization strategies are often far too expensive and detached from the day-to-day reality of low-income populations in communities, Nigeria's capacity to reach net zero is contingent on raising its population out of poverty, first and foremost. With this lens, a critical analysis of the Nigerian ETP reveals additional and complementary actions that could be taken to realize a net-zero emissions energy system.

Regardless of financial strata, the ETP envisions the deployment of sustainable technologies like electric cars, more solar PV, Liquefied Petroleum Gas (LPG) for rural communities and electric stoves by 2023. This is even when more than 40% of Nigerians are extremely poor[16]. Regardless of their carbon footprints, those who are poor often choose to purchase the things with the lowest upfront costs. Findings from studies reveal that the adoption of clean cooking facilities is influenced by income[17]. Research on low-carbon energy options for low-income households is required, especially in Nigeria's rural and peri-urban areas, given the sizeable population that lives in poverty today. This research will help find suitable and affordable low-cost technologies.

About 87% of Nigeria’s primary energy supply is from biomass, primarily used for cooking in the residential and commercial sectors and harvested in an unsustainable manner. The ETP targets the expansive use of biomass for liquid fuels in transportation and agricultural industries and for direct combustion for industrial purposes. But this will not be possible without a broader re-engineering of how biomass is cultivated. If Nigeria intends to continue biomass use, the government must outline a strategy for industrial cultivation in a sustainable manner and at a greater scale. The ETP is silent on the role of energy efficiency in driving a net-zero emissions energy system. Energy efficiency is an essential tool in reducing carbon emissions in Nigeria because it will reduce power demand, and subsequently, the amount of fossil fuel that would have been burnt by the conventional gas power plants and stoves. SMEs account for 70% of Nigeria’s industrial employment and about 50% of manufacturing output. Given the role of SMEs in Nigeria's industrial sector, large-scale adoption of energy-efficient technologies (e.g., advanced electric motors, fans, boilers, etc.) will be required to accelerate the transition to net zero by 2060 by reducing total power requirements in the sector, as well as putting practical incentives to encourage the off-take and switch to these new technologies – this is most often trade-offs the governments do not take.

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15 Aarti Gungah, Nnaemeka Vincent Emodi, & Dioha, M. O. (2019). Improving Nigeria’s renewable energy policy design: A case study approach. Energy Policy, 130, 89–100. https://doi.org/10.1016/j.enpol.2019.03.059

16 The National Bureau of Statistics 2019 Poverty and Inequality in Nigeria Report

17 Nnaemeka Vincent Emodi, Emmanuel Umoru Haruna, Abdu, N., David, S., Dioha, M. O., & Abraham-Dukuma, M. C. (2022). Urban and rural household energy transition in Sub-Saharan Africa: Does spatial heterogeneity reveal the direction of the transition? Energy Policy, 168, 113118. https://doi.org/10.1016/j.enpol.2022.113118

Finally, The ETP offers sector-specific decarbonization initiatives but lacks an overall strategy for the energy system. A bottom-up, integrated planning of the entire energy system is required for a net-zero emission energy system that is dominated by electrified end users and a variable renewable energy supply to thrive. Increased integration of the electrical, transportation, cooling, and heating sectors is necessary to meet the cost-effective aims of Nigeria's ETP while also increasing the overall energy system's efficiency, flexibility, and affordability.

More recently and still running are numerous powering agricultural projects and programs in Nigeria designed to increase energy access in poor off-grid communities, and stimulate socio-economic growth in farming communities by transitioning farmers, and SMES to renewable energy solutions; empowering women and youth. Some of these projects include -

The Nigeria Electrification Project (NEP)

The Nigeria Electrification Project (NEP) is a Federal Government (FG) initiative that is private-sector driven and seeks to bridge the energy access deficit by providing electricity to households, MSMEs, and educational and healthcare facilities in unserved and underserved rural communities through the deployment of mini-grid, Solar Home Systems (SHS), captive power plants and productive use appliances to ensure the sustainability of these off-grid solutions. The Nigeria Electrification Project is fully aligned with the Rural Electrification Strategy and Implementation Plan and also supports the Power Sector Recovery Plan (2017-2021) objectives to increase private investment into the energy sector, including implementation of rural energy access and off-grid/mini-grid energy services.

To support the implementation of the NEP, the Federal Government of Nigeria, through the REA, has successfully secured financing from both the World Bank ($350m) and the African Development Bank ($200m).

NEP comprises four components:

(i) Component 1. Solar Hybrid Mini-Grids for Rural Economic Development: Funding the rollout of a minimum subsidy tender for mini-grids in 250 sites across six geopolitical zones in the country;

(ii) Component 2. Productive Appliances and Equipment for Off-Grid Communities (PUE): Funding performance-based grants to both mini-grid and stand-alone solar installation companies that increase the number of productive appliances in their operations;

(iii) Component 3. Energizing Education (Phase 3): Financing the installation of dedicated power systems for eight federal universities across the country's six geopolitical zones; and

(iv) Component 4. Institutional Capacity Strengthening: Providing technical assistance and capacity building to REA and other relevant stakeholders to support national rural electrification scale-up activities

The objective for Component 2: The Results-Based Financing for Productive Appliances & Equipment aims to increase the productive use of energy in remote communities by increasing access to efficient, electric productive equipment. The component targets to electrify 24,500 MSMEs and 1,050,000 with improved access to energy services from productive use systems. **The focus of**

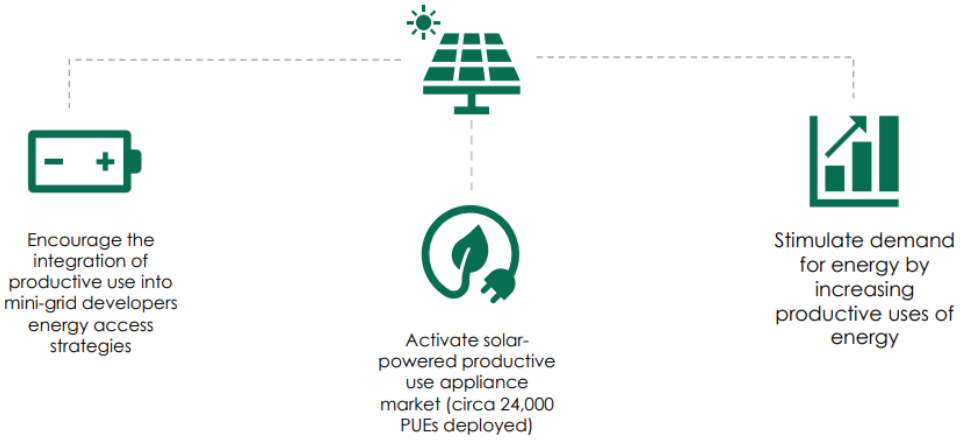
the PUE Component is mini-grid demand stimulation and is therefore geared towards facilitating the deployment of PUEs in mini-grid communities[18].

Specifically, it seeks to –

I. **INCREASE** productive use of energy in rural communities by facilitating access to energy-efficient, electric productive equipment

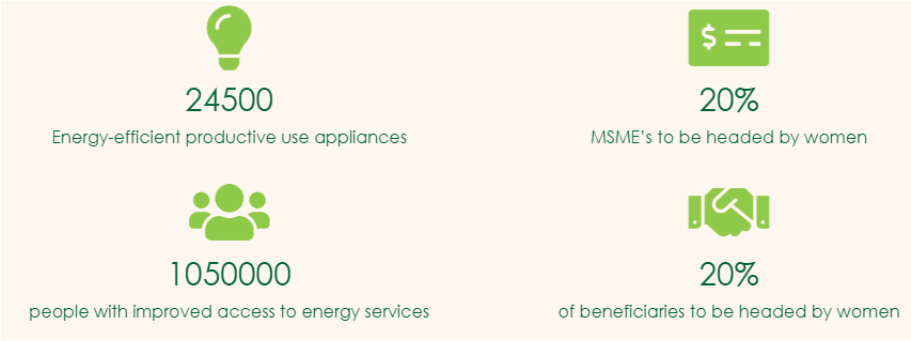
II. **ENCOURAGE** developers to make productive use of power and energy-efficient appliances part of their overall strategy for mini-grid viability; and

III. **ACTIVATE** the energy-efficient productive use appliance and equipment market



Funding: US$19,000,000 (Total Value of results-based financing channelled to private sector providers of Productive Use Appliances and Equipment). US$10 from the Africa Development Bank Group (AFDB).

Targets:



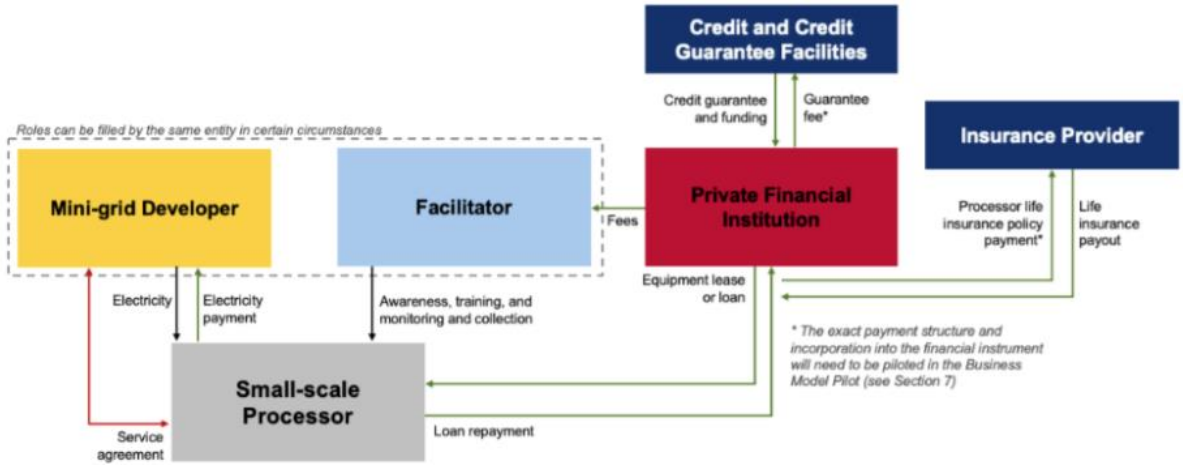
The Productive Use Equipment in the NEP includes an electric motor for retrofit onto the existing machine, a Bagging and packaging machine, a Boiler/boiling machine, a Destoning machine, a Dryer/drying machine, a Fermenter/fermenting machine, a Freezer, Fridge, Fryer/frying machine, Grater/grating machine, Grinder/grinding machine, Husking machine, Miller/milling machine, Oil Press, Solar Irrigation, Solar Cold Storage, Oven, Packaging/labelling machine, Palm oil processing machine, Processing Machine, Sprayer/spraying machine, Thresher/threshing machine, Tractor, Television/TV, Water pumping machine, Welding machine, Winnowing machine, Others.

[18] Rural Electrification Program (NEP Presentation at the Off-Grid Donor Meeting in May 2023): https://nep.rea.gov.ng/result-based-financing-for-productive-appliances-equipment/#pueapplicatio

The Business Models for PUE in the NEP:

- **Facilitator Business Model or Lease to own model/ Developers on-lend to MSES**
    - The aim is to reduce the cost of MSES

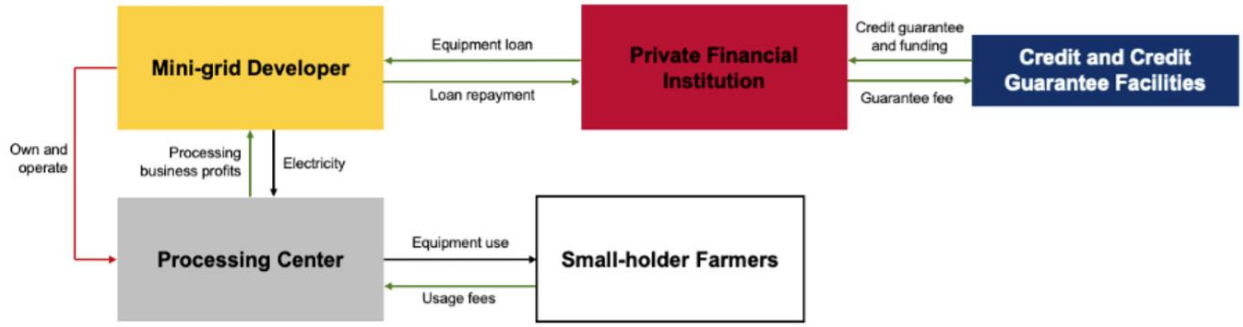
The Facilitator Model is led by a facilitator who enables small-scale processors in the community, to invest in PUE equipment by serving as their education resource and connection point to finance providers. In this model, the small-scale processor will be responsible for the credit and operational risk. The facilitator builds awareness about the investment opportunity and provides business development training to support loan applications and equipment selection, within the community.



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. According to the REA, 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.

- **Operator/Processing Centre Business Model**
    - Co-operative, suppliers

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.



For instance, the mini-grid developer, who already provides reliable electricity services, will be the owner of the processing centre by investing in the energy-efficient productive use appliances necessary to operate the processing centre/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 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, and WEMA Bank Debt.

Impact on Component 2: Productive Appliances and Equipment for Off-grid Communities. Report as of 09.06.2023 from the AfDB[19] shows that – even though more women seem to have received support with productive appliances and equipment, the number of Medium Small and Micro Enterprises (MSME) that have gotten support is low at 0.04%. This is equivalent to the proportion of allocation for PUE – component 2 ($10mn or $200mn).

Table 2: Outcome Report from ABDG as at 09.06.2023

Outcome indicators (as per RLF)	Baseline value	Most recent value	End target	Progress toward endtarget (%)	Assesment
Productive uses of electricity increased					
No. of MSMEs supported with productive appliances and equipment (% female headed) (nbr)	0.000	10.000	22,692.000	0.04%	**Achieved/Likely to be achieved** A few MSMSE are benefiting from the PUE . However, with the recent apporval of More PUE's , this is bound to increase and meet targets
[WOMEN]-No. of MSMEs supported with productive appliances and equipment (% female headed) (ppi)	0.000	8.000	10.000	80.00%	**Achieved/Likely to be achieved** Most of the support from PUE Phase 1 AND 2 HAS BENEFITTED WOMEN msmse'S
Percentage of the funds disbursed for Component 2 allocated to energy business that are targeting women owned MSMEs and activities (%)	0.000	18.000	20.000	90.00%	**Achieved/Likely to be achieved** This will improve as the project nears completion
owned MSMEs and activities targeted to supply and benefit from energy access solutions (nbr)	0.000	5.000	50.000	10.00%	**Achieved/Likely to be achieved** THis numbers will imporve tremendously once the project progresses in Q4 2023.

Source: Afdbf https://projectsportal.afdb.org/dataportal/VProject/show/P-NG-F00-020

Challenges:

- Limited knowledge and understanding of the agricultural dynamics of the communities and their people by developers
- The inclusion of PUE in existing mini-grids seems to be an afterthought to improve the viability and demand for mini-grids. In other words, PUE does seem not to be in the original design and business models of developers, at least for the initial 7 deployed mini-grids.

[19] AfDB Evaluation Report (June 2023): Implementation Progress and Report Reporting (IPR): https://projectsportal.afdb.org/dataportal/VProject/show/P-NG-F00-020

- Affordability -Delayed deployment due to lack of customer commitment (no down payment by community members for PUEs)
- Mini-grid Developers' inability to raise upfront costs of deployment for the PUE
- On-sight verification due to security concerns
- Overburden for the mini-grid developers as they have to develop new skills in running agro-processing businesses and finance linkages, rather than specialise in their energy development business. This may either be a burden to developers or an avenue to diversify their portfolios,
- Business models would likely work where community MSMEs have proven business experience and good credit history; do not give room for fresh young/potential enterprises from the community,
- No smart meters are connected, making remote monitoring difficult
- Delays in data collection from developers
- Seems rather limited to solar-powered renewable technology and mini-grids. This is restricting and most likely will not offer the best affordable, environmentally, sustainable and viable renewable energy solution needed in the agricultural process.

Recommendations:

- Consider community/cooperative-based funding and ownership models
- Deploying a few PUEs without requiring a down payment encourages end users to join the program as it gives them a chance to see the PUE in action and estimate the monetary benefits
- Increase engagement with customers before committing to purchasing PUE
- Capable technical staff required on sight that can provide data from developers and community
- Widen the range of qualified PUEs to include Stand Alone Systems (SAS) for scalability.
- Expand project scope to include other renewable energy solutions that are stand-alone and can encourage circular economy in the communities

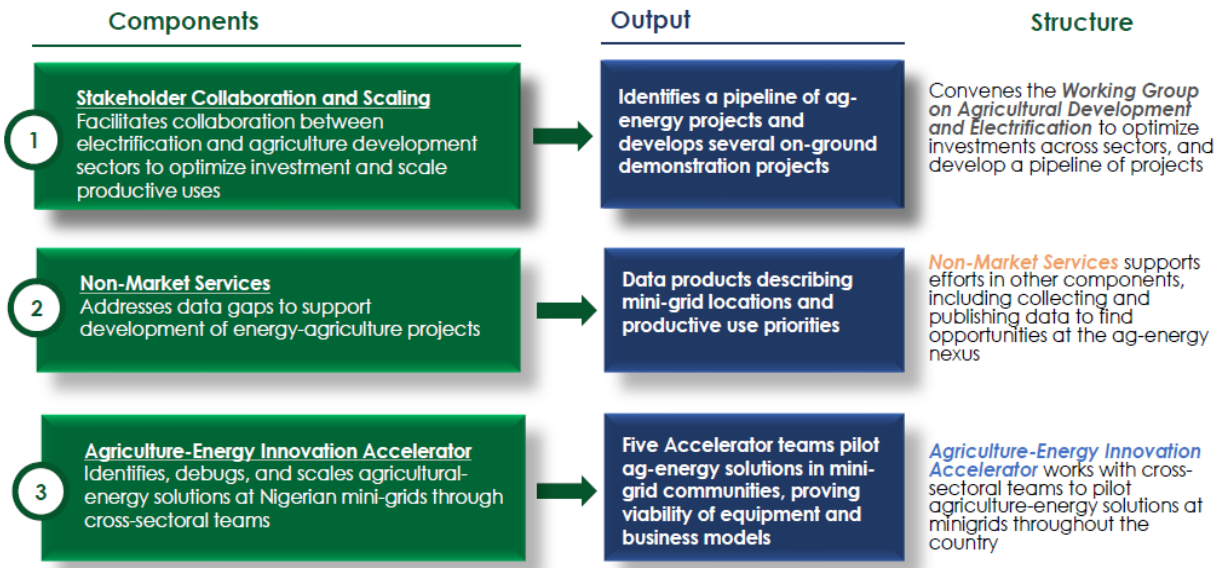
The Energizing Agriculture Programme (EAP)

Very similar to the NEP, the EAP is a three-year initiative that aims to stimulate the use of mini-grid electricity in agricultural productive uses, co-implemented by Rocky Mountain Institute with funding from the Global Energy Alliance for People and Planet (GEAPP) and the GEF UNDP through the Africa Mini-grid Program.

The program was launched to catalyze economic development and improve rural livelihoods in Nigeria by linking mini-grids and agricultural productivity. As distributed energy resources (DERs) are deployed across Nigeria, newly connected electricity customers and communities need help in accessing the means to use their power and unlock the benefits of reliable energy access. The EAP is accelerating productive uses of DERs by:

- ✓ Helping energy and agriculture programs collaborate across sectors by developing a pipeline of agriculture-energy projects.
- ✓ Identifying, testing, and scaling commercially viable agriculture-electrification solutions and models through a project-focused Innovation Accelerator.
- ✓ Across these activities, the EAP is designed to ensure local ownership of solutions and scaling by partnering widely and sharing insights broadly.

The EAP is organized into three components.



Business Model: 100% renewable energy 'pay-as-you-go' service, using a mobile-enabled smart metering system. With a 24-hour onsite service team and a maximum four-hour response time when issues arise. Provide reliable, low-cost AC power that matches the aspirational needs of customers; for households, community services, small businesses and factories.

Target: If implemented at scale, these product use initiatives in Nigeria are expected to reduce greenhouse gas emissions by 1.4 million tons of CO2 by 2030 and 7.4 million tons over the full life cycles of the supported electric machinery. The EAP could lead to the creation or improvement of over 150,000 jobs and boost the livelihoods of nearly four million Nigerians. If successful, the EAP will help prove a new scalable model for rural development.

As part of the GEAPP's broader efforts to bring reliable electricity to 1 billion people by the decade's end, avert 4 billion tons of greenhouse gases and enable 150 million green jobs that generate inclusive economic growth, the EAP will build on existing agriculture and electrification initiatives in Nigeria and then accelerate the deployment and adoption of the most effective solutions for rural communities across the country. The EAP will achieve this by bringing together teams of local partners to validate commercially led business models and demonstrate agricultural appliances and scale-proven solutions.

Impact so far: Innovation Accelerator Teams Bring Together Expertise From Agriculture, Equipment, And Energy Experts To Identify, Test, And Scale Ag-Energy Solutions

Electrifying rice milling

Integrate rice mills at minigrid sites to assess their technical and economic potential for scale.

Team Members:

Energy Excell (Equipment Provider), SEEDFIRST (Value Chain Expert), Powergen & Nayo Tropical Technologies (Minigrid Developers), Koolmill (Rice Milling Service Provider)

Electric vehicles for farm logistics

Assess the economic rationale for and scaling potential of EVs for farm logistics in the maize value chain.

Team Members:

Babban Gona & One Acre Fund (Value Chain Experts and Vehicle Operators), MAX (Vehicle Provider), ACOB Lighting & SOLMENZ (Minigrid Developers)

Minigrid-powered oil palm milling

Assess the economic rationale for electric palm milling and its scaling potential in crude palm oil production areas.

Team Members:

Releaf (Value Chain Expert and Palm Oil and Kernel Offtaker), ACOB Lighting (Minigrid Developer), Muhat Engineering Ltd. (Equipment Manufacurer)

Electrifying incumbent fossil-fueled processing

Test a business model that profitably provides electric processing options at scale to rural entrepreneurs alongside minigrid deployment.

Team Members:

Prado Power (Minigrid Developer), Farm Warehouse (Retrofit and Equipment Replacement Service Provider), Fabunmi Ltd. & AMEFAN (Equipment Providers)

Minigrid-powered cold storage

Identify, test, and scale cold storage models in minigrid sites.

Team Members:

Koolboks, Manamuz Coldhubs, & Ecotutu (Cold Storage Providers), Husk Power, GVE, Prado Power, & Nayo Tropical Technologies (Minigrid Developers)

Source: EAP result (https://energizingagricultureprogramme.org/results/)

Lesson Learns and cautions: From the signing of the 11 solar mini-grid Purchasing Power Agreements (PPAs) in 2011 to the introduction of the key maker model and the Performance Based Grant in 2021 to induce or force the viability of many mini-grids in Nigeria, it is clear that many mini-grids lack economic viability as most seem not to be designed to induce productive activities in off-grid communities. Programs like the EAP are commendable as it is, and seem to be designed primarily to improve the economic viability of mini-grids in the country.

Most mini-girds in the country were first designed to light households, hence their technical reliability was questionable when it came to powering heavy productive equipment. Aside from this, subsidized tariffs in these off-grid communities in the form of donor grants for mini-grid developers hid the true cost of electricity. In the absence of these grant elements, most of the mini-grid tariffs would not be affordable in poor agrarian communities. This questions the financial viability of many mini-grid projects – hence their lack of bankability.

Wrong citing of mini-grids. For mini-grids to meet the production needs of communities, they have to the located in the community's productive areas. For most communities, the mini-grids are in the

community residential areas where productive activities are less, compared to the farm processing clusters and market squares where actual processing is done. This reiterates the fact that the productive use of mini-grids is an afterthought, this is also reflected in the size of the systems, locations, choice of technology – Stand-alone-solar or mini-grid or other renewable energy technology i.e. biomass, as well as their financial viability.

Secondly, high off-grid tariff. Most mini-grids have tariffs costing N200/kWh. The first set of communities powered with mini-grids experiences some customer self-disconnections as they cannot meet up with the cost of tariffs.

Technical limitation, because the primary project goal is to make the mini-grid economically viable, provided solutions are limited to the solar system and haulage (transportation) of produce to make more returns and have community energy users more able to pay their electricity tariff. In other words, the goal seems capitalist – "fatten the cows so they can be eaten" "help farmers make more money to pay electricity bills, not necessarily making farmers wealthy", or address the dirty traditional manual production processes. Otherwise, the solution offered to the farmers will more than likely, stretch beyond the mini-grids. In summary, it can be said that it is designed to improve the economic viability of mini-grids. This questions the sustainability of the technology after the developer break-even.

Agro Integrated Facility (AIF)

The AIF's objective is to finance innovative approaches and business models that integrate rural electrification through solar mini-grids with the provision of services that improve the agriculture value chain and livelihoods in rural communities.

The Pilot will build on lessons learned from NOMAP's existing Productive Use Financing pilot that tests the viability of financing productive use equipment at "friendlier" terms than the prevailing market rates.

Under the AIF, NOMAP will provide a debt facility (through a Security Exchange Commission -SEC licensed fund manager) to three mini-grid developers for the deployment of agro-integrated services in mini-grid-powered rural communities. It will closely monitor the types of business models deployed and their impact on the mini-grid utilisation and viability, the agro value chain, and the rural economy with an emphasis on improved livelihoods and job creation for women and youth.

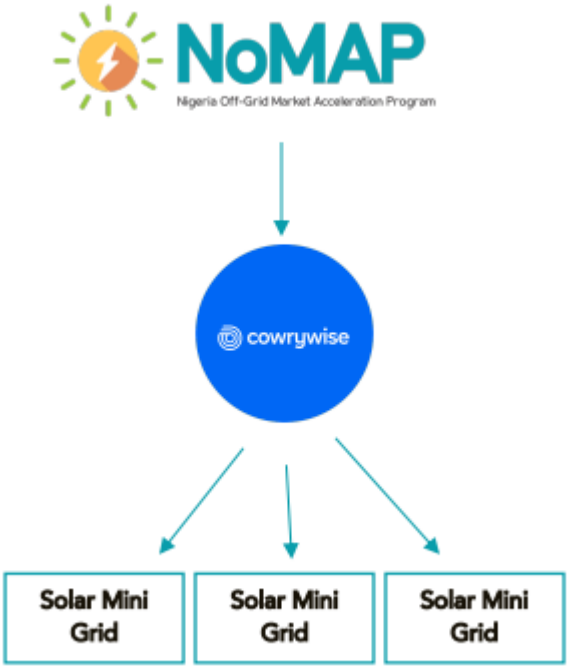
The Primary objectives of the Pilot include:

- Improve the viability of mini-grids through economic value-added services in the agriculture sector
- Improve the agro value chain in rural communities through clean energy access
- Catalyse rural livelihoods and rural economies through increased rural income and job creation

Proposed Pilot Structure of the AIF

NOMAP has earmarked a total sum of USD 150,000 (USD 50,000 per developer) with a possibility of increasing to USD 300,000 (USD 100,000 per developer) for three developers at an interest rate of 18% per annum. The interest rate was pegged at the current Monetary Policy Rate (MPR) by the Central Bank of Nigeria. The fund will be channelled through a licensed Security and Exchange

Commission (SEC) Fund Manager (Cowrywise) to the three developers. The Fund Manager will manage the day-to-day running of the fund (disbursements and repayments from the portfolio companies). NOMAP will be responsible for the overall management of the pilot and the parties involved in the initiative. The implementation timeline is June 2023 to 2024



Each Portfolio Solar Mini-Grid (SMG) Developer is entitled to a loan equal in value to USD 50,000 of the total AIF fund amount. The loans will be disbursed in local currency to portfolio companies. Repayments with interest will be made by the Mini-Grid Developer to the Fund Manager on a quarterly or monthly basis. NOMAP will provide the funds to the mini-grid developer(s) on the following conditions:

- Loan tenor: 12 - 18 months
- Interest rate: 18% per annum
- Repayment: Monthly or Quarterly

Impact Measurement: Mini-Grid developers will share relevant datasets required for monitoring the impact of the facility in line with AIF's objective

Criteria for Selecting Mini-Grid Companies

- Mini-Grid company has been in existence for three years and above and has a minimum of three active mini-grid sites.
- Pilots must be in mini-grid-powered agrarian communities with clear potential for agro-value chain services. Mini-grids must have the capacity to accommodate the agro-value-added service.
- Viable business plan and model, with established demand/off-taker for the agro-product
- Comprehensive plan for co-financing the pilot, including specific details on the sources of funding such as debt, equity, etc.
- High-level impact plan summarising the social, economic and environmental benefits of the facility.
- Willingness to share data sets required for the pilot.
- Fulfilment of all regulatory and technical requirements in line with SON, REA, Ministry of Environment and NERC.

Role of NOMAP

NOMAP will be responsible for the management of the initiative, data collection, monitoring and evaluation exercises, provision of funds to the Fund Manager, and other relevant pilot tasks. After

the pilot, NOMAP will develop a learning report to be shared with sector stakeholders particularly financiers to attract increased commercial finance for similar initiatives in the sector.

Role of Solar Mini-Grid Developers

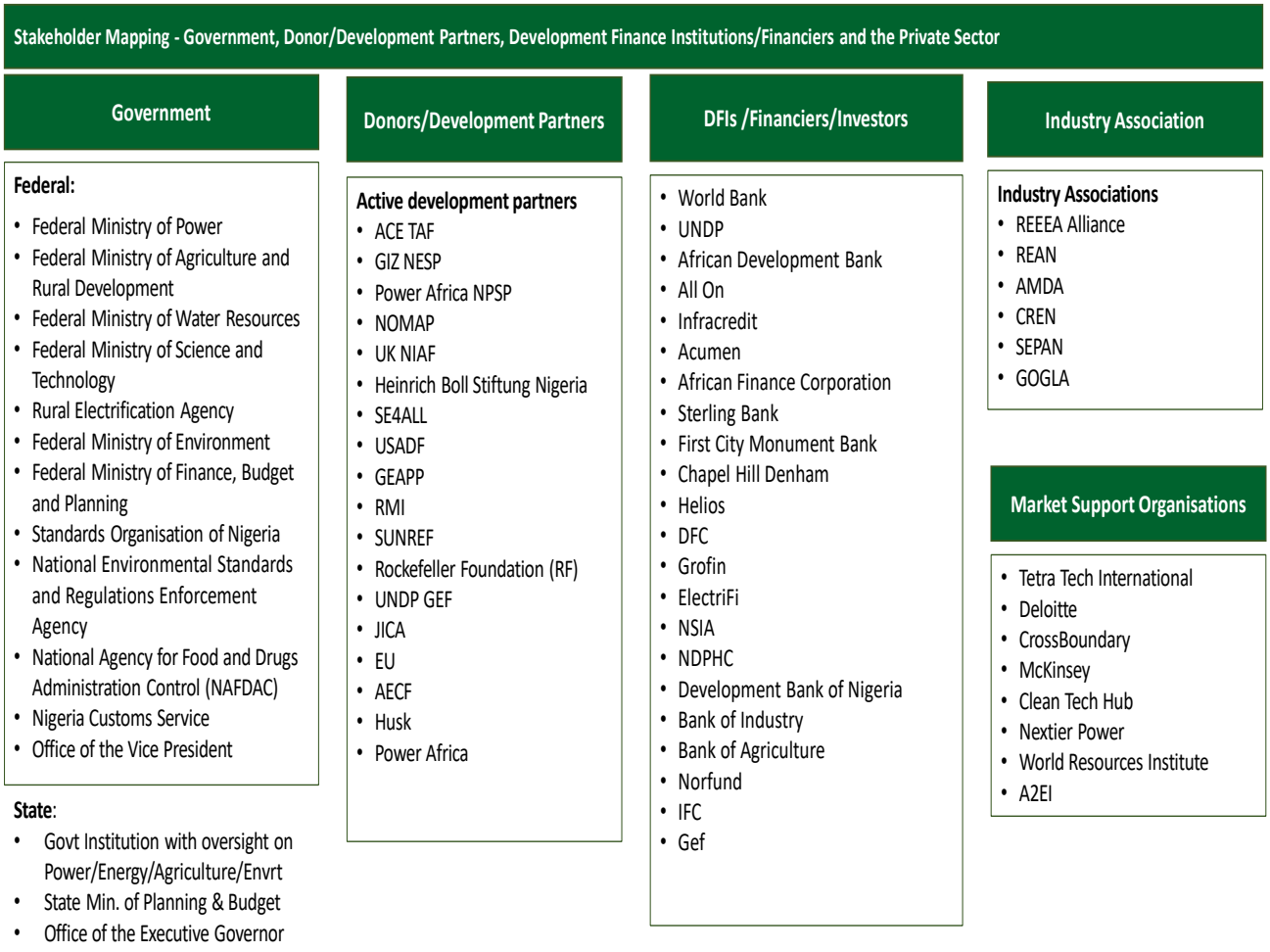
- Deployment and provision of all relevant equipment, machinery, and requirements for the pilot
- Obtaining relevant community buy-in and support for the pilot, including carrying out an evaluation of potential risk factors for the project and mitigative measures
- Provision of relevant pilot data to NOMAP as required for the pilot. A monthly report will be provided by the developer to NOMAP on the progress of the pilot.
- Appointing a designated focal person to oversee the pilot and be the point of contact with NOMAP
- Obtaining co-financing for the pilot if the capital cost for the deployment of the pilot exceeds NOMAP's debt amount

Limitations and Caution:

- The intervention is limited to just the mini-grids; designed to make mini-grids more economically viable
- The interest rate of 18% per annum for developers seems reasonable if disbursed as fixed. By implication, the users of the productive equipment may bear at least 50% of the lending cost per annum.
- Monthly and quarterly repayments for the developers must not be applied to the users of the PUE, as their income and cooperative contribution patterns are mostly daily or weekly. Hence, the developers must ensure a payment structure that fits into their income stream and saving patterns.
- The initiative is centred around the mini-grid solar technology provided; hence other gaps in the agricultural value chain that require massive heating and are located away from the grid locations cannot be powered and their emissions are cut off or reduced.

Stakeholder Mapping

Donor/funders/development agencies supporting or funding alternatives in the agriculture and energy sectors across the board.



See the mapping of the stakeholders on the end page.

Cases of Dirty Agricultural Processes/ Businesses in Nigeria

Live Cases of Dirty Business/Processes & Potential Clean Technology Options and Socio-economic Gains

Cases of Dirty Processes in Palm Oil Making:

In the 1950s and 1960s, Oil palm (Elaeis guineensis) was a significant agricultural export product and the nation's leading source of foreign cash before large quantities of crude oil were discovered in Nigeria. With an average production of 1.4 million metric tonnes, Nigeria, which was formerly the world's top palm oil producer, has dropped to fifth place.

The major oil palm producing states include Enugu, Imo, Ondo, Edo, Cross River, Delta, Akwa Ibom, Ekiti, Bayelsa, Rivers, Anambra, Oyo, Abia, Edo and Ogun State.

In many parts of Nigeria, especially in rural areas, the traditional or manual process is often used for palm oil extraction. The stages in this process comprise grinding the kernels into small particles, heating (boiling), and extracting the oil using an oilseed manually or mechanically. Across the value chain, these processes can either be clean, dirty or relatively okay.

Dirty processes: Smallholder women farmers contribute 80% of Nigeria's palm oil production yet they suffer from low oil yield and low quality due to a reliance on manual processing techniques. These processes generate huge carbon emissions all through palm oil processing. Heavy reliance on diesel machines, massive use of fire woods (from tree felling), lots of water usage, and very labour intensive for women and youth. In many cases, especially in the South Western part of Nigeria, the process of pressing via foot raises worry over hygiene. Waste from palm oil effluent is also an environmental threat to soil and surface water. These dirty and labour-intensive processes make farmers poorer[20]. Nigeria's palm oil production industry alone generated over 90 million tonnes of effluent (liquid waste) annually.[21]

The traditional process involves the following steps, and the dirty business cases highlighted along the value chain:

1. **Harvesting:** The oil palm fruits are harvested manually using a bunch cutter or machete. The ripe bunches are cut down from the palm tree.

[20] Rocky Mountain Institute (May 2023): Energizing Agriculture Program Innovation Accelerator May, 2023. Presentation by Suleiman Babamanu, Program Director, RMI.

[21] Businessamlive (October 31, 2022): Nigeria's agro-waste challenge offers wealth potential https://www.businessamlive.com/nigerias-agro-waste-challenge-offers-wealth-potential/

9. **Fruit Separation/threshing:** After harvesting, the fruit bunches are placed on the ground or on a mat. The individual fruits are separated from the bunch by hand and/or cutlass. This is typically done by twisting and pulling the fruits from the stalk or beating them with sticks. This is labour-intensive and done mainly by women in the communities.

10. **Palm Fruit Sterilization Process:** In most parts of Nigeria, the separated fruits are boiled or steamed in large pots or open vats to sterilize them. This step helps to facilitate oil extraction and prevent spoilage. However, most sterilization is done using enormous amounts of trees as firewood, burning in open spaces with massive emissions and resulting body heat on women. **(Dirty Case 1)**

Figure 7: Palm Fruit Sterilization in South East Nigeria - Abia State

Figure 8: Palm Fruit Sterilization in Eredo Village in Ogun State

Figure 9: Palm Fruit Sterilization in South West Nigeria: (left) Ebun Akintola Village –Oni Gambari, Ibadan Oyo State, & (right) Eredo village, Ogun State.

A 208-litre drum (or 55-gallon drum), is boiled for a minimum of 1 hour 30 minutes in open firewood using approximately 110 pounds = 50kg ≅ 0.05 tons of wood. A heap (20kg) of firewood sells for a minimum of NGN2,000 (USD 2.65) in Nigeria. That is an average of NGN5,000 (USD 6.63) for wood to sterilize palm fruits a week.

Figure 10: Heaps of firewood in Lugbe Abuja

Note: An average tree weighs somewhere between 10 and 100 pounds/45kg, depending on the species of tree. Burning 50kg of firewood just for sterilization is equivalent to falling at least an average tree a week. According to the Arbor Day Foundation[22], in one year a mature tree can absorb more than 48 pounds of carbon dioxide from the atmosphere and release oxygen in exchange.

Nigeria's daily firewood consumption stands at 266 million kg[23]. The World Health Organization states that "Over 98,000 Nigerian women die annually from the use of firewood[24].

11. **Palm Fruit Pressing Business or Process:** In the absence of machines (or by preference) in the south-western part of the country, the sterilized fruits are transferred to a large underground pit, mortar or grinding stone, where they are pounded or crushed manually, mostly using their feet. This traditional labour-intensive method has been passed from generation to generation – as a means of preserving cultural heritage. However, the quality and quantity of oil from this process are poor and relatively lower. This pounding process breaks down the fruit cells and releases the oil; as large volumes of water are added in the process. The pounded fruits are gathered and transferred to a woven mesh or palm fibre mat. The crushed fruits are then squeezed and pressed manually to extract the oil. **(Dirty Case 2)**

Figure 11: Palm Pounding & Oil extraction in South West Nigeria: (left) Ebun Akintola Village –Oni Gambari, Ibadan Oyo State, & (right) Eredo village, Ogun State.

22 Arbor Day Foundaiton: Tree Fact (accessed on May 25, 2023) https://www.arborday.org/trees/treefacts/
23 WHO (07 April 2022): Women using firewood face increasing health risks. https://www.afro.who.int/countries/nigeria/news/women-using-firewood-face-increasing-health-risks
24 WHO (07 April 2022): Women using firewood face increasing health risks. https://www.afro.who.int/countries/nigeria/news/women-using-firewood-face-increasing-health-risks

In most parts of the southeastern part of Nigeria and some western villages where hydraulic press and crushing machines exist, the sterilized palm fruits are pressed using diesel-powered machines with an average of 6.5 HP (4.8kW/4800 watts). On a daily average, these diesel-powered palm oil milling machines require at least 100 litres (26 gallons) to operate a week. A litre of diesel costs an average of NGN 800/litre, which is an estimated cost of NGN84,200 (120 USD) weekly (that is NGN 336,800 a month, NGN 4,041,600 a year, and approximately NGN 20million/$ 25,509USD in five years).

A 7kVA (9.38 HP) stand-alone solar system costs between NGN 4.7 million and NGN 6 million with a minimum of 3 years warranty on the backup lead battery storage system, and 15 years on solar panels. Where a solar mini-grid exists, cost-reflective tariffs are typically near N200/kWh (US$0.57/kWh), which is still less expensive than the cost of running a diesel-powered generator machine. Modular palm oil processing machines can also be fabricated locally that are powered electronically to use either grid electricity or solar PV.

Nearly 20 pounds of carbon dioxide are produced from burning one gallon of gasoline. That is 520 pounds of carbon dioxide. **(Dirty Case 3)**


12. **Oil Clarification:** in the traditional southwestern method, the milled palm kernel fruit is poured into the pit, where lots of water is added and stirred vigorously, until the oil and water separate naturally. Oil is skimmed at the top of the pit using buckets and transferred to containers. Over 200 litres of water is used to extract less than 25 litres of oil. The extracted oil is collected in containers such as buckets or pots. To clarify the oil and remove impurities, it is typically left to settle for some time. The lighter oil floats to the top, while solids and water settle at the bottom; after which is boiling. **(Dirty Case 4)**




Photo from: Traditional method of palm oil clarification in South-Western Nigeria – photo from Ebun Akintola Village –Oni Gambari, Ibadan Oyo State

13. **Boiling for Oil Separation, Purification and Skimming:** In the south-eastern part of Nigeria, unlike the western part where foot pressing is not a cultural process, the milled palm kernel fruit is poured into drums or pots for boiling and lots of water is added to separate the oil from the water. Like the Western part, a lot of fire food is consumed in this process of palm oil purification. With boiling for over 2 hours. **(Dirty Case 5)**

Photo : Traditional method of palm oil clarification in South-Western Nigeria – photo from Ebun Akintola Village –Oni Gambari, Ibadan Oyo State

Like the sterilization stage, boiling for oil separation takes even longer time and more wood. On average, the boiling is done for a minimum of 2 hours in open firewood; using approximately 150 pounds = 68kg ≅ 0.08 tons of wood. A heap (20kg) of firewood sells for a minimum of NGN2,000 (USD 2.65) in Nigeria. That is an average of NGN6,800 (USD 9.10) for boiling for oil separation a week.

In total, at least 260 pounds of firewood (approximately 5 trees at the cost of NGN 11,800) is burnt a week in the production of a maximum of 50 litres of oil palm a week. The average price of 25 litres of palm oil sells for an average of NGN18,500 across the country to middlemen (so 50 litres average of NGN 37,000) depending on the season and location. The cost of N11,800 a week for firewood excludes the cost along the other value chain i.e. labour (from harvesting the fruits to handling), a service fee for the machine press, rent of farmland (most of the women don't own the land/trees in the farm season) and socioeconomic and environmental cost. After an estimate of all other costs,

an average farmer will be incurring a minimum cost of NGN20,000 on the assumption that she will be covering a lot of unpaid labour.

14. **Oil Filtering:** Once the oil has separated from the impurities, it is carefully skimmed off the top using a ladle or other utensils. This helps to separate the clarified oil from any remaining solids or water. To further remove any remaining impurities, the clarified oil may be filtered through a cloth or sieve. This step helps to achieve a cleaner and purer final product.

15. **Storage:** The filtered palm oil is usually stored in containers, such as jerry cans, bottles, jugs, or calabashes, for domestic use or local sales. Proper storage is important to protect the oil from light, heat, and moisture. However, there are no advanced storage methods for palm oil to ensure proper temperature control and increase the shelf life of the new refined oil. The best temperature for storing palm oil is between 20 and 25 degrees Celsius. High temperature as it is common in Nigeria causes the oil to spoil and become rancid. While low temperatures can cause the oil to solidify or form crystals. **(Dirty Case 6)**

16. **Use of by-products and sludge:** palm kernel nuts after the peeling and oil extraction have been done are hand-picked, washed, sun-dried and broken manually using stones, or using a kernel-breaking machine powered by diesel. The use of machines for kernel breaking is not common in Nigeria. The kernels can be pressed for oil extraction using pressing machines that are also diesel-powered. Very few palm oil-making companies are into kernel oil making or breaking. They either dispose of the kernels as waste around the communities or palm oil process cluster areas or hopefully get companies or middlemen interested in the off-take. This is often rare. Along the entire value chain, from pressing to purification and filtering, a vast amount of pail oil effluence is produced and still on the ground and surface water, causing massive pollution. Nigeria's palm oil production industry alone generated over 90 million tonnes of effluent (liquid waste) annually. **(Dirty Case 7)**

In summary, manual and traditional palm oil processing vary slightly across different regions or communities in Nigeria, but the general principles of manual extraction, pounding, and clarification are commonly followed. Identified dirty cases in the palm oil process value chain include:

Clean technology option for palm oil processing: Introduction of efficient palm oil processing mills with improved extraction methods. The machines can be powered by electricity solar PVs or biomass from waste produced. Palm fruit sterilization and boiling for separation and oil extracting can be done using biomass or biogas-powered boilers; as well as efficient clean cooking stoves that require little wood, or better still use the waste by-products such as the kernel shelves, dried waste shaft to fire as biogas feeds to make clean regulated fire.

Socio-economic gains of the clean technology options in the palm oil processing value chain: Reduced environmental pollution, improved oil extraction efficiency, reduced energy costs, and increased income for smallholder women farmers and young agroprenuers. These technologies are already fabricated in Nigeria and will be shared in the alternative clean section of the study.

Cases of Dirty Processing in the Cassava Value Chain:

Cassava (Manihot esculenta) a popular crop of roots and tubers, is a perennial crop that grows in tropical and subtropical areas of the world. With 59,490,000 tons (of cassava produced in 2019[25], Nigeria is considered to be the world's top cassava producer. However, Thailand is the world's largest exporter of dried cassava. Cassava is mostly grown in the states of Imo, Anambra, Kogi, Cross River, Enugu, Ogun, Ondo, Taraba, Benue, Delta, and Edo. It is also grown in smaller numbers in other regions of Nigeria.

Cassava can be converted into starch, which can then be mixed with other components to create textiles and paper. If the quality of the cassava flour is high enough, it can also be processed into flour and combined with pricey foreign flour to make cakes, bread, and biscuits. Additionally, it can be made into chips and utilized as animal feed. When mixed with additives, cassava-derived ethanol can be used as biofuel. Cassava can be processed to make ethanol. Fructose may be produced from cassava, and this fructose is used in the beverage sector to sweeten carbonated beverages. Garri and fufu can be made from cassava.[26]

Cassava processing generates large volumes of solid and liquid wastes. Wastes generated from cassava production and processing include the leaves, stems, peels, wastewater and starch bagasse. In Nigeria, these generated wastes are usually disposed of indiscriminately into water bodies, undeveloped plots of land and any available open spaces along major roads and streets by farmers despite the negative impact of these wastes on both the environment and general health of the people.

[25] Rob Cook (Jun 28, 2023): Ranking Of Countries That Produce The Most Cassava (FAO). Beef2Live.com (accessed 28.6.2023) https://beef2live.com/story-ranking-countries-produce-cassava-fao-352-215805

[26] Finelib (Accessed 08.06.2023): Cassava Production In Nigeria And The Main Producing States. https://www.finelib.com/about/nigeria-cash-crops/cassava-production-in-nigeria-and-the-main-producing-states/76

Dirty process: Manual or rudimentary processing methods, such as manual peeling and pressing, open sun drying, and open fire frying, feature huge amounts of waste such as open discharge of effluent from pressed cassava and landfill dumping of cassava peels. These all lead to low-quality cassava products, high post-harvest losses, massive environmental pollution, etc. Cassava grinding in Nigeria depends on the use of heavy diesel-powered machines.

The manual or traditional cassava processing in Nigeria typically involves several steps. We will highlight the dirty business cases in the value chain as practices in various parts of the sample:

1. **Harvesting:** Cassava plants are harvested by cutting the stems close to the ground. The tubers (root crops) are then dug out of the ground using tools such as machetes or hoes. Some clean technology options can be applied in the harvesting stage, such as; implementing efficient harvesting techniques and tools, such as improved machetes or mechanical cassava harvesters, to minimize crop damage and increase productivity. Promoting sustainable agricultural practices, such as intercropping or crop rotation, to enhance soil health and reduce the need for chemical inputs. However, at this stage, we cannot boldly label this phase as dirty.

2. **Cassava Cleaning and Peeling:** Over 70% of cassava processing in Nigeria is done by women. The first stages of cassava processing – the harvesting and peeling in Nigeria is mostly done by women. The process of peeing in most parts of the country is done manually using kitchen knives. This is time-wasting, very labour-intensive, and also results in waste of cassava parts. According to the FAO, Nigeria discards more than 10 metric tons of cassava peels from the 59.5 metric tons of annual cassava production without regard to the environment[27]. The majority (91%) of the cassava peels in Nigeria are abandoned close to the processing site, while some are used for landfilling or burning. The open dumping of cassava peels and/or burning emits CO2, methane, aflatoxins, and offensive odour **(Dirty Case 8).** Some studies have shown that in some art of the country, cassava residues are sometimes used for animal feeds. Other findings show that the peels, when dried, can be used as biofuel for heating and cooking, as the dried peels have significant potential for biogas production[28].

[27] Kigho Moses Oghenejoboh, et al. “Value Added Cassava Waste Management and Environmental Sustainability in Nigeria: A Review.” Environmental Challenges, vol. 4, 2021, p. 100127, www.sciencedirect.com/science/article/pii/S2667010021001062, https://doi.org/10.1016/j.envc.2021.100127.

[28] Olukanni, David O., and Tope O. Olatunji. 2018. "Cassava Waste Management and Biogas Generation Potential in Selected Local Government Areas in Ogun State, Nigeria" Recycling 3, no. 4: 58. https://doi.org/10.3390/recycling3040058


Timi-dare Garri Processing Cluster in Ajegunle, Oyo East LAG, Oyo State and the cassava waste dump site.

3. **Cassava Grating or Grinding Business:** The cleaned cassava tubers are grated or ground into a pulp. Traditionally, a manual grater or grinding stone is used for this purpose. In most recent times, cassava grinding and pressing are mostly done by diesel-powered machines. The grated or ground cassava is collected in a container or woven sacks. For pressing. The process of grinding and pressing generates a lot of cassava effluence disposed of in the environment as well as CO2 emissions from the machines. **(Dirty Case 9)**

Temidire cassava processing cluster, Ajegunle Oyo East LGA, Oyo State

4. **Pressing and Fermentation:** The grated cassava pulp is placed in a porous bag or sack and pressed to remove excess liquid. This can be done by hand or using a simple press, such as a wooden lever press or a manual screw press machine. This is very labour-intensive. The liquid extracted during pressing is often referred to as "cassava water" or "cassava juice" and may be used for other purposes, but most often discarded

in the environment – polluting water and soil surface. The pressed cassava pulp is transferred to fermentation containers or pits. Fermentation is a crucial step that helps reduce the cyanide content and improve the flavour and texture of the cassava. The fermentation period can range from a few days to several weeks, depending on the desired outcome. **(Dirty Case 10)**

Temidire cassava pressing cluster, Ajegunle Oyo East LGA, Oyo State

5. **Cassava Drying:** After fermentation, the cassava pulp is spread out to dry. Traditionally, this is done by spreading it on mats or trays under the sun, allowing it to dry naturally. It can also be dried using firewood-fueled ovens or traditional smoking methods. **(Dirty Case 11)**

6. **Cassava Grinding and Frying:** The dried fermented cassava is milled or ground into a fine or semi-fine powder. This is mostly done using a mortar and pestle, a diesel-powered grinding machine. The resulting powder is commonly known as cassava flour or garri. The ground garri is then fried in an open fire, using lots of firewood. In most likely cases, the garri is over-fried as the open fire is hard to unregulate **(Dirty Case 12)**

Figure 1: Temidire Garri processing cluster in Ajegunle Oyo East LGA, Oyo State. Over 100 workers mostly women. 66 working clusters. Processing 130,000ton of cassava a year.

7. **Sieving and Packaging:** The milled cassava flour is sieved to remove any coarse particles or lumps, ensuring a uniform texture. The flour is then packaged in bags, sacks, or other suitable containers for storage or sale.

Clean technology option: It's important to note that the traditional cassava processing methods may vary in different regions of Nigeria, and there may be slight variations in the steps or tools used. Additionally, modern processing techniques and machinery are also being adopted to improve efficiency and productivity in cassava processing most of these are fossil fuel-powered. Solar dryers or mechanized cassava processing machines that ensure efficient drying and processing can be introduced to the cassava business value chain to make them cleaner. The introduction of mechanized cassava processing machines such as cassava peelers, graters, and hydraulic pressers, powered by renewable energy sources should also be encouraged.

Socio-economic gains: Increased processing efficiency, reduced labour requirements, improved product quality, decreased post-harvest losses, and enhanced income for smallholder women farmers and young agro-processors. The use of renewable energy can also lead to reduced energy costs.

Cases of Dirty Processes in Shea Butter Business:

Shea Butter popularly known as 'Ori' in the Yoruba language of Nigeria is a vegetable fat derived from the nuts or seeds of the African Shea tree. The Shea tree is quite common and grows naturally in the West African Savannah and other parts of Africa. Nigeria is one of the top producers of shea butter in the world, with an estimated annual production of 350,000 tons. It is produced primarily in Kwara and Niger states; other states include Kogi, Kebbi, Oyo, Benue, Kaduna and Ogun states.

Shea butter, also known as karite butter, has been used for centuries as a skin and hair moisturizer, cooking oil, and medicinal product. According to the Global Shea Alliance, Africa produces 600,000-900,000 metric tonnes of shea nuts annually, with 16 African countries including Nigeria, Burkina Faso, Mali, and Ghana, among the largest producers. The global shea butter market size was valued at $1.39 billion in 2020 and is projected to reach $2.74 billion by 2028, growing at a CAGR of 9.0% from 2021 to 2028. Shea butter is highly sought after in the global market, especially in Europe, North America, and Asia, for its use in cosmetics, skincare, and hair care products.

Shea butter production is predominantly a women-led business in Nigeria and Africa, providing income and economic empowerment to rural women. Traditional extraction methods involve manual pounding and boiling, leading to low yields and high energy consumption.

Dirty processes: Shea butter production is a labour-intensive process that involves collecting, cracking, roasting, grinding, and pressing the nuts to extract the oil. Processing of shea butter is a way of life for many women in Northern Nigeria in particular. While many of these women still use the traditional shea butter processing method they learnt from their elders years ago, others think the method involves lengthy, arduous processes requiring large quantities of fuel wood and water which are often carried from long distances. The traditional process of shae butter making requires large manpower demand, water and fuel wood and has detrimental environmental effects.

1. **Shea butter sterilization (boiling):** After harvesting and washing, the outer skins are removed through a parboiling process with open firewood and lots of water usage. Afterwards, the nuts are roasted outside, over an open flame before going into the girding state A lot of wood and water usage is done in these traditional methods. In total at least a truck of firewood (500 pounds or 226.8kg) is used in 2 days at the cost of N50,000 a truck. If an average tree weighs 50kg, this implies that approximately 5 trees have fallen in two days; to produce at least 100 pounds (45kg) of shea butter in two days. In the local market, 1kg of shea butter costs N5,000; that is N225,000 for 45kg/100 pounds. **(Dirty Case 13)**

Women at a shea butter cluster in Kolonji village parboiling fresh nuts to remove the outer skins. Source BusinessDay Newspaper 2023.

Photo from Aaaie community in Niger State community where Shea Butter is processed. Source – Happy Amos (2 July 2023)

2. **Shea butter milling:** after boiling and frying using open firewood, the nuts are then taken in for grinding, through a diesel-powered milling processing machine that squeezes the oil from the shea residues. A diesel lister engine serves as the source of power for motorised mechanical milling. The lister engine for milling is the costliest item of equipment used. The price per kg of shea butter at the processing centre is about N500.00 while the corresponding market price was ₦ 1000.00. In the absence of a milling machine, the use of traditional grinding stones and mortar is employed by the women. The produced paste from the pressed nut is usually a dark-brownish paste, which is then kneaded by hand for up to two hours to get the preferred quality of Shea butter. This is very labour-intensive for women and has a low-quality yield. **(Dirty Case 14)**

Photo from Aaaie community in Niger State community; shea butter grinding machine powered by 6 horsepower lister engine type machine. Source – Happy Amos (2 July 2023)

Photo from Aaaie community women in Niger State heating and kneading shea butter. Source – Happy Amos (2 July 2023)

Clean technology option: The concerns about the high labour requirement in the traditional method of shea butter production and the use of large amounts of water and fuel wood have led to the evolution of a second method of production at the village level in some areas.

This method is semi-mechanized with a nut crusher, an improved roaster, a kneader or a hydraulic screw press introduced to reduce the drudgery associated with the traditional manual process of shea butter production. The semi-mechanized method of shea butter processing makes good use of a crusher taking the place of the mortar and pestle in breaking the kernel into tiny units for roasting. The semi-mechanized method of shea butter processing has also introduced an improved technology for roasting the kernel after it has been broken into tiny pieces.

The improved roaster retains the heat in the compartment to roast the kernel at a reduced time, energy use (both fuel wood and human effort) and the processor exposure to the heat generated by the fire. To further reduce time, energy and human effort, the semi-mechanized method of processing has introduced another technology called a kneader to convert the milled kernel into an emulsion ready for cooking or heating. This technology has replaced the use of the hand in kneading.

The introduction of mechanized shea butter processing machines or oil expellers powered by renewable energy sources and the use of efficient gook stoves and ovens for boiling as well as biomass for boiling are being considered to improve the process of shea butter.

According to Happy Amos, CEO of Roshan Renewable Energy – "it's not enough to have these novel solutions designed to ease the lives of women i.e. shea butter making process in Minna Nigeria State. Many solutions are not designed according to the specifications and needs of the women; as they may be novel renewable energy projects but not sustainable. For instance, a UNwomen and Stanbic Bank project, in collaboration with the Niger State government to improve the shea butter value chain in Minna, was a big failure. Why? A large processing shea butter plant powered by LGP Gas was installed for community women in the state in 2021, less than 6 months after the gas cylinder finished, the plant was abandoned as the women could not source LPG". The alternative technology solution needs to the practical, and sustainable, achieve efficiency sufficiently before a total switch, and ensure the solution is affordable and easily managed and handled by the women, without external technical aid.

Socio-economic gains: Increased shea butter yields, reduced energy consumption, improved product quality, and enhanced income for smallholder women farmers and young agro-processors.

Cases of Dirty Process in the Rice Milling Business:

80% of rice produced in Nigeria is milled by local processors that predominantly rely on inefficient and expensive diesel-powered mills that give low-quality output. Nigeria generates 4.34 million tonnes of rice straw and appropriately 1.1 million metric tonnes of rice husk annually[29]. These generate millions of tonnes of carbon dioxide into the atmosphere from burning and open-air dumping. These volumes of rice husk waste can generate around 337.67 megawatts per year of electricity at a conversion rate of 1.7 kilogrammes of rice husk/straw/ kilowatt of electricity.

An assessment of the status of the use of mechanization in both farm and post-harvest operations in the rice system in Nigeria reveals a plethora of challenges that range from purely technical, to operational and policy-related issues, resulting in a very low percentage of farmers who have access or can afford the use of mechanical equipment in the rice production systems in Nigeria. Over several decades, successive national and state governments have tried to change the narrative by the uncoordinated importation of agricultural equipment to improve mechanization, decrease drudgery and increase efficiency in farm and post-farm operations. Reasons for failures of such initiatives could be due to the following reasons: complete absence or inadequate maintenance culture, poor local adaptation plans, misapplication of machinery, poor business models, and a business environment to make the mechanical equipment function sustainably. The production of machines, the growth in population, and market growth for agricultural machinery have remained low (less than 10%) in sub-Sahara Africa, including Nigeria due to similar factors.

[29] Businessamlive (October 31, 2022): Nigeria's agro-waste challenge offers wealth potential https://www.businessamlive.com/nigerias-agro-waste-challenge-offers-wealth-potential/

Dirty Processes and case studies in the rice value chain:

1. **Manual Rice Threshing:** After harvesting, the rice paddy is spread out on a flat surface or mat, and farmers use traditional methods like tossing or beating the paddy to separate the rice grains from the chaff. Apart from being very labour-intensive, this process generates a large amount of by-products such as rice husk, bran, and straw. In many cases, these byproducts are not properly managed as they are disposed of in open lands either burned or left to decay. These contribute to major environmental pollution in the area; releasing harmful pollutants into the air, contributing to air pollution and greenhouse gas emissions. **(Dirty Case 15)**

Rice threshing and rice husk mounds at Abakiliki Rice Mill Cluster in Ebonyi State. Photo Source. Mr Akachukwu Okafor (20.6.2023)

2. **Rice Parboiling:** Parboiling is a common traditional method used in rice processing in Nigeria. In this process, the harvested paddy is soaked in water and then boiled for at least 30 minutes. Parboiling helps loosen the husk, making it easier to remove during milling. These traditional rice processing methods rely on inefficient energy sources, such as the burning of wood or other biomass for fuel. This not only leads to deforestation but also contributes to air pollution and carbon emissions. This largely contributes to the environmental burden and can impact air quality in the area. A vast amount of water is also wasted in the traditional parboiling process. **(Dirty Case 16)**

Traditional Rice parboiling and drying in Kaduna State. Photo Source D.A.R.E (28.6.2023)

3. **Rice Drying using open sun:** After parboiling, the rice is spread out on clean mats or flat surfaces to dry under the sun. This traditional method of drying helps reduce moisture content in the grains and prepare them for milling. However, sun drying may be susceptible to contamination if proper hygiene measures are not followed. **(Dirty Case 17)**

Traditional Open Sun Drying of Rice in Kaduna State. Photo Source D.A.R.E (28.6.2023)

4. **Manual Milling:** In traditional rice processing, milling is often done manually using a mortar and pestle or grinding stone. The rice grains are pounded or ground to remove the husk and obtain edible rice. This process requires significant physical effort and is time-consuming compared to modern milling technologies. This is mainly done by women in the communities. Inefficient milling processes can result in the production of broken grains and rice dust. Besides, the by-products can contribute to environmental pollution if not managed properly. Dust control measures, such as using proper ventilation systems and dust collectors, should be implemented to minimize the release of rice dust into the air. **(Dirty Case 18)**

Clean technology option: Solar-powered rice threshers, mechanical rice milling machines powered by renewable energy, or mini rice mills can be employed.

Socio-economic gains: Increased processing efficiency, reduced labour requirements, improved product quality, decreased post-harvest losses, and enhanced income for smallholder women farmers and young agro-processors. The use of renewable energy can contribute to cost savings and environmental sustainability.

Cases of Dirty Processes in Maize Processing:

One of the crops that is most frequently cultivated worldwide is maize. Nigeria, after South Africa, is likely Africa's second-largest maize producer with a total production of 11 MMT. Nearly two-thirds (64%) of the maize produced in Nigeria is produced in the top 10 states (Borno, Niger, Plateau, Katsina, Gombe, Bauchi, Kogi, Kaduna, Oyo, and Taraba). Nearly 98% of all animal feeds produced in Nigeria are utilized by poultry farmers, and about 45.5% of the maize grown in

Nigeria is used to make animal feeds (such as chicken feeds)[30]. 60 to 65 per cent of the ingredients in poultry feed are made of maize. Meanwhile, Nigerian brewing companies consume 6.5% of the country's maize crop, while 13% is used to make industrial flour, cornflakes, and other confections. However, 10-15% of household consumption is made up of maize.

Maize production in Nigeria amounted to 12.75 million metric tons in 2021[31]. This slightly increased from the previous year, when the volume reached 12.4 million metric tons, the highest within the observed period. The quantity of maize produced in the country has generally increased since 2010. This is low compared to South Africa's yield of 15 million metric tons. According to the International Institute of Agriculture (IITA), the challenge of poor yield which leads to reduced maize output is exacerbated by post-harvest losses which are estimated to be about 20–30% of total maize production[32].

Dirty process: Manual or traditional methods of maize shelling and milling, resulting in low yields, high energy consumption, and post-harvest losses.

1. **Maize Threshing/Shelling and Winnowing:** In most parts of Nigeria, Maize kernels are typically manually separated from the cobs using traditional methods like rubbing or hitting the cobs against hard surfaces. This process can be inefficient and result in a significant amount of corn waste, including broken kernels and cobs. After shelling, winnowing is done by tossing the maize kernels in the air to separate them from the lighter chaff or husk. These traditional maize processing methods generate significant amounts of waste, including corn cobs, broken kernels, and husk or chaff. Improper disposal of this waste can contribute to environmental pollution and take up valuable landfill space. The processes of shelling and winnowing maize can release dust and airborne particles into the environment. Prolonged exposure to these particles can be harmful to human health and contribute to air pollution. These methods are labour-intensive, time-wasting, and cause physical hurt **(Dirty Case 19)**

[30] PWC (2021): Positioning Nigeria as Africa's leader in maize production for AfCFTA. https://www.pwc.com/ng/en/assets/pdf/positioning-nigeria-as-africa-leader-in-maize-production-for-afcfta.pdf

[31] Statista Data (2023): Production volume of Maize in Nigeria. https://www.statista.com/statistics/1300743/production-volume-of-maize-in-nigeria/

[32] PWC (2021): Positioning Nigeria as Africa's leader in maize production for AfCFTA. https://www.pwc.com/ng/en/assets/pdf/positioning-nigeria-as-africa-leader-in-maize-production-for-afcfta.pdf

2. **Maize Milling or Grinding:** Traditional maize processing involves manually grinding the maize kernels into flour or meal using grinding stones or manual mills. In most recent times, the use of a lister-type diesel-powered engine is mostly employed for Maize milling at service cost between N500 –N1000 per kg. This process requires physical effort and can result in inconsistent grinding, low production efficiency, and potential contamination if the grinding equipment is not properly cleaned. This inefficient use of energy contributes to increased greenhouse gas emissions and environmental degradation. **(Dirty Case 20)**

Diesel-powered flour milling machines in Niger State. Photo source. RMI (2023)

3. **Maize Boiling/Boiled Corn:** Traditional maize boiling in Nigeria involves cooking maize kernels (with or without cob) in water until they become soft and edible. While this process is a common cooking method, there are some environmental issues associated with it. Traditional maize boiling typically relies on the use of open firewood or charcoal as fuel for cooking.

   The unsustainable collection of firewood for the boiling of crops like maize, groundnut, etc. contributes to deforestation and habitat destruction, leading to the loss of biodiversity and disruption of ecosystems. Additionally, the burning of firewood and charcoal releases carbon dioxide and other pollutants into the atmosphere, contributing to air pollution and climate change. Maize boiling is often done indoors or close to residential homes, particularly in rural areas, without proper ventilation causing indoor air pollution. Prolonged exposure to indoor air pollution can have severe health impacts, especially on women and children who spend significant time near the cooking area. Boiling maize requires a significant amount of water. In regions where water resources are scarce, excessive water usage for cooking maize can strain local water supplies, leading to water scarcity. The continuous use of firewood for this process is not economically sustainable as firewood becomes more scarce. **(Dirty Case 21)**

Photo of Corn Boiling process using a vast amount of wood in Shishipe Abuja 19.06.2023

Clean technology option: introduce small-scale modular solar-powered maize shellers and mills, or electric-powered mini-machines utilizing renewable energy sources. The use of efficient stoves, and biomass boilers can significantly reduce the amount of trees fallen for firewood. An efficient biomass boiler can utilize agricultural waste like corn cobs and shafts to create controlled fire for boiling and drying maize and other crops.

Socio-economic gains: Increased processing efficiency, reduced energy costs, decreased post-harvest losses, improved product quality, and better livelihoods for smallholder women farmers and young agro-processors.

Cases of Dirty Processes in Fruits, Grains and Vegetables Management

Perishable food especially fresh fruits and vegetables start to deteriorate as soon as they are harvested because they are cut off from their source of water and nutrition. They lose weight, texture, flavour, nutritional value and appeal. Cooling significantly slows down the rate of deterioration, thereby increasing the storage life of the produce, if available.

Non-existent cold chains in most parts of Nigeria: The nutritious value of fresh agricultural vegetables and proteins begins to decline practically immediately after harvest. According to ColdHub, an average fruit farmer and vegetable seller loses an average of NGN300,000.00 (USD 429) worth of fruits and vegetables monthly. According to estimates, ineffective or non-existent cold chains cause 37% of Nigeria's agricultural products that need refrigeration to be lost. In Nigeria, 470 million small farmers lose 25% of their annual income owing to food spoiling caused by a shortage of cold storage. The annual loss of tomatoes in Nigeria is between 45 – 60 per cent of the total production, while 50 per cent of onions and 20-30 per cent of chilli pepper are lost at different parts of the chain. More than often, their fruits are disposed of in market dumpsites, uncompleted buildings and farm corners; allowed to rut in open spaces, with the effluent that pollutes soil and water surface with offensive odours polluting the atmosphere **(Dirty Case 22)**

Mostly available in urban markets are fish and chicken cold rooms, that burn an average of 20-30 litres of diesel to power traditional cold rooms per day; spending at least $32/NGN22,400.00 a day. That is $11,680/NGN 8,176,000 a year.

Dirty process: Traditional or manual methods of preserving vegetables like tomatoes and peppers in most of Nigeria include sun drying, and smoking/per-boiling the paste. While these methods specifically open sun drying have been practised for generations, they come with certain health and environmental effects.

Seeds and grains are also stored traditionally using granaries mostly made from mud, wood or bamboo that are elevated off the ground to protect stored seeds and cereals from pests, rodents, and moisture. The traditional granaries are mostly elevated from the floors to keep the grains dry and well-ventilated. Earthen pits are also used in very few parts to store grains. Earth pits are dug in the ground and lined with materials like clay, leaves, or straw to create storage spaces. Grains are stored in these pits and covered with layers of protective materials to prevent moisture, pests, and rodents from reaching the stored produce.

Traditional storage methods may not provide full proof protection against pests, rodents, and insects, leading to post-harvest losses and quality deterioration. Because these traditional storages cannot temperature fluctuation, this method most often does not offer adequate protection against moisture and humidity, which contribute to mould growth, spoilage, and loss of nutritional value in stored seeds and cereals. Traditional storage methods are often suitable for small-scale storage but may not be efficient for larger quantities of produce or commercial purposes.

Photo: Traditional Grainary in Shishipe Village, Mpape Abuja. A Typical model used in the north and north central Nigeria.

1. **Sun Drying of Vegetables (pepper, tomatoes, etc.):** Sun drying involves spreading sliced or whole vegetables in the open air to dry under the sun. While this method is effective in reducing moisture content and extending the shelf life of the vegetables, there are some health and environmental concerns. Sun drying is often done on the ground or on mats, which may not provide adequate protection against contamination from dirt, dust, insects, and animals. Additionally, exposure to open air increases the risk of microbial contamination and mould growth, which can impact the safety and quality of the preserved vegetables. **(Dirty Case 23)**


Photo of fruit and vegetable waste in Mile 12 Market in Lagos in June 2023. Source Daniel Plalfer and Samson Adeleke in Lagos 2023.



Photo top left by D.A.R.E Kaduna 2023, and Top Right photo of sun drying for tomatoes in Kokami village in Katsina State. photo by Umar DW 2019.

Clean technology option: deploy solar-powered fruit drying facilities, efficient tomato processing machines, and solar-powered cold storage units, either as a community-owned project or pay-as-you-go. The deployment of biomass dryers can also help with the drying of fruits, vegetables and chips from yam, cassava, plantain, etc.

Socio-economic gains: Reduced post-harvest losses, improved product quality, increased market value, and enhanced income for smallholder women farmers and young agro-processors.

Cases of Dirty Processes in Bakery

Traditional mud bakeries are commonly found in most of northern and western Nigeria. In the eastern part of Nigeria are mostly done with very few locally fabricated metal ovens powered by either firewood, coal or gas. While the formers come with a heavy economic cost for fuelling and relatively lesser use of firewood, the former – traditional mud bakeries while accommodating more volumes, are more open to hygiene threats and pose more threats to the environment.

Dirty process: Traditional mud bakeries often rely on inefficient energy sources, such as burning firewood or charcoal, for baking. These practices contribute to deforestation, air pollution, and greenhouse gas emissions. Inefficient energy use also impacts the economic sustainability of the bakery by increasing fuel costs. For instance in Jigawa state, Creed Energy's CEO Hanna Kabir reported that over 300 trees are cut down daily to provide fuel for ovens where bread is baked. This is equivalent to 108,000 trees every year. 1 tree is fired per bakery per day to bake bread in Jigawa state, like most parts of the country where traditional bakeries are used. **(Dirty Case 24)**

Over 500kg of firewood – the equivalent of a fully grown tree is used a day to power the traditional bakery oven for the day's production.

Clean technology option: With more efficient bakery ovens, this loss could be reduced by 80 per cent, and the bakers would save money on their firewood as well. Promoting the use of efficient energy sources like improved oven cookstoves or renewable energy-powered bakery ovens can reduce the environmental impact of traditional mud bakeries and improve energy efficiency.

Socio-economic gains: Efficient ovens enable faster baking times, higher production capacities, and consistent baking results. Efficient oven technologies, such as electric and gas ovens, are designed to optimize energy usage. They have better insulation, temperature control, and heating efficiency, resulting in reduced energy consumption and lower operating costs. Efficient oven bakeries contribute to environmental sustainability by reducing greenhouse gas emissions, minimizing fuel consumption, and mitigating the ecological impact associated with traditional mud ovens or inefficient energy sources.

Cases of Dirty Processes in Domestic Cooking and Meat/Fish Smoking Business

According to Nigeria's Energy Transition Plan (ETP), cooking accounts for 91% of total domestic energy consumption and wood is the most widely utilized cooking fuel, with 175 million Nigerians estimated to be vulnerable to illness and deaths from exposure to cooking smoke. 40MtCO2 emitted in 2020 mainly from cooking with traditional fuels such as firewood, charcoal and kerosene. **(Dirty Case 25)**

Smoke inhaled while cooking with firewood causes 93,000 deaths per year in Nigeria, with women and children being the most vulnerable. This indicates that if any other technique of cooking is not introduced at a cost-effective rate, at least 450,000 Nigerian women will die from cooking with firewood or charcoal in 5 years.

Photo: Smoke Fish Business in Dukpa village, a community at Gwagwalada Area Council in the Federal Capital Territory (FCT)

According to the United Nations, Nigeria has the highest deforestation rate in the world, with an estimated 3.7% of its forest lost every year. The Global Forest Watch dashboard[33] shows that in 2010, Nigeria had 10.9Mha of natural forest, extending over 12% of its land area. In 2022, it lost 105kha of natural forest, equivalent to 69.7Mt of CO_2 emissions. From 2002 to 2022, Nigeria lost 166kha of humid primary forest, making up 14% of its total tree cover loss in the same period. The total area of humid primary forest in Nigeria decreased by 8.7% in this period. From 2001 to 2022, Nigeria lost 1.25Mha of tree cover, equivalent to a 12% decrease in tree cover since 2000, and 671Mt of CO_2 emissions.

Clean technology option: The key decarbonization strategy suggested by the ETP (2023 – 2060) is a move from traditional firewood, charcoal and kerosene to Liquefied Petroleum Gas (LPG) (until 2030), electric stoves, and biogas (particularly in rural areas). According to the transition plan, LPG will play a significant role up to 2030 due to the urgency of the achievement of universal access to clean cooking (SDG7). However, the economics of LPG gas for cooking in far remote rural villages in Nigeria is not financially and economically viable, as investment and supply of LPG gas by private gas distributors is dependent on the volume of market demand and product availability which in many rural locations of Nigeria is not available and unsustainable. Government public initiatives to drive LPG cooking gas in sub-urban areas and villages have not been sustainable or successful.

With more efficient clean stoves, grills and ovens fewer fire-woods and waste by-products can be used as an intermediate solution to curbing the aggressive use of fire-wood and deforestation. Promoting the use of wood-efficient clean stoves like improved clean cookstoves can significantly reduce the use of firewood and reduce the energy transition shock in new technologies.

Socio-economic gains: Clean cookstoves promote fuel efficiency and cost savings resulting in reduced household expenses, and freeing up resources for other essential needs. Time savings in cooking contribute to increased productivity and opportunities for education, income generation, and quality family time. Furthermore, the use of clean efficient stoves helps protect natural resources, such as forests, by reducing the demand for fuelwood and mitigating environmental degradation. Overall, clean efficient stoves contribute to improved livelihoods, economic resilience, and sustainable development.

Cases of Dirty Processes in Generators for SMEs and Homes

More than 20 million small fuel generators run daily in Nigeria alone to overcome power scarcity. This is because grid availability is low. According to the World Bank, in an average month, a business owner will not have power for 239 hours (out of 720 hours) in a month. A2EI suggest that grid outages are even more frequent. Findings show that the needed energy load of most businesses (lights, fans, recharging mobile phones, TVs etc.) are relatively low (with an average of 230W power needed per business), compared to the energy supply used by most of the generator used. Generators running at less than 20% of their maximum load will lead to a potential drop in the cost for a substituting solar generator of already 40% of fossil generators in use. In a scenario where some result-based finance, carbon credits and other consumer financing and subsidies are applied, more SHS can be adopted by small businesses and rural productive businesses and homes.

[33] Global Forest Watch (July 2023): Dash Board for Nigeria. https://www.globalforestwatch.org/dashboards/country/NGA/

Dirty Cases: On average, customers are spending over 47 USD per month, just for fuelling generators. The use of these generators has a significant negative impact on the environment, public health, and business costs. **(Dirty Case 26)**

Clean technology option: a solar system providing as little as 350W would already replace more than 75% of generators in Nigeria. With 700W, the percentage augments up to 94% of generators used. In a scenario with more efficient appliances saving 25% of power, these percentages are increased.

Socio-economic gains: Using small standalone solar systems to replace small fossil generators in Nigeria brings significant socio-economic gains. It leads to cost savings by eliminating the need for expensive fossil fuels, improves access to electricity in underserved areas, enhances productivity for small businesses, promotes health and safety by eliminating harmful emissions, contributes to environmental sustainability by reducing greenhouse gas emissions, and creates job opportunities and supports the local economy. This transition empowers communities with clean and reliable energy, fostering economic development and improving the overall quality of life.

The next section presents detailed cases of clean alternative technologies executed or proposed by renewable energy providers who are engaging and rethinking the deployment of renewable energy solutions to address the dirty processes in the agriculture value chain and household energy deficits.

List of alternative clean technologies and preferred solution providers with grass root designs and potential/estimated impact.

Energy need		Type of productive use		Renewable energy technology	Solution Providing Companies in Nigeria
		Improvement to existing activity	New productive use activity		
Electrification	Services	Replacement of fossil generators	Provision of SHS services & proportion of standalone RE electric appliances e.g. television, sewing, solar refrigerator, battery charging	Solar PV, micro-hydro	Solar Centric, Blue Camel, Sosai Energy, CREED Energy
Food issues	Drying and Smoking	Preserving & Improved the quality of the existing product (e.g. compared to open sun drying)	Preservation, storage, selling products off-season or in higher value markets	Solar dryers, biogas-powered dryers, biomass power plants	D.A.R.E, Quintas Renewable Energy, Rochen Renewable Energy
	Cooling	More efficient smoking e.g. fish, meat, fruits, vegetables, etc	Preservation, storage, and selling of products at higher value markets (e.g. fish, vegetables, beef, etc.)	Biogas to electricity, solar cold storage, etc.	ColdHubs, ColdBox Stores
	Cooking & baking	Increase efficiency of food businesses and clean cooking	Creation of value-added products that can be sold locally	Solar Cold storage, Biogas-powered ovens, solar ovens, biomass ovens, clean efficient stoves, rocket ovens	Rochen Renewable Energy, CREED Energy, DARE Energy, Sosai Energy Ltd
Agriculture	Irrigation	Increase in yields, higher sales/availability	Cultivation of new crops with higher value/previously unavailable	Water pumps, Micro-hydro power, biofuel-powered pumps, wind pumps, solar pumps	CREED Energy, Excell Energy Ltd
	Post-harvest processing	Higher productivity, higher quality production, less labour-intensive	Creation of value-added agricultural products and provision of processing services.	Grinding mills, threshing and husk machines, biofuel-powered motors and dryers, small wind turbines, biogas to electricity, solar PV dryers, micro-hydro, biomass-efficient stoves, electric peeling and shredding machines	Quintas Renewable Energy, Excell Renewable Energy, Rochen Renewable Energy

The Working Cases of PUE for Agriculture and Energy in Rural Areas in Nigeria for Women and Youths

Case 1: ColdHubs Nigeria – Affordable Cold Stores for Vegetables and Proteins

Case Title: Cold Hubs: Solar-Powered Cold Storage for Developing Countries

Institution: Coldhhbs Nigeria
Contact Person: Nnaemeka C. Ikegwuonu (CEO)
Tel:+2349011695995
Email: info@coldhubs.com or terrence@coldhubs.com
Website: https://www.coldhubs.com/

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks, individuals, partnerships

The problem (max 10 lines)

According to estimates, ineffective or nonexistent cold chains cause 37% of Nigeria's agricultural products that need refrigeration to be lost. In Nigeria, 93 million small farmers lose 25% of their annual income owing to food spoiling caused by a shortage of cold storage. For instance, the nutritious value of fresh agricultural vegetables and proteins begins to decline practically immediately after harvest. The distance between the farms and urban markets where demand is usually high, and the poor road networks connecting urban and rural areas make the diminishing rate of fruit and vegetables even faster. This is even faster in hot climatic regions. Farmers and traders of perishable produce are often reluctant to make bulk harvests and purchases because of the gap in cold storage services – as this will automatically lead to business losses from spoilage.

The solution (max 10 lines)

ColdHubs, is a “plug and play” modular, 100% solar-powered walk-in cold room, with 24-hour off-grid solar cold storage containers for the preservation of perishable foods. It adequately addresses the problem of post-harvest losses in fruits, vegetables and other perishable food. ColdHubs are installed in major food production and consumption centres (in markets and farms), farmers place their produce in clean plastic crates, and these plastic crates are stacked inside the cold room. Coldhubs extend the shelf life of perishable food from 2 days to 21, reducing post-harvest loss by 80%. With more of their harvest to sell, smallholder farmers can increase their annual income by 25%. The target is to hire mainly women to manage the operations and collection of revenue at Coldhubs stations.

Business Model:

How the business works: The social enterprise operates on a ‘pay-as-you-store’ subscription model, where farmers or traders pay approximately NGN200 for each 20-kilogram plastic crate of fruits and vegetables stored overnight. Its reusable plastic crates with built-in hands have perforated

edges to improve ventilation. Meat and seafood cost NGN 500.00 per night. Traders deliver boxes of their produce but wait to pay until they are prepared to take them up.

Ownership Model: ColdHubs currently operates under an owner-ship-based business, meaning the supplier ColdHub both owns and operates all facilities. In this business model, based on the key performance indicators, the initial investment of 28,500 USD is profitable. The utilization rate of 110% reflects the high productivity, exceeding the theoretical full capacity of the Cold Hub. The financial model revealed that the investment would be profitable as long as the utilization rate is above 94%. The current high productivity only adds to the viability of the innovation. Extensive use leads to a faster discharge of the batteries compared to the usual durability of six years. However, even when battery replacement is assumed after every three years, the Internal Rate of Return (IRR) still exceeds 40% which adds to the robustness of the business model and proves the profitability of the innovation.

Third-party/user model: In a third-party/user model, the users would purchase the cold hub and finance it through either a loan (bank/supplier) or through a lease-to-own model where they would pay a monthly leasing fee to the supplier Cold Hub. The initial investment/selling price would be 33,500 USD to secure a profit margin of 17.5% for the supplier Cold Hub. Compared to a diesel-powered cold room operating at a fueling cost of $11,680 a year and $35,040 in three years (excluding maintenance and renting on space), this seems more cost competitive, however, it open to investment credit risk if utilization drops as competition grows or interest and operational cost increases.

Franchising model: this would mean Cold Hubs leasing the branding and technology to franchisees, who then would operate the hubs and collect the cooling fees. This business model would allow faster upscaling. However, the franchising model would result in lower profitability (IRR) from the franchisee's standpoint. For this model to increase the DSCR, the sensitivity analysis suggests reduced investment costs combined with higher cooling fees. Alternatively, the franchisees could increase the down payment or raise the cooling fees to NGN 500/crate.

Key Character and Unique Features:

The solar-powered walk-in cold room is made of 120mm insulating cold room panels to retain the low temperature. Energy from solar panels mounted on the rooftop of the cold room is stored in high-capacity batteries which feed an inverter which in turn feeds the refrigerating unit. During the day, the hub is directly powered by the sun, while energy is saved in batteries. When the sun goes down, the batteries take over. It is capable of storing 6 kilowatts and 1.5 kilowatts of solar energy, and it stores excess energy of 4.5 kilowatts every hour in the batteries. When there is no sunlight at night, on rainy or cloudy days, or in the case of other climate changes, the inverter automatically pulls energy from the batteries and runs the cooling units. This is because at night or during these climatic changes, the solar panels are no longer pulling energy as they were designed.

Each storage cold room cabin can store up to 2 tons (150 crates) to 3 tons (300 crates). It can also be designed to take an even larger capacity should the need arises

The temperature of cold storage typically ranges from between -10°C to 10°C, vegetables such as cabbage, lactose, apples, tomatoes, and fruit with similar constituents are stored between +8 °C to

+12 °C, which means the cold room can be adjusted according to the specific requirements of the products being stored.

Competitor/Competition:

ColdBox stores, and local silo cold rooms in markets for fish and meat.

Target Market:

Fruit and vegetable markets in city corners, local government markets, farm centres, poultry clusters and meat markets in urban areas, vegetable traders are the most at high risk.

Selling Preposition:

With roughly 429 markets in Nigeria, there is a large potential market. One of the analysed cold hubs in the Relief market, Imo State indicated to have 45 monthly customers, of which 30 were regular. However, since the area hosts at least 100 fruit- and vegetable traders, the solar cold room would not have the capacity to accommodate them. This is a vast market need. With solar cold storage within the reach of farmers and women trades, they can experience a 25% increase in their current business profit.

Effect and results (max 10 lines) (Successes)

ColdHubs has scaled up its growth and expanded its operation from 21 to 28 states in Nigeria. Massive expansion in the south and northern Nigeria. The company is taking over the cold-chain industry in Nigeria, with 58 operational cold storage facilities and another 14 under construction in various parts of the country. The company is doing everything in its power to cut post-harvest loss in fruits, vegetables, meat, fish, milk and dairy products.

- 42,000 tons of food were saved in 2020 and saved 52,700 tons in 2021.
- 2,418,743 kgs of food saved
- They have registered over 6371 small-scale farmers, retailers and wholesalers currently using Coldhub stores.
- 2 refrigeration trucks
- Created over 80 new jobs for women as of 2022.
- Increased income of customers by 50%
- By using solar energy and avoiding fossil fuel, ColdHubs was able to prevent the release of 2,466,816 Kg of carbon dioxide. This is an example of using an environment-friendly innovation to save food.

The key takeaways (max 10 lines)

The cost of the daily service is very affordable for the farmers and market women. This makes the investment and impact highly guaranteed. Very few solution providers in this space exist and the need is very obvious. There is a need to explore PPP to upscale the solution, as well as present community-based or joint cooperative models to install such technologies in rural market squares, and can centres.

Feasibility (max 20 lines)

A solar-powered cold room is also economically cheaper compared to traditional generator-powered cold rooms. For instance, a typical cold room for meat and fish burns an average of 20-30 litres of diesel to power traditional cold rooms per day. That is an average of 25 litres at NGN842.25/per litre, this amounts to N21,056.25 (or $30) a day. That is about NGN7,685,531 (or $10,979) a year, and NGN23,056,593 ($32,937.99) in three years. That is an average of 25 litres at NGN 842.25/per litre, this amounts to N21,056.25 (or $30) a day. That is about NGN7,685,531 (or $10,979) a year, and NGN23,056,593 ($32,937.99) in three years. This cost does not include - the cost of maintenance, capex for purchase of the power generating machine, replacement cost of the machine parts (in the 3 years), and the diesel-powered generators are not run overnight - no backup systems (so the cost is for approximately 10-12 hours of power). It also does not include the cost of rent of stores/traditional cold shops.

The initial cost for installing a cold hub varies between $28,500 and $33,500, depending on what kind of financial model is used. In addition, a viable scenario analysis indicates that these costs may further decrease or increase depending on how the cooling fee, interest rate and equity financing are adjusted. This makes the solar cold hub cheaper.

The solution is in line with the Energy Transition Plan (2023 – 2027) of the government. It fits well in cutting down waste in states like Lagos and Benue that ate confronted with huge food wastage. He Coldhubs also scored well in the deployment of renewable energy in Nigeria. Hence, supporting Nigeria meets her National Determined Contribution commitments in cutting CO2 and other pollutants.

Coldhubs with over 58 coldhubs in 28 states, have shown great experience and expertise in the deployment and running of the solution.

Potential for scaling (max 20 lines)

One of the core mandates of the organization is to empower women and reduce gender gaps in labour participation. ColdHubs, as an agritech organization, through its reboot tech activities, promotes the advancement of transformative technology and digital education for rural women, especially farmers and vegetable traders.

The training exposes the women to how to improve their income and sales through digital marketing and how to best assess loans and farming tools from government agencies.

Since its invention, ColdHubs has been providing employment opportunities for women, who tend to seek careers in the tech world.

ColdHubs is looking at making more impact, especially with the addition of new hubs and refrigerated logistics trucks. With more refrigerated logistic trucks to complement the solar-powered cold rooms, ColdHubs has become an industry leader in the Cold Chain sector in Nigeria and Africa at large.

Over 80 women and youths are employed in the various Coldhub stores as operators and managers.

As the hubs expand, they plan on expanding and improving manpower. The organization is also open to partnering with state governments and private organizations and individuals to set up similar cold stores and offering training to state governments in this regard.

Financial and Non-Financial Instruments Received

Cold Hub has received supports from various supports from grants and donors to seed investment and technical support from various organizations such as - Catalyst Fund, Fledge, Factore, Husk, GIZ, Heifer International, USAID, Feed the Future, AYuTe Africa, EDP – Portugal, Basel Agency for Sustainable Energy (BASE) and EMPA.

The government of Japan and the International Food Policy Research Institute (IFPRI) have also extended financial support to Coldhubs in the deployment of coldhubs stores. Financial advisory support has also been enjoyed by PWC. Aston University through awarded support from the Global Challenges Research funding supported ColdHubs to undertake research and development. ColdHubs has won several international and local awards that have also supported their innovative work.

Challenges Faced

1. Low awareness; Need to increase awareness among the farmers, and get sustainable support and recognition from more state governments,
2. Limited funding to scale up: More investment funding to reach more agrarian communities and urban markets is needed
3. Lack of integration of the Cold hubs with government programs on climate change and agriculture.
4. Monitoring activities in all the regions where ColdHubs are installed is sometimes hard
5. Access to urban space and government bureaucracy for authorization

Government regulations, labour shortages, climate change, the cost of equipment, poor transport systems, and import charges are among the enormous issues encountered in the business

Lessons learned

- Improving the technology for affordability: The initial design, created in 2016, was unsuccessful. It was based on the idea of air conditioning. The present version, according to Nwadike, costs about 15 million - 19 million naira to construct one unit of the Coldhubs type that is currently being used. Improvements were made as a result of the lessons gained.
- Need for a closer working relationship with government and market/farm stakeholders: The Coldhubs team interacts with market participants and governmental organizations before establishing operations in a certain area to identify a suitable place to lease for the installation of the solar-powered cold station. Before bringing their commodities to be stored, merchants put their items in crates provided by the hub's operators to make sure the cold station's area is used effectively.

Opportunities Available

- Their biggest achievement in 2022 was setting up a standard refrigerated transportation service. This made Coldhub a full cold-chain company offering end-to-end cold-chain services across the country."
- The company is also putting up strategies and plans to ensure that the demands of their customers are met and to drastically improve in all spheres of this business.
- They are also exploring more relationships and partnerships with local market authorities to set up more Coldhubs, especially in northern Nigeria. Expectations of the company in 2023, are to consolidate its growth to extend its innovation to the entire 36 states of Nigeria.
- The solution will be filling a huge gap in the health sector, ensuring vaccines are stored at the right temperature in off-grid locations or underserved locations. Their haulage systems when fully functional can also be an easy space for the distribution of quality food.
- ColdHubs plans to commence production of storage crates and launch the Cold Connect App, which will enable proper business engagement and interactions among customers and partners across the country and beyond.

What should we do next (max 5 lines)

- Approach ColdHub to explore possible partnerships to propose more coldhubs (but with smaller operating units) for women clusters in agrarian communities.
- Coldhub to consider an alternative model of cooperative ownership cold hub and haulage service to enable poor communities to own, invest and operate the coldhubs
- Financial needs to be provided based on the outcome of the above conversations, and agreement reached.

Backing documents, knowledge and inspiration

Links to report/backing documents, public articles, audiovisual material, key people

ColdHub website: Visit https://www.coldhubs.com/

3-5 illustrative photos


Cold Hubs
LOGISTICS


Cold Hubs
Cold Hubs


VEGETABLES
FRUIT
MILK
FISH
MEAT

Case 2: D.A.R.E Nigeria – Solar Bubble Dryer for Vegetables & Grains

Case Title: Improved Solar Bubble Drying for Fruits and Vegetable Farmers (replacing open sun drying)

Institution: D.A.R.E Nigeria ltd
Contact Person: Mr. Yahaya Ahmed (CEO)
Tel: +2348033110130, 2348084424356
Email: yahaya@gmx.de
Website: www.dareworld.org

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks, individuals, partnerships

The problem (max 10 lines)

Open sun drying is very common in many parts of Nigeria. While this method is effective in reducing moisture content and extending the shelf life of the vegetables, there are some health and environmental concerns. Sun drying is often done on the ground or on mats, which does not provide adequate protection against contamination from dirt, dust, insects, and animals. Additionally, exposure to open air increases the risk of microbial contamination and mould growth, which can impact the safety and quality of the preserved vegetables.

The solution (max 10 lines)

Introduction of a solar bubble dryer (SBD). A Solar-Bubble-Dryer (SBD) is an innovative solar drying technology that utilizes a transparent plastic enclosure to harness solar energy for efficient dehydration and preservation of agricultural produce. It creates a controlled environment, capturing sunlight to generate heat and facilitating the drying process while maintaining product quality. The SBD offers advantages such as cost-effectiveness, faster and more uniform drying, protection from contaminants, and reduced reliance on fossil fuels. It promotes sustainability by utilizing renewable energy and is particularly beneficial in regions with ample sunlight and limited access to electricity, contributing to food security and sustainable agriculture.

Business Model:

D.A.R.E operates different business models depending on locations and clients. In the operation of Solar-Bubble-Dryers (SBDs) in a poor off-grid community, they consider several business models to make the service affordable, economically viable and sustainable. Their business models mostly involve:

1. Pay-per-Use Model: This model involves charging users a fee for the time or quantity of produce they dry using the SBD. Users pay a predetermined rate based on the duration or capacity utilized. This model allows for flexibility and affordability, as users can access the drying service as per their specific needs and financial capacity. DARE charges NGN300/ per basket of 35-40kg of tomatoes. It takes up to 2-3 days to dry (depending on the water content and type) to dry 1 ton

(or 30 baskets of 35kg) of tomatoes (full capacity). For fruits like mango or pineapple, they charge NGN400/kg to dry the fruits.

2. Product Processing and Sale Model: In this model, the SBD operator collaborates with local farmers to dry their produce using the SBD. The operator charges a fee or takes a percentage of the value of the dried products. Once dried, the operator can either directly sell the dried produce or assist farmers in marketing their goods, thereby generating revenue from product sales.
3. Cooperative Model: Establishing a cooperative where farmers jointly own and operate the SBD can be a viable option. Members contribute to the initial investment, maintenance costs, and operational expenses. They have access to the SBD for drying their produce at reduced rates and collectively manage the operations, ensuring sustainability and equitable distribution of benefits.
4. Value-Added Product Model: The SBD operator can leverage the dried produce to create value-added products. This can involve processing the dried goods into packaged snacks, spices, or other value-added products for sale in local markets or even for export. The operator can generate revenue through product sales, taking advantage of the higher value associated with processed and packaged goods.
5. Micro-Entrepreneurship Model: In this model, the SBD can be made available for rent or lease to local entrepreneurs who want to start their drying businesses. The SBD operator provides training, technical support, and maintenance services while charging a rental or leasing fee. This model fosters entrepreneurship, empowers individuals in the community, and expands the reach of the SBD technology.
6. Community-Based Service Model: The SBD operator can offer a range of services related to drying, such as training, maintenance, and support, to the community. This can include training farmers on proper drying techniques, providing maintenance and repair services for SBDs, or offering consultancy services to other organizations interested in implementing the technology. Revenue is generated through service fees or contracts.

For DARE, it is essential to tailor the chosen business model to the specific needs, capabilities, cultural and market dynamics of the community. Collaboration with local stakeholders, assessing market demand, and considering the socio-economic context are crucial steps in developing a sustainable business model for operating SBDs in a poor off-grid community.

Key Character and Unique Features:

The Solar-Bubble-Dryer (SBD) is made of solar PV energy, a transparent enclosure for heat-trapping, a controlled drying environment, natural convection and ventilation, faster and uniform drying, scalability, and environmental sustainability. These features make it an effective and eco-friendly drying solution for preserving agricultural produce. The machine had a life span of over 20 years when properly used and maintained, while it comes in varying sizes with the current model having a 0.5 to one-litre batch capacity.

The SBD comes in two sizes. The SBD25™ has a drying area of 269 ft2 (capacity of 1100 lbs, with dimensions - length: 49 ft by width: 7 ft). While the SBD50™ has a drying area of 538 ft2. (capacity of 2200 lbs, with dimensions - length: 85 ft by width: 7 ft)

Both come in solar and plug-in electric models. The power is used for ventilation (one fan for the SBD25, two for the SBD50), which also keeps the bubble inflated.

Solar models come with a charge controller to re-charge, one 100Ah battery, two 100w PV panels and two jumbo blowers (fans), two dryer beds (for fruits and vegetables), the main dryer membrane (mostly for grains; rice, maize, millet, etc) and an ultra-ray filter sheet, covering the whole surface of the dryer. It can also come as a Plug-in model with a 500w transformer so it can be powered via electricity.

Competitor/Competition:

Open traditional sun drying, GrainPro Solar, etc

Target Market:

Farmers, Fruit and grain traders in rural areas, farm gate clusters, aggregators, food processing companies for backward integration, cooperative farmers and communities, etc.

Selling Preposition:

The machine could be used for drying a wide range of crops such as tomatoes, Mangoes, apples, grains and other crops, without losing their taste. The SBD is mobile and not dependent on either fuel or electricity and, therefore, has very low operating costs. Dried produce retains its taste, colour and flavour because there's no contamination and no direct contact with the UV rays of the sun. It is the cheapest and the best way to preserve all farm produce in Nigeria. Some key selling points of the SBD include:

1. Cost Savings: The SBD harnesses solar energy, which is freely available, to power the drying process. By eliminating the need for costly fossil fuels, it helps users save on energy expenses, making it a cost-effective solution for small-scale farmers and entrepreneurs.
2. Improved Product Quality: The controlled drying environment provided by the SBD helps maintain the quality and nutritional value of the dried produce. The transparent enclosure protects the produce from contaminants, dust, pests, and adverse weather conditions, ensuring higher-quality dried goods compared to traditional drying methods.
3. Faster Drying Times: The combination of solar heat and optimized airflow in the SBD enables faster and more efficient drying. This allows users to increase their productivity, reduce overall drying time, and meet market demand more effectively.
4. Versatility and Adaptability: The SBD can be designed and customized to suit various drying needs and agricultural commodities. It can be adapted for drying grains, fruits, vegetables, herbs, and more, making it versatile for different farming contexts and product requirements.
5. Environmental Sustainability: The use of solar energy in the SBD contributes to environmental sustainability by reducing greenhouse gas emissions and promoting renewable energy usage. By choosing the SBD, users demonstrate their commitment to sustainable practices and reduce their carbon footprint.
6. Support for Small-scale Farmers: The SBD provides a practical and affordable drying solution for small-scale farmers, enabling them to preserve their harvest and extend the shelf life of

their produce. This helps reduce post-harvest losses, increase income opportunities, and support the economic sustainability of small-scale agricultural operations.

7. Adaptation to Off-grid Areas: The SBD is particularly beneficial in off-grid or rural areas where electricity access is limited. By utilizing solar energy, it offers a reliable drying solution without the need for grid connectivity or costly diesel generators, making it an ideal choice for remote farming communities.

In summary, the selling points of the Solar-Bubble-Dryer (SBD) revolve around its cost savings, improved product quality, faster drying times, versatility, environmental sustainability, support for small-scale farmers, and adaptability to off-grid areas. These advantages make the SBD an attractive and practical solution for farmers, entrepreneurs, and communities seeking efficient and sustainable drying methods for their agricultural produce.

Effect and results (max 10 lines) **(Successes)**

The faster drying times achieved with the SBD allow farmers and entrepreneurs to process larger quantities of produce in less time. This increases their overall productivity and efficiency, enabling them to meet market demands, take advantage of favourable pricing, and expand their businesses. The Solar Bubble Dryer can dry 1 ton of any of these products per batch and more, depending on the water content of the product:-

- Tomatoes take 3-4 days (to attain the recommended moisture content of 7-8%).
- Onions - 2 days
- Okro -1 full sunny day of at least 8 hours.
- Pine apple - 3 days.
- Mushroom - like Okro.
- Pepper - 3 days
- Irish potatoes - 4 days.
- Grains (rice) - after parboiling (to attain moisture content of 12-14% (from 48%) - 12 hours, etc.

The key takeaways (max 10 lines)

The key takeaway of Solar-Bubble-Dryer (SBD) projects is the positive impact they have on agricultural communities, particularly in off-grid and resource-limited areas. SBD projects provide a sustainable and cost-effective solution for drying agricultural produce, leading to improved product quality, reduced post-harvest losses, increased income opportunities, and environmental sustainability. The SBD empowers farmers, promotes economic development, and contributes to food security and sustainable agriculture.

Feasibility (max 20 lines)

DARE reported higher-quality dried produce compared to traditional drying methods. The controlled drying environment and protection from contaminants result in better colour, flavour, texture, and nutrient retention in the dried goods. This improves marketability and consumer acceptance of the products. The SBD provides an opportunity for small-scale farmers and entrepreneurs to add value to their agricultural produce. By being able to preserve and sell dried goods, they can access new

markets, command higher prices, and generate additional income. This contributes to their economic empowerment and livelihood improvement. DARE reported that the users of the SBD benefit from reduced energy costs as solar energy is used for drying instead of relying on fossil fuels or grid electricity, which is hardly available. The SBD harnesses a readily available and free energy source, resulting in long-term cost savings and improved profitability. The use of SBDs in rural or off-grid areas supports community development by providing access to affordable and sustainable drying technology. It empowers farmers and local entrepreneurs, creates employment opportunities, and strengthens the local economy.

SBD technology fits very well with food safety laws and programs. With the persistent threat of Lassa fever, diarrhoea, and food poisoning, technologies like this fit into proffered solutions. Also, the ETP and renewable energy policy provide cover for the solution.

For the deployment of the solution, local government permits may be necessary. However, there is a need to ensure that the traditional customary leaders are also sensitized to the working of the solution and its benefits.

Potential for scaling (max 20 lines)

A unit of the SBD costs between $4500 to $7500 depending on several factors such as size, capacity, design, materials used, fright-transport and location. Solar-Bubble-Dryer (SBD) technology is scalable. It can be designed and implemented in various sizes and capacities to suit different drying needs and production volumes. The scalability of the SBD allows for flexibility in accommodating the requirements of small-scale farmers, larger agricultural operations, or community-level drying facilities.

The size of the SBD can be adjusted based on the available space, the quantity of produce to be dried, and the desired drying capacity. Multiple SBD units can be installed in parallel to increase the overall drying capacity and accommodate higher production volumes.

Additionally, the scalability of the SBD extends beyond its physical size. It can also be adapted to cater to different agricultural commodities, such as grains, fruits, vegetables, herbs, and spices. The drying parameters, such as airflow control, temperature settings, and ventilation, can be customized based on the specific drying requirements of different crops.

The ability to scale the SBD technology makes it suitable for a wide range of applications, from small-scale farming operations to community-level drying facilities, allowing for efficient and scalable drying solutions for various agricultural contexts.

Once installed, the SBD requires ongoing management and maintenance. This can be handled by a smaller team or even a single person depending on the scale of operation. The responsibilities include monitoring the drying process, adjusting airflow and ventilation as needed, performing routine cleaning and maintenance tasks, and troubleshooting any issues that may arise. This can be done by a dedicated operator or by involving the farmers or entrepreneurs who use the SBD as part of their daily activities.

Financial and Non-Financial Instruments Received

Learn-Help-Life (Lernen-Helfen-Leben) Germany with funding support from Initiative Transparente Zivilgesellschaft, has supported the work of DARE. DARE has also been able to execute some projects via proceeds from Carbon Credits via the Clean Development Mechanism (CDM)

Challenges Faced

The challenges of deploying Solar-Bubble-Dryers (SBDs) in Nigeria can be summarized as follows:

- ✓ Limited access to financing and affordability.
- ✓ Lack of technical expertise and trained professionals.
- ✓ Infrastructure limitations, including unreliable electricity and water supply.
- ✓ Market and value chain development for dried agricultural produce.
- ✓ Limited awareness and adoption of SBD technology.

Lessons learned

SBDs have consistently improved the quality of dried produce, reduced post-harvest losses, and increased income opportunities for farmers. They contribute to environmental sustainability by minimizing greenhouse gas emissions and promoting community empowerment by providing affordable drying technology and supporting local economic development.

Opportunities Available

The opportunities for SBDs in Nigeria lie in food preservation, supporting rural communities, empowering SMEs, building climate resilience, promoting renewable energy, and facilitating knowledge transfer. By capitalizing on these opportunities, SBDs can contribute to improving agricultural productivity, reducing post-harvest losses, and enhancing the livelihoods of farmers and communities in Nigeria.

What should we do next (max 5 lines)

To get Solar-Bubble-Dryers (SBDs) working effectively in Nigeria, key actions include conducting research and assessment, providing policy and regulatory support, offering capacity building and training, establishing pilot projects and demonstration sites, and exploring financing and funding options. Collaboration and partnerships between government agencies, agricultural organizations, research institutions, and the private sector are crucial. Monitoring and evaluation systems should be implemented to assess impact and identify areas for improvement. By taking these steps, Nigeria can create an enabling environment for SBD adoption, leading to improved agricultural practices, reduced food waste, and increased economic opportunities.

What to do next; support DARE to gain access to appropriate financing mechanisms, such as low-interest loans, grants, or dedicated funding programs for renewable energy and agricultural development. This can help address the financial barriers associated with SBD implementation. Collaboration between government agencies, development organizations, financial institutions, and the private sector is essential to mobilize the necessary support and financing to accelerate SBD deployment in Nigeria.

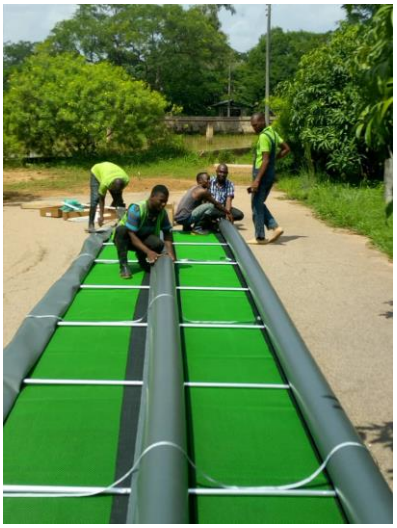
Backing documents, knowledge and inspiration

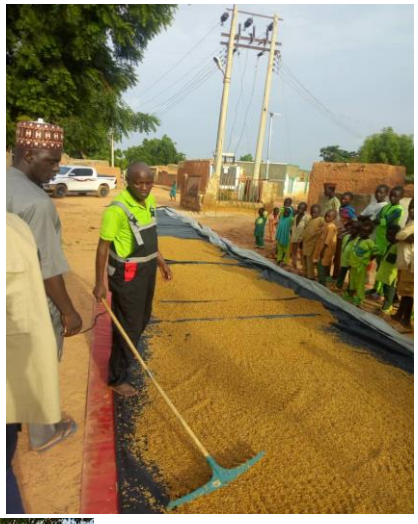
Links to report/backing documents, public articles, audiovisual material, and key people

https://www.adaptive.ag/shop/solar-bubble-dryer

https://thefarmersmanual.com/dare-introduces-solar-dryer-to-improve-post-harvest-management/

3-5 illustrative photos








Case 3: Roshan Renewable Happy Clean Stoves to Reduce Firewood for Cooking & Industries

Case Title: Happy Fuel Efficient Cookstoves

Institution: Roshan Renewable Energy
Contact Person: Mrs Happy Amos
Tel: 08069169129, 09095444424
Email: happyamos@ymail.com, info@roshanrenwables.org
Website: www.roshanronewables.org

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks, individuals, partnerships

The problem (max 10 lines)

Cooking accounts for 91% of total domestic energy consumption in Nigeria. Wood is the most widely utilized cooking fuel with over 70% using open firewood and 175 million Nigerians estimated to be vulnerable to illness and deaths from exposure to cooking smoke. 40MtCO2 emitted in 2020 mainly from cooking with traditional fuels such as firewood, charcoal and kerosene. Nigeria already stands as the country with the fastest deforestation rate. Wide-scale deployment of LPG for cooking and electric cooking is far from a reality in most parts of Nigeria; even in metropolitan cities with a relatively higher income, compared to far rural communities. Hence, it is only practical to focus on improving the efficient use of firewood and agricultural waste produce to significantly reduce the amount of wood used, as well as improve the health of women and children.

The solution (max 10 lines)

Introduction of fuel-efficient cookstoves that reduce fuelwood consumption and carbon emissions. Clean stoves have an efficiency rate of over 60% compared to open firewood cooking. The stoves are also very affordable as they use local materials that can be sourced even in local communities. Prices for the stoves are within the range of N5,000 and N8,000. With carbon credit, an average clean stove for a family can be accessed with N1,000.00.

Business Model:

Roshan has various business models. The most common are:

1. Outright Purchase: Customers purchase the clean cooking stove upfront at its full price. This model works well for customers who have the financial means to make a one-time payment.
2. Instalment Payments: Customers pay for the clean cooking stove in multiple instalments over a predefined period. The stove is provided to the customer after they make an initial down payment, and the remaining cost is divided into manageable instalments. This model allows customers to spread the cost over time, making it more affordable.
3. Women Saving Cooperative Groups or Microfinance or Loan Programs: Roschan partners with women cooperative groups and sometimes supports women to form cooperative saving groups (or if lucky microfinance institutions or local banks) to offer loans specifically for

purchasing clean cooking stoves. Customers apply for loans with flexible repayment terms and lower interest rates (mostly no interest). This model enables customers to access financing options that they may not have otherwise.

4. Subsidies and Grants: Roshan also seeks and gets partnerships with government agencies, NGOs, or other organizations that provide subsidies or grants for clean cooking solutions. Customers in poor communities benefit from reduced prices or financial assistance to make clean cooking stoves more affordable. This model helps bridge the affordability gap and encourages the adoption of clean cooking technologies.
5. Group Purchasing or Community Financing: Encourage community members to pool their resources and make bulk purchases of clean cooking stoves. Offer discounts or special pricing for group purchases. This model leverages the power of collective purchasing to lower costs and make clean cooking stoves more affordable for individuals within the community.

Key Character and Unique Features:

The clean stoves can be used with very little firewood, briquettes, sawdust, charcoal, and even dried agricultural waste. Most of the stoves proceed with 100% local materials.

- A sturdy design with steel and ceramics
- Uses charcoal and/or charcoal briquettes for fuel
- Consumes about 60% less charcoal and/or charcoal briquettes
- Cooks fast and Smokeless
- One Year Warranty

The clean stoves come in various sizes, models and prices:

Home Size Happy Clean Stove	Commercial Size Happy Clean Stove	Happy Dual Fuel Stove
Wholesale Price: N5,000 (Purchase of 200 and above stoves) N5,500 (Purchase of 1 to 200 stoves) Retail Price: N6000	Wholesale Price: N7,000 (Purchase of 200 and above stoves) N7,500 (Purchase of 1 to 200 stoves) Retail Price: N8000	Wholesale Price: N6,000 (Purchase of 200 and above stoves) N6,500 (Purchase of 1 to 200 stoves) Retail Price: N7000 **Carbon Credit price: N1000**

Competitor/Competition:

For the specific technology, Happy Clean Stoves, have no competition. However, several producers and markers of clean stoves exist most are under the umbrella of the Clean Cooking Stove Alliance, but most are not built with local contents/materials.

Target Market:

Rural homes and villages; commercial restaurants, roadside food vendors.

Selling Preposition:

An average poor household spends at least NGN 500 on firewood daily to prepare food for the family. This is a huge economic cost to the household and the environment, without the inclusion of the health cost. Clean efficient stoves for poor rural households offer a smoke-free cooking environment, reduced reliance on expensive and harmful fuels, increased cooking efficiency, and improved indoor air quality, leading to better health outcomes and cost savings.

Effect and results (max 10 lines) **(Successes)**

Roshan has delivered over 43,400 clean stoves to women and communities in over 7 states and IDP camps across Nigeria.

The key takeaways (max 10 lines)

Collaboration and Partnerships are key for scale-up: Roshan fosters collaborations with relevant stakeholders such as development partners, NGOs, government agencies, and local communities to leverage their expertise, resources, and networks.

The solution needs to be a User-Centric Approach: Roshan places the needs and preferences of end-users at the centre of product design, distribution strategies, and after-sales services to ensure high adoption rates and customer satisfaction.

Behaviour Change Communication: Implement targeted awareness campaigns and education programs to promote behaviour change, emphasizing the benefits of clean cooking stoves and addressing cultural, social, and economic barriers.

Technology Innovation: Roshan continues to explore more innovation to ensure that their solution is updated with the latest advancements in clean cooking technologies, fuel alternatives, and stove designs to continuously improve product performance, energy efficiency, and user experience.

Feasibility (max 20 lines)

According to testing at the Energy Research Center at the University of Nigeria, Nsukka, the Roshan stoves, known as Happy Stoves and available in four sizes, are 60 per cent fuel-efficient and achieve tier-four speed in a standard water boiling test. To date, Happy Stoves has manufactured and distributed around 45,000 stoves across Nigeria. Roshan also makes briquettes – about 400 kg per day – from agricultural waste (palm kernel shells and waste bamboo), replacing the need for charcoal made from trees. The briquettes have a high calorific value and are long-lasting, quick to heat, and cleaner burning than wood charcoal. Happy also manages empowerment programs for women, including savings and loan groups and a training program for Roshan sales agents.

Since starting Roshan Global Services in 2013, Amos, who is also the Managing Director of the company, has sold over 40,000 “Happy Stove” cookstoves. Amos has recruited more than 60 women as sales agents across Northern Nigeria and has trained over 350 women, including refugees, on the negative impacts of cooking with fuels like wood, charcoal, and animal dung.

The solution is in line with the set national climate and developmental goals. As of now, no legal requirement is needed to deploy clean stoves. Roshan has great expertise in making clean stoves. They are currently working with 300 women in Taraba through a savings loan group, and about 50% of them are small women farmers. In 2023 alone they have sold over 15,000 stoves, 10,000 under carbon credit and 5,000 under open market. Roshan has over 45 permanent staff and 50 ad-hoc staff.

Potential for scaling (max 20 lines)

Roshan has huge potential for scale-up if they get more support and funding. They already have a good number of demands for their stoves and have close working relationships with women groups and local influence that are pressing the gains of clean cooking.

Financial and Non-Financial Instruments Received

Roshan has received a series of financing and technical support from groups and organizations like UNDP-GEF, MEDA – Global Affairs Canada, Christina Rural and Urban Development Association of Nigeria, GreenCODE, Mercy Corps, World Bank, and also some CDM – carbon credit. They also get technical assistance from MIT D-Lab Biomass Fuel and Cookstoves Research, and GIZ Nigeria,

Challenges Faced

The major challenges faced by Roshan in the deployment of clean stoves include:

1. Affordability: Clean stoves can be relatively expensive for low-income households, making affordability a major challenge for adoption and widespread deployment.
2. Access to Financing: Limited access to financing options or microcredit facilities for purchasing clean stoves can hinder adoption, particularly in resource-constrained communities.
3. Awareness and Behavior Change: Lack of awareness about the benefits of clean stoves and resistance to change ingrained cooking practices pose challenges in promoting behaviour change and convincing households to switch to clean cooking technologies.
4. Distribution and Last-Mile Delivery: Establishing efficient distribution channels to reach remote and underserved areas can be challenging, requiring infrastructure development and logistical coordination.
5. Fuel Availability and Infrastructure: In areas with limited access to clean cooking fuels or inadequate infrastructure for fuel distribution, ensuring a reliable and sustainable fuel supply for clean stoves can be a significant challenge.
6. Cultural and Social Factors: Cultural preferences, traditional cooking practices, and social norms can influence the acceptance and adoption of clean stoves, requiring culturally appropriate strategies for deployment.
7. Multiple taxation on the company is also a challenge.

Lessons learned

Lessons learned in the clean stove business:

1. Prioritize user needs and cultural context for effective adoption.
2. Implement behaviour change campaigns to educate and encourage adoption.
3. Develop sustainable business models considering affordability and partnerships.

4. Focus on product quality and reliable after-sales support for customer satisfaction.
5. Foster collaborations with stakeholders for expertise and market expansion.

Opportunities Available

Opportunities for clean stove businesses in Nigeria include:

- Large Market Potential: Nigeria has a significant population and a high demand for clean cooking solutions, presenting a substantial market opportunity.
- Government Support: The Nigerian government has shown commitment to promoting clean cooking technologies, offering incentives, subsidies, and policy support for the sector.
- Energy Transition Agenda: Nigeria's focus on transitioning to cleaner energy sources creates an environment conducive to the adoption of clean cooking stoves.
- Rural Electrification Initiatives: Leveraging ongoing rural electrification efforts presents opportunities for integrating clean cooking solutions with electricity access in rural areas.
- Partnerships and Funding: Collaborating with NGOs, development agencies, and impact investors can provide access to funding, technical expertise, and market connections for clean stove businesses.

What should we do next (max 5 lines)

Engage Roshan on project vision and goal and jointly agree on the mode of the business of deploying more stoves.

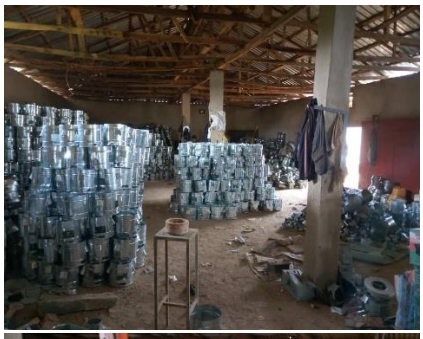
Backing documents, knowledge and inspiration

at www.roshanronewables.org, fliers and interview recordings are available.

3-5 illustrative photos









Case 4: Quintas Biomass for Agro-processing Value Chain & Electricity Generation

Case Title: Biomass Energy for Heating

Institution: Quintas Renewable Energy

Contact Person: Dr Omotayo Dairo

Tel: 0810 178 2786, 0803 451 0340

Email: tayo@quintasenergies.com.ng

Website: www.quintasenergies.com.ng

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks,

The problem (max 10 lines)

Agricultural processes in many parts of Nigeria involve the use of traditional and manual machines that use up a lot of firewood, fossil fuels such as diesel-powered machines and resulting in economic and environmental waste and pollution. The outcome of these agricultural processes is mostly poor quality, unhygienic, expensive, and do not take advantage of the possibility of operating a circular economic model. Boiling, drying, and milling are essential parts of most agricultural processing value chains. Unfortunately, this is largely done using lots of firewood, open drying, landfill disposal of waste, and patronizing expensive and dirty diesel milling and grinding machines for crops like cassava processing, palm oil processing, etc.

The solution (max 10 lines)

Quintas Renewable Energy Solutions is an indigenous renewable energy company focusing on Off Grid Electricity generation and productive use of Energy. They manufacture biomass energy generation equipment and simple agro-processing machines. Qunitas Biomass Burners and Dryers machines, and her farm value chain processing centres. The systems are all locally fabricated machines that combust any solid, dry biomass (such as crop waste i.e. kernel shells, corn hobs, rice husks, shrubs, palm oil shafts, etc.) into combustible gases for efficient extraction of heat energy, and electricity for crop dryers (i.e drying cassava, yam peels, plantain, etc), agro-industrial processing such as par-boiling and steaming of produce.

The target markets are farm gate processing centres i.e. cassava or palm oil processing units in villages, as well as unelectrified off-grid communities.

Qunitas Energy operates various **business models** to either suit their clients, meet community needs and design, or proof of a concept. These models range from an **owner operation model**, where Quintas established and operates a farm processing centre using biomass and charges a fee (pay-as-you-use) from customers that want to process their palm oil or cassava (in this model, payments are either in cash or commodity). They also operate a **cooperative model**, where groups of farmers or processors charge Quinta Energy with the task of setting up or retrofitting their

processing units, training their members of management to maintain the equipment and improving the value chain in packaging and trading. The latter sometimes is also done in collaboration with Quintas, and not only the setup service provided. Lastly, Quintas also work with rural communities, offering them a range of services related to waste collation, usage, machine handling, and after-delivery support.

Effect and results (max 10 lines) **and success**

- The Climatology Department of the World Bank named Quintas as one of the ten inventors in the world, whose works could cause a significant reduction in global carbon emissions - 2009
- Quintas won the World Economic Forum “Technology Pioneers Award” for 2011
- They are the Award winner of the BoI/UNDP Access to Renewable Energy Challenge in Nigeria in 2012.
- They are also an Award winner of the United States of America, Africa Development Foundation (USADF) 2014 Power Africa Energy Challenge Competition
- They are also an award winner of the 2014 West Africa Power Industry Award as the Best Renewable Energy Project in West Africa
- Quintas Energy is also a top runner-up at the 2016 Siemens/Stiftung 2016 Empowering Peoples Award
- They have two certified patent awards for two of their technological solutions from the Federal Government of Nigeria Patent in 2018

The key takeaways (max 10 lines)

Quinta's solution is a 100% local content base. The concept of waste to energy addresses the problem of agricultural waste generation, showing the practical working of a circular system in the sector. The solution as a stand-alone solution is suitable for heavy energy load demand.

Quinta's Energy also fabricates cabinets and Flatbed dryers are batch dryers for diverse agro-industrial products, using biomass or steam-generated hot air as a drying medium. The size of the dryer and the number of trays are designed to meet the needs of clients. For temperature-sensitive products, they introduce temperature gauges to guide drying clients during drying.

Feasibility (max 20 lines)

The cost of establishing a biomass processing plan, or integrating the technology into existing processes depends on the size of the proposed project and the economics and preference of the client. Because each biomass machine is flexible and can be designed to fit the community or client, the cost range is between NGN 300,000 to N8,000,000.

Quinta's proof of concept and experiences are evidenced in the awards and recognitions from various international bodies already listed above.

With waste now part of Nigeria's improved National Determined Contribution 2023, solutions like Quintas Energy biomass waste to energy is a great solution to promote as a strategic driver to cut back the emission of carbon and other toxic chemical i.e. methane. The National Environmental

Standard Regulation Act 2007 is a good backing for this solution as it proffers a solution to environmental waste management from the agricultural sector on solid waste management.

Potential for scaling (max 20 lines)

Quintas is set to train over 100 young people in collaboration with NASENI in Biomass – waste to power machine production.

With the proof of concept of producing dried, processed and packaged agricultural products using waste energy now established, Quintas Energy plans to replicate the farm gate process cluster to over 300 farm processing communities and space with the right support.

With the local and state governments, like Lagos state seeking sustainable ways to address their waste problems, Biomass waste to energy for electrification and agro-processing is a viable strategic solution.

Financial and Non-Financial Instruments Received

The project has received $30,000 from the UNDP, $100,000 from USAID for improvement of her cabinet biomass drivers and also technical support from Semen Stiftung part of which includes technical trips to Germany, Ghana, and South Africa.

Over $3000,000 have been committed by various donors some of which are mentioned above.

To execute a biomass-powered mini-grid to power 500 households and support agro-processing in the community, at least NGN100,000,000 will be needed.

To set up a farm gate processing cluster to process 4 crops – cassava, palm oil, plantain and ethanol, at least NGN35,000,000 will be needed to fabricate the machines, set up the construction work, space, and legal registration such as NAFDAC registration and LGA registrations.

Challenges Faced

- ✓ The biggest challenge is the low awareness of the potential of biomass and its low cost of installation compared to diesel
- ✓ The fuel supply for biomass is largely wasted – these are wasted materials
- ✓ Low manpower the knowledge of biomass machine development
- ✓ Low Finances; this will not be a problem with one's awareness

Lessons learned

If Africa wants to develop, we need to improve on biomass energy innovation and improvement. With the amount of waste in the agriculture and trade sector, biomass waste to power remains the only technology that produces electricity, heat, and stream at the same time. Heat, steam and electricity are all that are needed in mostly off-grid agricultural agro-processing for parboiling, drying and cooking (electricity). The injection of solar technologies and other renewables, may provide reliable energy, but they do not address the waste generated along the various production value chains in the agric sector – the waste remains with the other renewable energy solutions. Also,

biomass energy is more affordable compared to other renewable energy – it gives a good sense of community ownership and provides guaranteed base load energy compared to solar energy.

Opportunities Available

The opportunities are enormous with the increasing waste and urbanization in Nigeria. Government, private sector and communities do not use their waste and end up burning it in open spaces, polluting the environment and wasting potential energy. Large-scale conversion of Nigeria increasing waste to generate electricity in Nigeria. There are over 1000 biomass plans in Germany and over 500 in China, with expansion in agricultural production, and the waste that will emit from there, we need over 5000 Quintas energy to clear the waste.

What should we do next (max 5 lines)

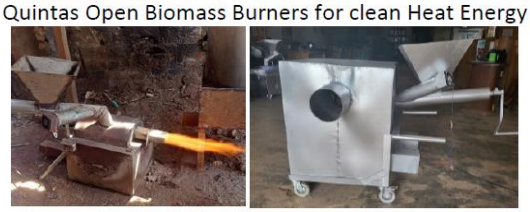
Engage Qunitas Energy on project vision and goal and jointly agree on the mode of execution.

Backing documents, knowledge and inspiration

www.quintasenergies.com.ng, video recordings, production fliers, etc

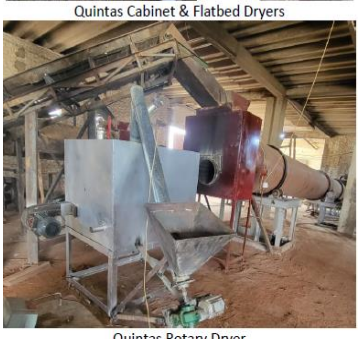
3-5 illustrative photos

Quintas Open Biomass Burners for clean Heat Energy



Quintas Closed Biomass Burners

Quintas Cabinet & Flatbed Dryers



Quintas Rotary Dryer

Case 5: Creeds Energy Rocket Bakery Ovens – saving the Trees

Case Title: Efficient Rocket Bakeries

Institution: Creeds Renewable Energy Ltd

Contact Person: Mrs Hannah Kabir

Tel: +234(0)8035997030

Email: hkabir@creedsenergy.com

Website: http://www.creedsenergy.com/en/

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations,

The problem (max 10 lines)

Jigawa State is losing over 300 trees a day for bakery activities alone: 1 tree is fired per bakery per day to bake the ubiquitous bread, which has become the staple food for many Nigerians on low incomes. With more efficient bakery ovens, this loss could be reduced by 80 per cent, and the bakers would save money on their firewood as well.

The solution (max 10 lines)

Creeds Energy's improved rocket bread baking ovens help to achieve relatively efficient firewood combustion and maximize heat transfer to the baking products.

The bread is enclosed in a metal box/baking chamber which prevents it from getting contaminated with smoke, ash and hot gases. The bottom, sides and top of the baking chamber are exposed to the fire, which results in increased heat transfer. The fired clay tiles and other insulative materials are used for heat retention. The baking pans rest on the mesh so that heat is not directly transferred to the baking products through conduction thus minimizing the risk of burning.

Effect and results (max 10 lines)

The improved oven technology has a high potential of reducing firewood consumption by 80%, guaranteeing a more efficient combustion and heat transfer mechanism that evenly distributes heat around a properly sealed baking chamber. This shortens the baking time from 5 hours to 30 minutes, reduces operating costs and negative health implications from indoor air pollution on bakery workers, and pollution from high emissions.

It was established that the Rocket Oven is the best choice for Bakers in Jigawa state. It is an improved version of traditional ovens and can be fabricated locally for N2,500,000 per oven. This oven can produce up to 800 loaves of bread in 20 to 30 minutes, compared to a traditional oven with 300 loaves and a baking time of 5 hours, with more wood and emissions.

The key takeaways (max 10 lines)

The attraction of local fabricators to the design is a good opening to train more locals in the design and development of rocket ovens. There is need also to consider supports to see how biomass can be used in place of firewood.

Feasibility (max 20 lines)

The rocket ovens are cost-effective and affordable to the bakers, but to prove the point of their efficiency and their positive contribution to climate resilience, the first 3 ovens were funded by the Nigerian Erosion and Watershed Management Project (*NEWMAP*) with funding from the World Bank. After their installation, Hannah Kabir visited the bakeries to ascertain the economic viability of the ovens. “A baker can recoup his or her investment within six months,” she says. In summary, the solution has achieved;

- ✓ Reduced operational costs for the bakery from less consumption of firewood
- ✓ More disposable income for the baker and their family to afford other necessities
- ✓ Technology transfer; artisanal skills for fabricating the ovens locally were developed by GIZ
- ✓ Business stimulation; GIZ provides a list of trained artisans to bakers interested in building the ovens, therefore, providing income for artisans. Private companies produce and sell improved ovens without subsidies.
- ✓ Quality control; GIZ supervises the performance of installed ovens numbering 68 to date.
- ✓ The oven is suitable for medium-scale bakeries

Potential for scaling (max 20 lines)

The Bakery association in Jigawa are aware of the benefits of the rocket ovens and has 3 ovens installed in collaboration with Creeds Energy. Local fabricators in the state are also imitating the solution, similar trends are also seen in Zaria where the oven is used at Amhadu Bello University (ABU Zaria). There is room to collaborate and properly train local fabricators on proper insulation and heat control in the ovens. With proper support, Creeds Energy can also replicate this solution for women and youths as a viable business- the bakery association in states can also be brought into a collaboration to see how more ovens can be installed.

GIZ and the Rural Electrification Agency in 2021 and 2022 made a REF Call to support clean stoves. These windows can also be explored to deploy more fuel-efficient ovens across Nigeria.

Financial and Non-Financial Instruments Received

Heinrich Boell Stiftung supported the rocket oven in pilot in Ahmadu Bello Zaria. While NEWMAP supported the 3 in Jigawa. Other private ovens have been deployed by individuals who saw the performance and awareness videos online. One such is in Zuba Abuja.

To deploy 2,000 Rocket bakery ovens for communities and women entrepreneurs as a startup, at least $ 10 million will be needed.

Successes

Three rocket ovens have been installed in Jigawa state – Dutse, Gumel and Hadeji communities in collaboration with the Bakery Association and Jigawa Chamber of Commerce. 2 more bakeries have been installed in Zaria (one in Ahmadu Bello University), Kaduna. Over 80% of firewood is saved in each oven per day.

Local fabricators are also learning from the technology in their design of ovens but do not properly deliver on the insulation and heat regulator.

CREDS has installed solar PV systems for households, businesses, and health centres, across 7 states. Developed expertise in decentralized energy systems and rural electrification. 200+ communities supported the implementation of 424kWp solar PV mini-grids and connected 2,323 plus households.

Challenges Faced

- ✓ Poor awareness of the gains of the improved rocket oven compared to traditional ovens
- ✓ Poor collaboration and continuity on the promotion of the rocket oven
- ✓ Lack of funding; the limited funding accounts for a large part of the first two points
- ✓ Engagement of the bakers association, the is a need to engage further with the bakery associations

Lessons learned

There are still more improvements in the pipeline, as Hannah is looking into ways to further improve the heating process of the ovens. She is looking at using gasifiers which would not necessarily have to use wood to fire the ovens but could be using agricultural waste such as rice chaff or palm kernel shells. The gasifiers are more energy-efficient than the combustion chamber of the rocket ovens.

Opportunities Available

- Large Market Potential: Nigeria has a significant population and the demand for bread as a daily meal is high, making bakery a very lucrative profit business.
- Government Support: The Nigerian government has shown commitment to promoting a cutback on CO2 emissions through clean cooking technologies, offering incentives, subsidies, and policy support for the sector. However, the cooking has not gone big in the bakery.
- Energy Transition Agenda: Nigeria's focus on transitioning to cleaner energy sources creates an environment conducive to the adoption of clean cooking stoves (the bakery subsector can be pressed forward).
- Rural Electrification Initiatives: Leveraging ongoing rural electrification efforts presents opportunities for integrating clean cooking solutions with electricity access in rural areas.
- Partnerships and Funding: Collaborating with Bakery associations, training local artisans and fabricators, NGOs in the clean cooking alliance, development agencies, and impact investors can provide access to funding, technical expertise, and market connections for improved rocket ovens and training on its fabrication can be largely explored.

What should we do next (max 5 lines)

Engage Creeds Energy on an impact review of the designed rocket ovens. Visit the existing rocket oven bakeries to inspect performance first-hand and do an estimate for upscaling for women cooperatives and youth empowerment in target communities.

Backing documents, knowledge and inspiration

https://ng.boell.org/en/2016/04/01/greening-jigawa-bakery-business

http://www.creedsenergy.com/en/

3-5 illustrative photos

Case 6: Sosai Renewable Energy for Community Productive Use

Case Title: Solar Dryers, Solar Irrigation Systems, SHS and Clean Stoves for Local Communities

Institution: Sosai Renewable Energy Ltd
Contact Person: Habiba Ali
Tel: 08033110130
Email: habiba@sosairen.org
Website: http://www.sosairen.org/

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks,

The problem (max 10 lines)

Over 45% of rural communities do not have access to clean affordable reliable energy. The rural energy deficits are evidenced by the high dependence on fossil-based energy for heating, lighting and poor agro-processing. Small businesses in rural areas operate in deficit due to the lack of energy and the high fuel and maintenance costs of generators. While many rural customers are poor but willing to adopt renewable energy solutions, they cannot afford the upfront cost of clean energy such as solar PV, clean stoves, solar irrigation systems and food processing machines.

The solution (max 10 lines)

Sosai offers a range of affordable, high-quality products to bridge the energy deficit gaps. Their solutions include Solar Home Solutions for homes and SMEs. They offer a minimum of a 1-year warranty, with payment options of over 24 months and more (their lease-to-own business model is designed to fit the clients). They also produce cooking stoves with a 30-60% efficiency rate with zero emissions. They provide solar dryers, small-scale solar irrigation systems, solar-powered milling machines and solar refrigerators.

The target market for Sosai is the northern part of Nigeria as they have the highest solar potential and yet have the lowest energy access rate in Nigeria.

Sosai products provide reliable and efficient alternatives. Their solutions also prove to improve business activities and the economic well-being of the users. Their model also involves many training and value chain improvements, especially solar drying ventures.

Effect and results (max 10 lines)

Sosai is driven by the passion to provide a safe, affordable clean environmentally friendly solution for all economically challenged communities, through sound human-centred business-minded strategies.

They distribute low-cost, high-impact technologies across northern Nigeria. So far, they have distributed over 150,000 improved cookstoves, 65,000 solar solutions and 5 mini-grids in Northern Nigeria all for productive use, and have impacted 1,500,000 lives across 200+ communities.

Their goal is to ensure sustainable development for communities by deploying renewable energy products that create economic growth and positively impact rural lives.

The key takeaways (max 10 lines)

- ✓ Highly focused on the northern part of Nigeria where the energy deficit is largest and few energy providers not present.
- ✓ A very good relationship with community leaders and women's group
- ✓ Working and empowering community women along the entire value chain of the solutions; community women can make extra income by also selling renewable energy solutions to other women and communities
- ✓ Very flexible end-user financing through instalment payments
- ✓ Solutions are tailored according to the user's need; never providing a size fit all solution
- ✓ Promotion of micro-enterprises around the solution

Feasibility (max 20 lines)

- ✓ Sosai's model has been proven hundreds of times over and is poised to scale across Nigeria.
- ✓ Sosai solutions are in line with the government's Energy Transition Plan and subnational efforts to increase energy access. Their solutions are also vital to the new constitution that enables state and regional governments to generate and implement energy projects. Sosai solution is a quick win for regions.
- ✓ Their experience is evidenced in the number of connections they have executed - powering over 200 communities, with over 150,000 products sold and impacting over 1,500,000 lives in northern Nigeria
- ✓ Sosai has experienced strong growth, with over 150,000 products sold.
- ✓ Sosai has implemented projects for several multinational and development partners, including state government projects such as the Relief International on behalf of Arthur Guinness Fund Water Filter Project 2012/2013, USADF mini-grid and solar dryer project 2016 and 2019, Nigerian Energy Support Programme, Green Innovation Centre for Innovation and Agric Food Sector(GiZ), Propcom Mai Karfi N200 Million Solar Drying Project, GACC Catalytic Grant, Output Based Fund of Nigerian Electrification Project, USTDA Project and AgriD Project of the European Commission

Potential for scaling (max 20 lines)

- ✓ Most of the market in Northern Nigeria remains unpenetrated. Sosai is poised to capture this market and expand into new ones. Few solar companies operate in Northern Nigeria, and Sosai is the only one in the community solar space.
- ✓ Sosai has trained 300 female energy entrepreneurs to sell solar products and develop businesses based on productive use. As this program is key to Sosai's business model, an investment in Sosai is an investment in female entrepreneurs.
- ✓ Over 250 youths trained as sellers and technicians, boosting their income

Financial and Non-Financial Instruments Received

Sosai has successfully raised funding and built solid partnerships along the way to create lasting impact across several communities: $500,000 from AECF, $150,000 from USADF, Euro 375,000 from Atradius, Euro 448,000 from BetterVest and $155,000 from Kiva.

They have also enjoyed partnership and technical support from Power Africa, Independent Energy, USTDA, UKAID, GIZ, Allon, and Fosera.

Need up to $10,000,000 ROI annually to bridge the target market and get the right partnership.

Successes

- Sosai has trained 300 female energy entrepreneurs to sell solar products and develop businesses based on productive use. As this program is key to Sosai's business model, an investment in Sosai is an investment in female entrepreneurs.
- Over 250 youths trained as sellers and technicians, boosting their income
- Powered over 200 communities
- Impacted 1,500,000 lives through distributed renewable energy solutions
- Sosai has raised over $ 2 million to provide renewable energy solutions for communities in northern Nigeria.
- A proud member of the Global Off-Grid Lighting Association (GOGLA)

Challenges Faced

- Making the business more bigger and attractive to foreign investors, as at now with an ROI of $1,000,000 foreign investors are still reluctant to invest in more rural energizing solutions
- Finding the right kind of financing, partnership and technical support; the available technical assistance to the sector is appreciated but still limited, if the goal is to accelerate energizing communities.
- Limited manpower and better remuneration to retain employees on the project

Lessons learned

According to Sosai, when you start the work of providing a clean renewable energy solution to communities, you need to go down to the grassroots and understand the community dynamics and the solution. Do not assume the solution fits the customers automatically, ensure the solutions are tailored fits for the user – affordable, easy to use, and fit culture and space. Continuous research is necessary to establish a bridge between the energy provided and its fitness for purpose in another sector. For instance, for the energy agriculture nexus, the energy and health needs, etc. the solution must be end-to-end, this helps innovation and better business model development.

Keep a proper clean book, keep the right strategies, responsible board and all that's needed to grow the right way.

Opportunities Available

Most of the market in Northern Nigeria remains unpenetrated. Sosai is poised to capture this market and expand into new ones. Few solar companies operate in Northern Nigeria, and Sosai is the only one in the community solar space.

Sosai aims to achieve a revenue target of over US$ 3 million by 2027 driven by an aggressive sales strategy across Northern Nigeria supported by innovative financing solutions.

With the removal of fuel subsidies in the country, and the national effort to cut back on CO2 emissions and deforestation, the cost of renewable energy is now at par with fossil-based energy and more homes are switching to clean energy. This is a big opportunity to promote the adoption of

renewable energy solutions like SHS for businesses and agro-processing zones. The increasing awareness and government actions to arrest poor food management practices and contamination like Lassa fever, is also opening the mind of users towards solar dryers and other clean energy solutions for food processing. The government's effort to revamp agriculture with all-year farming also opens the space for solar irrigation, especially for smallholder farmers.

What should we do next (max 5 lines)

Engage Sosai on their solutions. Offer rich technical support and let us have a projection of project scope and implementation strategies.

Backing documents, knowledge and inspiration

https://www.youtube.com/watch?v=RNDSjvXW0kQ

https://sosairen.org/

https://youtu.be/d_8dnkzmkFs?t=30

3-5 illustrative photos








FLAG OFF/INAUGURATION

Case 7: Energy Excel Solutions for Small-Scale Agricultural Processing

Case Title: Integrating Small-Scale Processing Machines in Farm Communities

Institution: Excel Energy Ltd

Contact Person: Nkechi Okenwa

Tel: +234 803 688 8279

Email: c.nkechi@energyexcell.com

Website: https://www.energyexcell.com/

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks, individuals, partnerships

The problem (max 10 lines)

Small-scale agro-processing in Nigeria faces several challenges. One major issue is the lack of access to modern efficient technology and equipment, which hampers efficient processing and lowers productivity, as most of the agro-processing is done manually or traditionally. The inadequate technical expertise and knowledge contribute largely to the huge volume of waste and environmental pollution from the agricultural sector. Unfortunately, the very little support channelled towards small-scale agro-processing is usually large-sized machines that depend largely on fossil fuel and are not sustainable for small-scale farmers who are mostly women and considered expensive to maintain by the operating agro-processors.

The solution (max 10 lines)

Energy Excell Systems and Solutions Limited is an indigenous Nigeria Renewable energy Social Enterprise committed to providing high-quality Energy Efficient productive use equipment and Appliances to Homes, Small and medium/commercial and industrial. They pride themselves in introducing tailor-made equipment to niche markets providing end-to-end services and making productive use appliances affordable and easily accessible to homes, industries and the farming community. They partner with the farming community, co-operatives, service providers, project developers and investors to accelerate the success of enabling the use of energy-efficient productive use machines, by increasing demand for energy and increasing household income, thereby enabling people to purchase more energy with our specially designed to fit machines. They also offer training and capacity building, equipment supply and sales, equipment financing and after-sales support services

Their solutions include; corn threshers, flour mill grinders, rice mills, self-sanction grinders, tooth claw flour mills, and inverter welding machines. All the machines can be connected to an electricity grid or powered by a standalone energy source i.e. solar power, etc.

Effect and results (max 10 lines)

Over 50 agro-processing machines have been deployed across Nigeria, especially in Nigeria, Kebbi, Enugu, Ebonyi and Abuja. The rice and wet and dry grinding are the most purchased.

The PUE machines have been installed in 4 solar mini-grids across Nigeria. They are also powered by electricity and standalone solar.

The key takeaways (max 10 lines)

Sensitization on the importance, setup and use of a machine is the first step of Enery Excel. Training on maintenance is also part of the deal.

They work with women cooperatives to allow for the pooling of funds and easy payments by the cooperatives either monthly or weekly instalment payments.

The machines are small-scale, not big large processing machines. This makes them easy to handle by women, very affordable, and easy to set up and purchase with a flexible payment plan.

Feasibility (max 20 lines)

They started in 2013 with over 7 staff. They also support community-based training to support women and youth, and farmers to empower them on knowledge of the machines and how they work and sot and time savings.

Potential for scaling (max 20 lines)

- Energy Excell works closely with community men and women, farmers and cooperative groups; training them on the use of the machines to ensure easy maintenance and usage.
- The more mini-grids that are coming up in agricultural communities, the more these energy-productive use equipment are needed.
- With more push for small-scale agro-processing machines admitting the country's effort toward economic diversification and carbon emission reduction, the use of energy-efficient machines that run on electricity and solar is a big win-win that should be encouraged more by stakeholders in the climate, energy and agricultural sectors.

Financial and Non-Financial Instruments Received

They work with Africa Development Banks, and RMI and also feed the machines to mini-grids to improve the demand for mini-grids. They have also gotten funding support from Cross-Boundary and technical support from Rocky Mountain Institute (RMI).

Energy Excel is key to getting financing from any donor or investor. All their solutions are demands from clients.

The machines from the smallest to largest range between NGN200,000.00 to NGN800,000.oo

For a start, $100, 000 to $300,000 can be used to energise over 400 – 5000 community women.

Successes

- Over 50 machines have been sold so far by clients directly
- Some communities that use petrol-powered engines are switching to cleaner machines
- More women in these communities now have residual income, making money from processing food with these machines

Challenges Faced

- Financing is still a major machine; if the cost can still be subsidized lower, it will aid more women to take up the solution.
- Mini-grid operators we partner with are also unable to make effective demands after calling for PUE even when households cannot utilize their machines
- Yet to get government support via their support of farmers and processors to take up more of these machines.

Lessons learned

- Start with a market survey to know what the customers want and design solutions to fit them
- Do more training and end-to-end technical support and training to the users of the machine to ensure they work optimally.
- Don't stock up on machines without ensuring demand and fitness of use.

Opportunities Available

- There is a vast opportunity. There are over 70 mini-grids in rural communities, where agriculture is dominant. Yet, these communities do not have machines that can be powered using grids. This is a huge market that should be explored.
- The government farmer anchor borrower program is an opportunity for the government to incentivize small-scale agro-processing. This is also a big window of opportunity that is untapped.

What should we do next (max 5 lines)

Contact Energy Excell Systems and Solutions

Backing documents, knowledge and inspiration

Links to report/backing documents, public articles, audiovisual material, key people

https://www.energyexcell.com/productive-use-of-energy-and-its-benefits/
, video recordings, production fliers, etc

3-5 illustrative photos

CASSAVA PROCESSING MACHINE

TOOTH CLAW FLOUR MILL

WET AND DRY GRINDER

SELF-SUCTION GRINDER

Deployment of Green house Vegetable farm at Nayo Solar Mini-grid Site, kare in partnership with REA/AFDB

Rice threshing and polishing machine used at Nayo Tropical Technology Mini-grid Kilankwa site Gwagwalada

Training of the community Liason officer on the use of Rice Thresher/Polisher, and destoner for PowerGen/RMI pilot project in Niger State

Rice threshing and polishing machine used at Nayo Tropical Technology Mini-grid Petti

ENERGY EXCELL
SYSTEMS & SOLUTIONS

Electric Pressure Cooker Deployed at Chikuku Mini-grid Site

Case 8: Improved Rice Parboilers for Rice & Other Grains

Case Title: DARE Institutional Cookstove Rice Parboilers

Institution: D.A.R.E Nigeria ltd

Contact Person: Mr. Yahaya Ahmed (CEO)

Tel: +2348033110130, 2348084424356

Email: yahaya@gmx.de

Website: www.dareworld.org

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations, networks, individuals, partnerships

The problem (max 10 lines)

Local rice parboilers who are over 70% of the local rice processing in Nigeria, use vast amounts of firewood annually in the production of local rice. This traditional rice par-boiling method is a major source of deforestation and environmental pollution. In many instances, the rice is over-parboiled as it lacks a proper heat control mechanism. This also compromises the quality of rice produced.

The solution (max 10 lines)

The DARE institutional cookstoves, can be used for industrial cooking, as well as par-boiling of rice, grains, oil processing, shea butter, etc It can be powered by biomass; dried agricultural waste like corn hubs, rice husks, kernel shells, sticks and small branches. The inside of the wood-saver rice parboiler is insulated to retain heat and enable fast cooking by over 70% compared to open firewood cooking. It is locally fabricated using local materials. Hence a rich curriculum content for youth skill development. The par boiler is multi-functional as it can be used for larger cooking and parboiling.

With a minimum capacity of 200 litres, it has a lid cover to prevent atmospheric debris from dropping into the pot (compared to open parboiling). Over 80% savings on firewood is estimated based on field trials. The stove also eliminates harmful smoke. DARE's business model is the same as her SBD solution.

Effect and results (max 10 lines)

The rice parboiler have been deployed for other use apart from rice parboiling, it is being used in big restaurants, boarding schools and hospitals in parts of Kaduna, Kano and Katsina. Over 200 of the rice par-boilers have been developed and installed in parts of the country.

The key takeaways (max 10 lines)

Because the parboiler can use other forms of fuel aside from firewood, it has a huge potential to eliminate the waste from rice husk, using it to generate thermal energy for the parboiling of the rice. The rice parboiler can also be used for other purposes aside from rice parboiling. It can be used for parboiling, sterilization and separation of water and other elements. It can be used for large institutional cooking.

Feasibility (max 20 lines)

The stove is constructed from durable military-grade thermal efficient alloy, capable of achieving 72 thermal efficiencies during the heating process as compared to 9.1% achieved by traditional

methods. DARE is renounced for its hands-on expertise in the design and installation of locally made energy-efficient solutions. They have an accumulated experience of over 15 years on energy-efficient solutions for grass root communities. The solution aligns property with the clean cooking initiative of the government to improve clean cooking in Nigeria. The solution also has a very strong economic sense, saving up to 80% of firewood usage and indirect costs compared to traditional open firewood.

Potential for scaling (max 20 lines)

DARE has trained over 50 youths in the fabrication and installation of rice parboilers. They have also worked closely with the rice association in parts of Nigeria like Katsina and Kaduna to test-run the parboilers. The vast use of rice parboilers can be used in the processing of other major stable and cash crops that are normally processed with dirty practices such as open firewood use for palm oil sterilization, palm oil segregation, as well as Shea butter parboiling and others.

Financial and Non-Financial Instruments Received

For reference, the current unit price of the 200 L industrial rice parboiler stove is 4,000.00 EUR. To deploy over 1,000 of the rice parboiler stoves and train more than 500 at least $40,000,000 is required. All the funds used in the development and deployment of the industrial rice parboilers are self-equity and client demand for the product.

Successes

- Successful proof of concept with field data to show the result when the comparison is made between the improved parboilers and open-fire boiling.
- Over 300 parboilers deployed
- For agro-processing that requires boiling and sterilization, the improved rice parboiler is a multipurpose clean stoke for intestinal purposes.

Challenges Faced

- Limited or poor awareness of the solution
- The alternative to using better-improved parboiling – the traditional open boiling is not sanctioned; in other words, the direct cost of an alternative to clean business is most often free.
- Poor food safety standards, regulations and enforcement at community levels
- Lack of funding and financing to upscale the solution is limited

Lessons learned

If the alternative to clean energy solution is free, people will often go for the alternative. Hence, there is a need for government regulations, monitoring and enforcement to ensure that dirty processes in the agricultural value chain are discouraged, and proper incentives are given to farmers and agro-processors who promote clean sustainable methods and technologies.

Opportunities Available

The opportunities for improved institutional parboiling across a variety of agricultural production are huge, especially among smallholder farmers in areas with vast deforestation and energy deficits. The need to expand the waste to energy is on the increase and institutional parboilers such as this, can bridge a wide gap for smallholder farmers and processors using waste from farms to create heat for parboiling in a very efficient manner.

What should we do next (max 5 lines)

Engage with DARE to develop a strategy for deployment.

Backing documents, knowledge and inspiration

Fliers, interviews, etc

3-5 illustrative photos

Case 9: Creeds Energy LiteDey-Mesh Grids for Rural Cluster Communities

Case Title: Efficient Rocket Bakeries

Institution: Creeds Renewable Energy Ltd

Contact Person: Mrs Hannah Kabir

Tel: +234(0)8035997030

Email: hkabir@creedsenergy.com

Website: http://www.creedsenergy.com/en/

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
*Eg: **TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country
Name of involved community groups, organizations,

The problem (max 10 lines)

Over 45% of Nigerian households do not have access to grid electricity. With the decentralized off-grid energy expanding in Nigeria, Creeds had deployed over 1,000 Standalone Home Solar (SHS) systems totalling over 1MWp across ten locations with a strong focus on small to medium Enterprises (SMEs). Since their previous installation, Creeds has identified 2 types of users: (1) High-powered prosumers and local businesses, and (2) Low-powered residential households primarily using mobile charging and lights.

The usage of the lower-powered households was not enough to commercially justify the installation of mini-grids in many areas, while the high-power users often had excess electricity capacity that they did not always use. However, when looking at the options for smaller SHS providers on the market, no other technology providers offered the ability to share power from the high-powered to low-powered users.

The solution (max 10 lines)

Mesh-grid as a means of enabling power sharing with other households. Furthermore, since the mesh-grid kits allowed for a power output of 1.2kW, it would allow for varied use from residential to productive needs. Mesh mini-grid solar systems are particularly suitable for rural areas or remote communities where access to the main grid is limited or unreliable. They offer an affordable and sustainable energy solution, reducing dependence on traditional fossil fuel-based generators and improving the quality of life for the communities they serve. CREEDs offer the community customer an energy-as-a-service model – payment for electricity used per unit; the customers only pay for the electricity supply. CREEDs own the assets and distribution line. This makes energy access affordable to the community.

Creeds Energy is one of Nigeria's leading solar energy services and solutions providers, with a vision to be recognized as one of the top 5 renewable energy companies in West Africa, distinguished by quality, innovation and professionalism. They aim to realize the development of a green economy with low emissions and social inclusivity through the efforts of their knowledge-driven team and network of internationally qualified experts.

Creeds Energy has energized 50 households in Bassa, Nasarawa State, with 24-hour solar energy access using mesh grids from Okra Solar. The project was installed in five days, with households generating clean power instantly. The total project has 10kW of solar PV generation, 51.2kWh of battery storage capacity (LFP), and supplies an average daily load of 460Wh/day, sized for 99% network uptime.

Their target market is small businesses located in underserved on-grid areas with unreliable power supply mostly in urban and unconnected peri-urban and rural communities with potential or productive activities.

Effect and results (max 10 lines)

- By sharing excess power, Creeds was able to get an additional 46 households energized than originally planned – almost double the original target.
- Creeds Energy deploys a 50-household mesh-grid pilot in Nasawara state, Nigeria
- Among the higher productive centres energized in the rollout were a Primary Healthcare Centre (PHC), a mosque, a barber shop and a phone-charging shop. These centres previously ran on diesel generator sets; now they can save money and power themselves with 100% renewable energy.
- The cost per connection for this 50-household pilot was less than $1,000/household, which represents an estimated 30% cost saving compared to delivering the same amount of power (460Wh/day) using a traditional centralized mini-grid.

The key takeaways (max 10 lines)

A mesh mini-grid makes power-sharing from renewable energy possible. With the solution, there is no idle or excess energy supply.

The solution is a step in between a stand-alone solar rooftop system (otherwise called SHS – solar home solution) and mini-grids. It is a very flexible renewable energy design, especially in rural areas where households and agro-processing clusters are within the same proximity.

Feasibility (max 20 lines)

- The project was installed over five days with a team of 20 people, including residents.
- Mesh-grid energizes community in Nasarawa State at 30% cost saving compared with mini-grid
- The mesh-grid kits allowed for a power output of 1.2kW which would allow for varied use from residential to productive needs.
- Creeds installed Okra's XL Kits targeting productive centres and high-powered users and connected them to nearby lower-powered users so that they could share power. By sharing excess power, Creeds can get an additional 46 households energized than originally planned – almost double the original target. This created a so-called Hub-and-Spoke topology.

Potential for scaling (max 20 lines)

CREEDS Energy also supports community women by providing Productive Use Equipment (PUE) like solar dyers, SHS, milling machines, and training to increase electricity utilization, increase income for women and empower youths.

CREEDs Energy is also training the locals in the community mostly youths, who they engage as connectors, customer supports, and light maintenance services in the community.

The scale-up phase of the project will see Creeds electrifying an additional 910 households and businesses spread across the Bassa community and the nearby market area. These areas currently lack access to electricity altogether or are predominantly using diesel generators as a primary source of electricity.

The scale-up project will also energise a mosque and a health care centre, creating a green hub in the centre of Nasarawa State. In 2015, the United Nations set out to achieve the Sustainable Development Goals by 2030, including SDG7: clean and affordable energy access for all. Nigeria still has about 90 million people without basic energy access, but projects like this one in Bassa are an example of how local companies are using innovative approaches to make an impact.

Creeds has a track record of deploying successful projects and is aiming to rapidly expand its mesh-grid portfolio to 910 households with the financial support of the Rural Electrification Agency's Solar Power Naija program.

Financial and Non-Financial Instruments Received

Initially, the project was designed to provide a target output of 460Wh/day with two days of battery autonomy. For 50 households, this came out to be:

- ✓ $32,094.64 total, or $642/household connection, which represents an estimated 30% cost saving compared to delivering the same amount of power (460Wh/day) using a traditional centralised mini-grid.
- ✓ ₦4,000 targeted Average Revenue per User (ARPU)

After Creeds reconfigured the mesh grid in their preferred Hub-&-Spoke design the delivered capex average cost per connection was reduced to $450/household. One consideration is that the hubs are prioritized for power availability, and the spokes take excess power. Currently, the network is performing at over 99% up-time.

They are looking to scale up and deploy new projects using a modified Hub-and-Spoke configuration of the mesh grid to reduce cost per connection. In addition to sweat equity, Creeds has raised funding from various investors aligned with its mission and growth strategies:

Successes

- 50 community households connected to a mesh grid system
- Approximately 400Wh/day is generated on the average
- The actual Average Revenue Per User (ARPU) is N3500; N500 less than the original modelled

Challenges Faced

- Local governance structure in the community can be a challenge as any disharmony in the community leadership is a problem
- Competition with other mini-grid communities for customers in the community can be a problem
- Need for respect of the agreement between local community members and CREEDS Energy

Lessons learned

This mesh-grid project has enabled small businesses and prosumer households to receive productive power and supply excess power to surrounding lower-power houses. By splitting the costs between several users, energy availability is made higher. As the village grows and energy needs increase, the Spoke houses can graduate to becoming Hubs with full Kits and extend the network further.

By these measures, we can see that the pilot project has been a success for the community and Creeds.

Opportunities Available

Partnership with Okra has ushered in endless possibilities for delivering energy access to the multitude of households and businesses in need. The first of many, this project showcases the potential of Creeds Litedey model with emerging technologies and solutions aimed at powering prosperity."

What should we do next (max 5 lines)

Engage CREEDS Energy to do a mapping of cluster agro-processing communities in the sample state, and engage with local authorities in the communities, local government and state to ensure buy-in and support to the project as a community development initiative. CREEDS Energy and the development lead can also approach REA and the National Primary Health Care Development Agency (NPHCDA) to see how the mesh grids can be expanded from the electrifying health care and school programs.

Backing documents, knowledge and inspiration

https://www.okrasolar.com/case-study/creeds-energy-deploys-a-50-household-mesh-grid-pilot-in-nasawara-state-nigeria

https://sun-connect.org/mesh-grid-energizes-community-in-nasarawa-state-at-30-cost-saving-compared-with-mini-grid/

https://www.okrasolar.com/what-is-a-mesh-grid

3-5 illustrative photos


DC/AC POWER INVERTER
600W
OKRA


SOLAR DRYER
SOLAR DRYER
SOLAR DRYER

Case 10: Consistent Energy: Solar for Small Business – Pay Small Small

Case Title: Solar for SMEs

Institution: Consistent Energy

Contact Person: Segun Adaju

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Email: segun@consistent-energy.com

Website: https://consistent-energy.com

Theme: (1) food systems or 2) renewable energy

Strategy (1 lines)
To [*what to win*] **in** [*where to play*] **by** [*how to win*].
Eg:
***TO** create electricity generation from renewable energy sources **IN** x region **BY** engaging people in community-owned model from the get-go.*

Summary (4 lines)
What is the main idea and its potential?

Place and constituency:
Name of location and country

The problem (max 10 lines)

There are over 41 million MSMEs in Nigeria with over 75% of them running on petrol generators from 1 – 10 hours daily. As such, more than US$10 billion is spent annually by these segments to fuel generators. Target customers include barbershops, betting shops, market stalls, pharmacies, schools, agribusinesses etc. that require energy for productive activities. We have carried out several market studies to determine the ability and willingness of customers to pay and results show SMEs especially barbershops, salons, frozen food vendors etc. spend an average of $15 – $35 weekly to power their generators.

The solution (max 10 lines)

Consistent Energy solves the problems of MSMEs through:

- ✓ Availability – deploying solar rooftop solutions (SHS) that are robust and have been tested and trusted
- ✓ Accessibility – they reduce to the barest minimum the entry requirements for MSMEs to access solar technologies
- ✓ Affordability – they finance solar thereby eliminating the constraint of initial capital cost of adoption for the energy user.

They create wider access to energy for productive use through pay-as-you-go or energy-as-a-service business models. This also allows rapid uptake of solar as beneficiaries can adopt with a low entry down payment and instalments. They also adopt digital finance via mobile money to de-risk investments with over 100% mobile penetration in the country. Their system increases productivity, creates more employment and reduces the negative impact of climate change as it displaces numerous generators and kerosene lanterns.

Their market remains the over 40m SMEs 80% of which are powered by small generators spending an average of $1600 yearly on fueling. The Total Available Market (TAM) is $10b annually with a Serviceable Available Market (SAM) of $0.5b. The competition is the small gasoline generators.

Effect and results (max 10 lines)

Consistent Energy started operations in 2016 to deploy stand-alone rooftop solar to SMEs for productive use with the pioneering of solar barbershops in Nigeria. To date, they have deployed well over 2.5MWp of cumulative energy and displaced over 2,500 small generators which consume an average of 2,000 litres of fuel per year.

The key takeaways (max 10 lines)

Consistent Energy offers a lease-to-own and pay-as-you-go business model to SMEs with a minimal down payment and options to pay over 2-3 years on an equal and weekly repayment. They work with trade associations, cooperatives and groups of SMEs and take cross-guarantees. They have also deployed PaygOps software for collections with remote monitoring and deployed the SolarDirect brand to create energy access for small businesses.

Feasibility (max 20 lines)

- ✓ Consistent Energy has 24 permanent staff and over 50 trained on-call engineers, and have opened new branches in Abuja, Kano, Akure, Ibadan, Calabar and Lokoja.
- ✓ They have attended training on Business models for off-grid electrification, technical solar PV installation, customer service, credit management in the energy sector and many others
- ✓ They have successfully developed business models that align with the spending patterns of potential clients e.g. payment by instalments, lease-to-own, PayGo etc.
- ✓ Promote continuous involvement and consultation of local authorities, monitoring of market trends, reacting to market changes and developing alternative strategies to make their solution not only adaptable but also ensure a good investment recovery rate.
- ✓ Smart payment and metering approach to incentivize payment; Install advanced management systems equipped with tamper protection to enable remote disconnection of non-paying customers.

Potential for scaling (max 20 lines)

Pay-As-You-Go solar creates more opportunities for small businesses as data collection aids further opportunities. The opportunity for scale is the total assessable market size of $ 10 billion annually and the assessable market for the company is $ 500 million.

Their successful alignment with industry/SME associations to promote a sustainable ecosystem for RE and EE e.g. Legislation advocacy for business easing

Their growth strategy is to deepen penetration in urban and peri-urban markets such as Lagos, Abuja, Kano, Akure, and Uyo. SMEs in Lagos alone spend almost $2 billion annually to purchase

fuel for generators, with over 145 days of outages in a year. They plan to displace 250,000 generators with their technology by the year 2030.

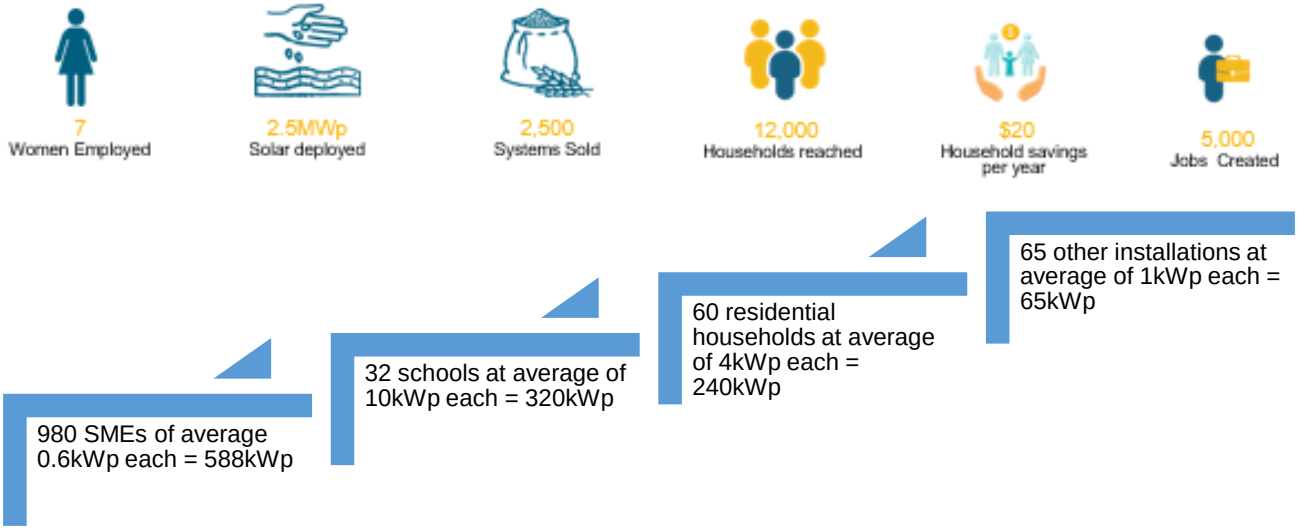
Financial and Non-Financial Instruments Received

Their project targets over 20,000 small businesses and households in 4 years (100,000 beneficiaries) with about 2MW of off-grid clean energy installed. 100 direct jobs and 500 indirect jobs are projected to be created by the project. A total of $2.5m - $5m private capital is expected to be leverage funding. They propose an investment memo seeking a total of US$2.25m to scale the project at an equity IRR of 24% and project IRR of 30% with an exit plan of 5-7 years.

Their authorised capital is being enhanced from 10 million units to 100 million units of ordinary shares. They are willing to offer equity investors up to 40% of the business. Break-even is projected to be achieved with a monthly sales revenue of US$600,000. An additional 200,000 connections (1 million beneficiaries) are projected to be achieved by Year 2030. Consistent Energy has attracted debt financing from Sterling Bank Nigeria and the Bank of Industry of N50,000,000 for the project. They also enjoy some grants and partnerships with SunKing Solar. They have also raised funding support from AECF to the tune of a $240,000 repayable grant and a $160,000 grant. They have also secured a grant of $300,000 from CLASP to deploy solar fridges to SMEs.

Successes

The company has deployed over 5,000 SHS (80% of beneficiaries are women) and over 1,000 rooftop solar for SMEs with an emphasis on productive uses. They have also distributed over 5,000 pico solar systems.



Challenges Faced

- ✓ Low capacity to finance initial capital outlay of adopting solar for productive uses
- ✓ Limited access to finance and the high cost of solar energy technologies are the leading constraints to the adoption

- ✓ Capital scarcity – liquidity constraints in domestic banking: Limited availability of long-term domestic loans
- ✓ Limited domestic investor experience with RE Fluctuating interest rates.
- ✓ Uncertainty due to volatile local currency: unfavourable FX rate movements resulting in a domestic currency not being sufficient to cover debt/equity servicing.

Lessons learned

- ✓ For financial sustainability, pursue dual international and domestic financing approaches, and ensure fixed-rate financing
- ✓ Collaboration and sustained engagement with business associations especially SMEs, markets and cooperatives is a great way to guarantee repayment.
- ✓ Awareness raising through experience sharing from existing users of the solution is the most effective way to decrease patronage and adoption of the solution; before this, the solution must be guaranteed quality.

Opportunities Available

With the removal of fuel subsidies, and the over 41 million MSMEs operating in the country with many depending on fossil generators; running for an average of 4–10 hours per day, the cost of running the business will be enormous compared to sales return. Hence, many SMEs will need tailored fit clean relabable, easy-to-pay solar systems. This is a big growth opportunity. Consistent Energy has also signed agreements with microfinance institutions to connect their SME customer base and enable easy pay-to-own packages.

Through their Sales Agents, they plan to reach the last mile efficiently and offer electricity as a service to customers across the SME value chain.

What should we do next (max 5 lines)

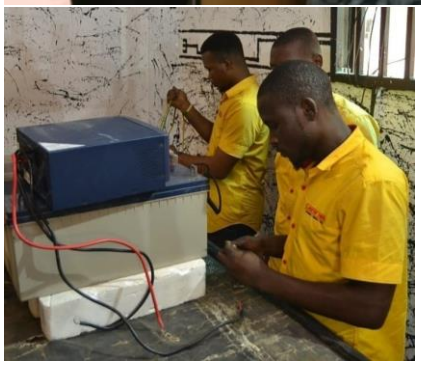
Build on the existing relationship between Consistent Energy and the various associations and microfinance banks to explore means of energizing target SME members of the associations or the bank customers in specific locations who need and are committed to paying for the Solar for SMEs.

Backing documents, knowledge and inspiration

https://consistent-energy.com/news/, https://www.instagram.com/solardirectng/
https://www.dw.com/en/nigerias-solar-stylists/video-38204341

REACT HS R2 Project Pitch slides and videos on solar barber

3-5 illustrative photos



Conclusion and Recommendation

Smallholder farmers, especially in rural Nigeria communities, generate close to 80 per cent of organic wastes such as manure, tree trimmings, grass clippings, and crop residues such as rice husk, rice straws, maize stalk, maize husk, maize cobs, cassava peels and stalk, groundnut shells and straws, soybeans pods, sugarcane bagasse and leaves, and cotton stalk, palm kernel shells and oil sludge, etc. Over 40 per cent of agricultural production is already wasted in Nigeria, as the sector contributes over 25 per cent of CO2 emissions. The waste in rural agricultural processes can be attributed to the vast energy deficit in the country. Over 45% of the Nigerian population mostly in rural communities lack access to grid electricity. The fraction of the population connected to the national electricity grid has to augment the poor grid supply with expensive, dirty polluting fossil generators. Over 20 million fossil generators are used in Nigeria mostly by small and medium-scale enterprises, many of which operate as agro-processors in rural areas.

Despite having a National Agricultural Technology and Innovation Policy (NATIP) 2022-2027, and the expansion of decentralised renewable energy projects and programs in Nigeria, small-scale agro-processing in the country continue to be neglected and unconnected.

To ensure a sustainable transition to clean reliable agro-processing and better off-grid electricity for rural communities and small businesses, this study has identified and documented twenty-six (26) cases of dirty, unhygienic, and polluting agricultural processes or businesses along various crop value chains and businesses in Nigeria. The study also presents ten (10) viable clean alternative cases to the identified dirty cases.

The study recommends the following five (5) clean cases to be included in the alternatives database under the Global Programme on Climate Justice, based on the following reasons/criteria:

6. **Case 4: Quintas Energy – Biomass for Agro-processing value chain & electrification.** The solution covers a wide variety of crops, (i.e. cassava, palm oil, yam, plantain). Unlike the other solution, it promotes a circular farm system with zero waste. The biomass machines use up the generated waste from the crops. The technology also produces heat, steam, and electricity. These are all that is needed in the processing of food; either for drying, boiling or electricity for cooling and lighting. The solution is also very affordable and is based on local fabrication technology using local materials. The latter ensures local technological transfer and development.

7. **Case 9: Creeds Energy LiteDey-Mesh Grids for Rural Cluster Communities.** The idea of electricity sharing in cluster communities in rural areas is not only novel but brilliant. The business model of electricity as a service; where the customer/connected household need not own the electricity assets, but pay only for the electricity supply, reduces the business risk drastically and makes electricity more affordable. The technical viability of electricity sharing between households and processing centres and public utilities (i.e. PHCs and Schools, etc.) improved electricity utilization capacities. The solution makes it easy for mesh-connected communities to purchase PUE for their small-scale agro-processing such as solar dryers, small milling machines, etc.

8. **Case 2 and 8: DARE Solar Bubble Dryers and Parboiler.** D.A.R.E-produced parboilers and solar bubble dryers are perfect to address food wastage and the popular practice of open

sun drying in northern Nigeria. Considering the massive grain production in northern Nigeria and the massive use of firewood for parboiling (and the subsequent deforestation and scarcity of scrubs), the energy-efficient parboilers are a perfect solution for the region. The solution provider also has rich use of local content, vast sustainable training elements that target youths, and good feet in local communities in the region.

9. **Case 3: Roshan Renewable Happy Clean Stoves to Reduce Firewood for Cooking & Industries.** Roshan clean stove solutions are practical and reliable. The efficient cook stoves provide the gradual shift needed from traditional open-fire cooking to 100% clean cooking. A lot of renewable energy developers and LGP promoters have executed a lot of campaigns and projects on LGP cooking and processing in rural areas. Too many of these LPG projects are in rural areas all right after the gas cylinders go empty, as the communities lack both will, financing, and proximity to LPG filing locations. The Roshan clean stoves for homes and industrial use. i.e. boilers ensure efficient and reduced use of firewood and are now promoting the use of briquettes. The intervention has received lots of acceptability in communities where it has been implemented. The flexible payment models also make the solution viable.

10. **Case 10: Consistent Energy: Solar for Small Business – Pay Small Small.** The only case that shows the largest potential of displacing the use of fossil generators by small and medium scale businesses, especially in the trade and services such as barbershops, salons, frozen food vendors, kiosks, community viewing centres, etc., is the Consistent Energy's solar instalment payments. The business models where target energy user pays monthly fees equivalent to the cost of fuelling their generators or kerosene lanterns have proven to work perfectly well. This is evidenced in the number of their connected customers. The tripartite arrangement among Consistent Energy (energy provider), the local trade association/microfinance banks, and the customer default in the agreement rates very low.

In conclusion, energizing agricultural processes must be a deliberate one, a primary objective, not an afterthought interventional to increase the economic viability and bankability of already installed solar mini-grids. Since over 70 per cent of agricultural products and processes are done by small-scaleholder farmers, most of whom are women, mechanisation projects, programs and schemes need to be tailor-fit solutions that meet the sector demography and realities.

Energy transition proposals need to allow for the gradual shift away from traditionally-manual processes, to energy-efficient use of fossils, and then 100% clean energy use. Transition to clean energy solutions cannot be rushed or coerced into without first ensuring local acceptability (measured by the ability to pay, willingness to pay and actual payments).

Locals will hardly adopt or take up any efficient, clean energy solution if the cost of operating in dirty businesses and/or agricultural practices is free and has no direct economic cost/consequences or sanction to the user. In other words, for alternative clean solutions to thrive, a multi-stakeholder approach is needed to promote clean hygienic solutions and stress the direct consequences of dirty polluting practices.

Stakeholders

Renewable Energy Companies with Special Focus on Energizing Agriculture Value Chain & Energizing Rural Homes:

DARE Developmental Association for Renewable Energies

ENERGY EXCELL SYSTEMS & SOLUTIONS

ROSHAN Renewables

FARM WAREHOUSE

PRADO POWER

PowerGen Energy Excell Systems and Solutions

Quintas RENEWABLE ENERGY SOLUTIONS

CLEAN COOKING ALLIANCE

Coldbox Store

HUSK.

ONE ACRE FUND

Solmenz Engineering

max

afrimash

Cold Hubs

CREEDS ENERGY

KOOLBOKS LIFE IS KOOL

Solar Mini-grid companies:

Solar Home Solar (SHS/SAS) companies:

Financiers, Development Partners & Technical Support:

Legal & Financing Consulting. Innovation Hubs & Research Firms:

Regulators:

Implementing Partners in Government:



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