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TETRA TECH

Scaling Productive Use of Energy Solutions in Sub-Saharan Africa:

Market Scoping and Design of a Results-Based Financing Window for the PUE Sector

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Acronyms/Abbreviations	Definition
ADELE	Access to Distributed Electricity and Lighting in Ethiopia
AECF	Africa Enterprise Challenge Fund
AfDB	African Development Bank
ANSER	National Agency of Rural Energy Services (DRC)
B2B	Business to Business
BGFA	Beyond the Grid Fund for Africa
C&I	Commercial and Industrial
Capex	Capital Expenditure
DFC	Development Finance Corporation
EnDev	Energising Development
EU	European Union
FASER	Fund for Sustainable Access to Renewable Energy
Forex	Foreign Exchange
GCF	Green Climate Fund
GEAPP	Global Energy Alliance for People and Planet
HFE	Health Facility Electrification
kg	Kilogram
kW	Kilowatt
MCFA	Modern Cooking Facility for Africa
MFI	Micro Finance Institution
MOPO	Mobile Power
Nefco	Nordic Environment Finance Corporation
O&M	Operation and Maintenance
Opex	Operating Expenditure
PAYGO	Pay as You Go
PPA	Power Purchase Agreement
PREO	Powering Renewable Energy Opportunities
PUE	Productive Use of Energy
R&D	Research and Development
RBF	Results-Based Financing
SACCO	Savings and Credit Cooperatives
SBCF	Somali Business Catalytic Fund
SEFFA	Sustaining Energy for Smallholder Farmers
Sida	Swedish International Development Cooperation Agency

SIR	Solar Irrigation Rwanda
SDG	Sustainable Development Goal
SHS	Solar Home Systems
SMEs	Small and Medium-Sized Enterprises
SSA	Sub-Saharan Africa
SWP	Solar Water Pumping
UNDP	United Nations Development Programme
UNEF	United Nations Environment Programme
UEF	Universal Energy Facility
USADF	United States African Development Foundation
VAT	Value-Added Tax
WE4F	Water and Energy for Food

1. Executive Summary

This study was commissioned by the facility manager of the Beyond the Grid Fund for Africa (BGFA) and funded by the Swedish International Development Cooperation Agency (Sida) with the aim to expand their productive uses of energy (PUE) activities. BGFA provides funding in the form of results-based financing (RBF) for companies selling solar home systems (SHS) and developing mini-grids, including those that incorporate PUE appliances and applications into their portfolios. BGFA has over €126 million to support projects in Burkina Faso, Democratic Republic of the Congo (DRC), Liberia, Mozambique, Uganda, and Zambia. The Governments of Sweden, Denmark, Norway and Germany (via KfW) are also contributing to the fund. As of December 2022, BGFA had signed contracts with 13 projects that expect to provide over 953,000 connections. BGFA has signed with one pure-play PUE company, Tulima Solar in Uganda, and at least six other portfolio companies incorporate PUE into their products, including solar water pumps, fridges, and freezers. Three of these companies are using over 60 percent of RBF for PUE. BGFA provides TA for the sector, including advocacy for policy, regulation, and fiscal incentives as well as a program of TA to portfolio companies.

As the off-grid sector continues to grow and evolve beyond basic household lighting, and as utilities strive to stimulate additional demand, attention by government, donors, and the private sector has turned toward boosting PUE by consumers. PUE has broad socio-economic benefits for the population, including economic growth, income generation, job creation, and often reduced workloads that allow time for additional productive activities.

This report consolidates findings from interviews with over 70 stakeholders as well as a literature review. The scope includes applications that generate income and create employment for socioeconomic development with a focus on the sectors described above and the 15 countries in sub-Saharan Africa with whom Sida has bilateral partnerships.

Multiple donor-led initiatives have emerged in the past few years and have been instrumental in helping the PUE sector grow. These range from more upfront milestone-based grants to pure RBF programs and are most effective when led or backed by governments that signal strong support for market-led deployment of productive use solutions.

For nascent markets, challenge funds and milestone-based grants are generally most appropriate as companies continue to conduct research and development of products and test customer acquisition strategies and refine business models. Lack of availability of equity and debt for these startups makes it difficult for them to take advantage of RBFs where payments come only after verification of sales. The availability of grant funding alleviates the need for companies at this stage to spend their own limited funds, which are often inadequate for their business needs and which ultimately increase the price of the final product, exacerbating the affordability problem.

More mature companies that can secure their own funding are more likely to take advantage of RBFs, though some may struggle to achieve the sales volumes required by donor programs. Working with companies that operate in multiple countries, including manufacturers that not only operate in several geographies but also work with multiple distributors, can help increase ticket sizes. Working with well-established SHS and mini-grid companies can enhance the chances of success, though RBFs should ideally be open to businesses that focus purely on PUE. To avoid market distortion and the exclusion of existing market players, especially local ones, programs could be open for extended periods and accept applicants on a rolling basis to mimic a subsidy that is available sector wide and benefits all companies. Even with such a scenario, donor flexibility can still result in requirements that are difficult to meet and effectively exclude smaller players.

Guarantees can also support the most mature companies seeking loans for larger ticket sizes through bilateral transactions or lenders that wish to establish a portfolio of PUE companies or PUE end users. Guarantees could enter at different levels, either directly to manufacturers and distributors or as supplier credits to distributors through receivables financing and microfinance institutions lending to consumers. Existing guarantees could also be modified to incorporate PUE, if appropriate, to reduce the high transaction costs of establishing new guarantees.

The range of donor-funded interventions mentioned above is welcome by the private sector. However, companies have often noted difficulties with these initiatives, including long procurement times, lack of flexibility to adjust program requirements midstream to account for realities on the ground, the high administrative burden of monitoring and evaluation requirements, and the potential for market distortion. While these problems are sometimes difficult to avoid, governments and donors should strive to make additional efforts to involve companies extensively during the design phase to address potential issues.

Technical assistance (TA) and policy and regulation can additionally be helpful for creating a conducive enabling environment for the private sector. Most PUE programs include a TA component, which should be of high quality and tailored to specific needs. It should ideally support a range of stakeholders, including end users and financial institutions in addition to companies and governments. Policy and regulation can play a critical role in raising awareness, while exemptions from taxes and duties can reduce prices to help address the affordability issue. Strong support signals from government will also give confidence to the private sector, encouraging investment in businesses that focus on deploying PUE.

Numerous recent PUE initiatives have resulted in some success, but these have been relatively small and there is nothing yet at scale. Challenges to deploying PUE are significant, including the higher cost of equipment compared to smaller SHS, affordability, risks in providing financing to entrepreneurs who can struggle to earn enough additional income to make reliable payments, fewer potential sales per village in remote rural areas, complications in the supply chain and after-sales servicing, the need for customization, competition with incumbent technologies, and challenges in customer acquisition and awareness.

Despite these challenges, some technologies are starting to scale in a few notable areas, but broadly speaking, the PUE market is nascent with only a few more advanced technologies, generally in East Africa. Solar water pumping is the most advanced sector, but refrigeration and cold storage, agricultural processing, and e-mobility are starting to show promise. In addition, companies are beginning to provide financing for appliances in on-grid and mini-grid settings, and governments are starting to work with donors and the private sector on providing solutions for health facility electrification.

As attention to productive uses of energy grows, stakeholders continue to identify and address gaps. Given the inherent unpredictability of nascent markets and the numerous challenges faced by the private sector in deploying PUE, governments and donors should co-design initiatives with the private sector and maximize flexibility in programming to the extent practicable. With the range of necessary components gradually falling into place, the PUE sector is poised to scale along with the ambitions of governments and donors to support energy access beyond basic needs and toward enhanced economic growth through new employment opportunities and increased income generation.

2. Methodology

A team of consultants conducted this assessment using data and insights from a range of sources, including a review of literature and more than 70 interviews with stakeholders in the productive use of energy (PUE) sector. The list of interviewees and reports was crowdsourced within Tetra Tech's energy unit and through subsequent interviews with experts. Information was gathered with a focus on applications that generate income, particularly for those living under the poverty line or close to it.

From the literature review and interviews, the consultants compiled data, summarized in Section 2.0, for each of the main PUE categories of interest to the Swedish International Development Cooperation Agency (Sida) and Nefco — the Nordic Green Bank, which is the facility manager of the Beyond the Grid Fund for Africa.

- Agriculture
  - Solar water pumping (SWP)
  - Cold storage
  - Agricultural processing
- E-mobility
- Mini-grid/on-grid appliances
- Health facility electrification (HFE)

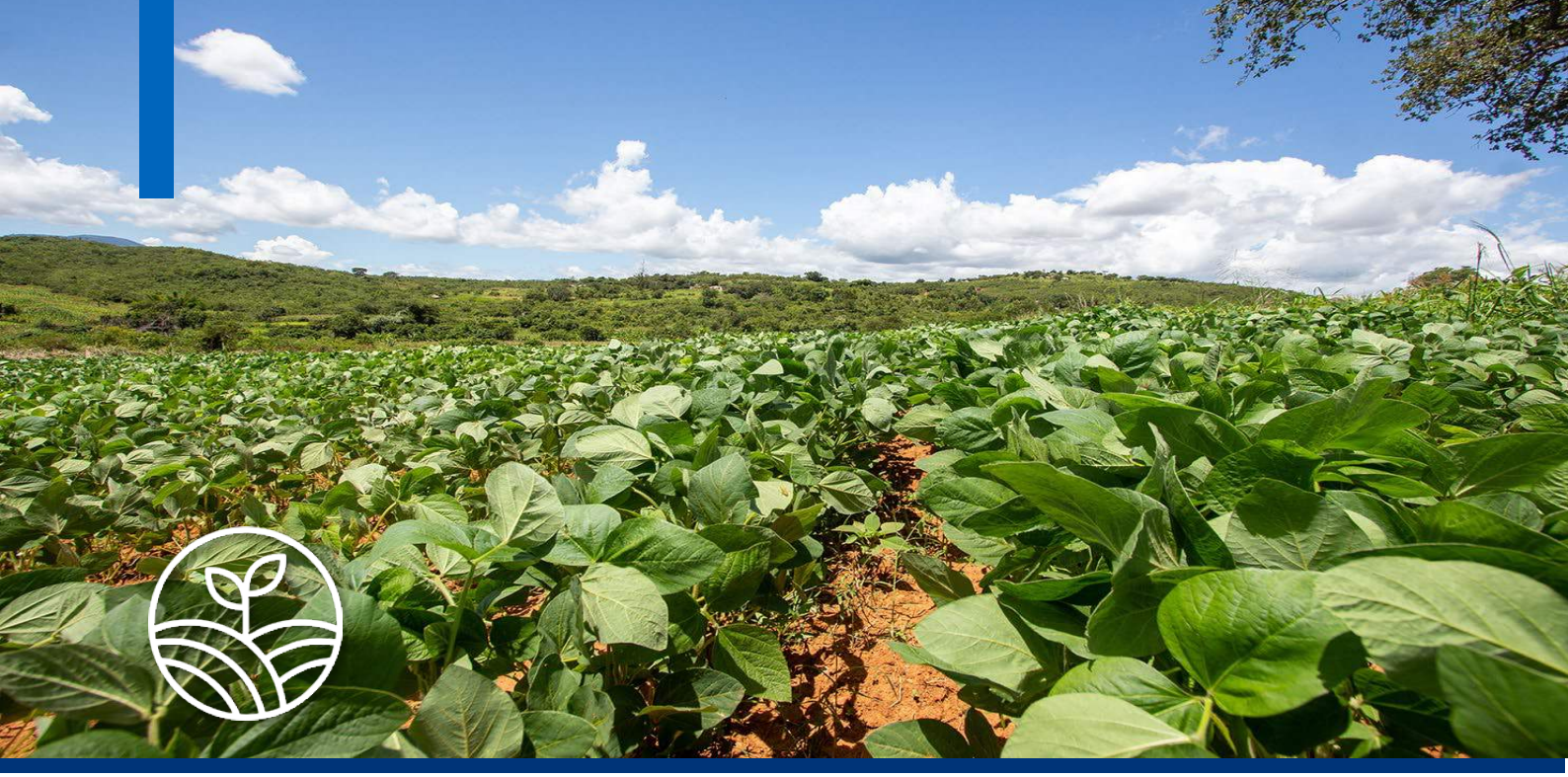
Section 3.0 contains analysis of these categories, resulting in overall lessons learned in policy and regulation, donor programs, finance, business models, and technical assistance. This analysis is based on the findings from our interviews and literature search.

Section 4.0 summarizes key takeaways and recommendations from the findings in the previous section with a particular view on how to deploy available funding from development partners and governments. A range of potential options are presented, including existing mechanisms already supporting PUE.

Section 5 contains profiles for each focus country of the assessment—Burkina Faso, DRC, Ethiopia, Liberia, Kenya, Mali, Mozambique, Rwanda, Somalia, South Sudan, Tanzania, Uganda, Zambia, and

Zimbabwe. Each country profile outlines information relevant to the PUE sector, including key government and development partner support as well as the activities of the most active private sector companies.

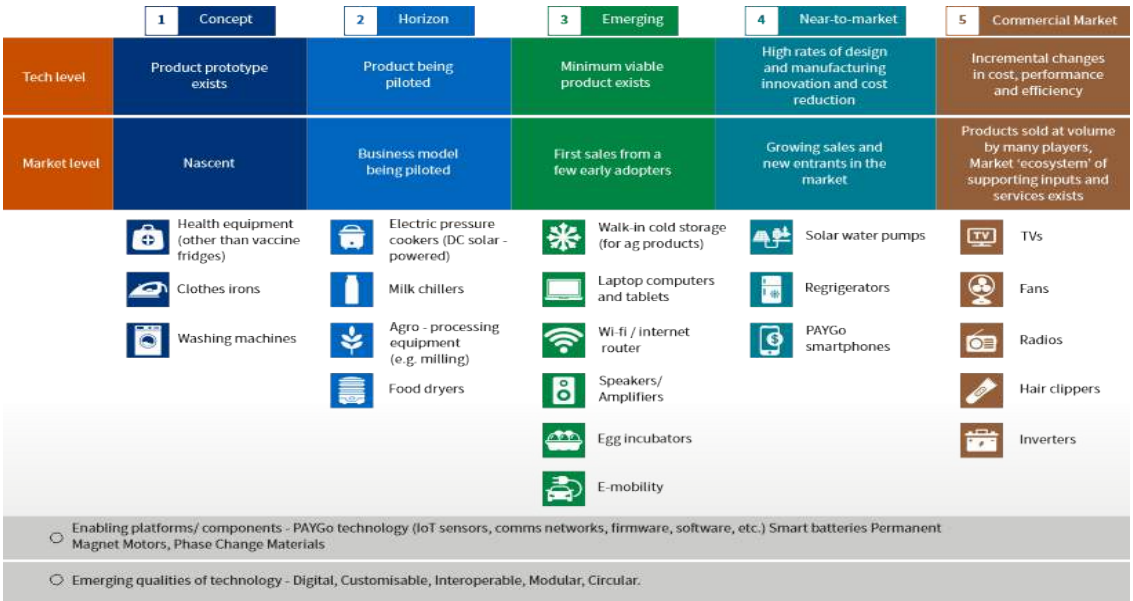
While no definitive sales numbers exist, GOGLA collects data from its members on sales of solar water pumps, fridges, TVs, and fans. Note that the data provided by GOGLA mentioned in the country sections are sales reported by their members and only represent a fraction of the total market. Furthermore, in any particular six-month period for which GOGLA makes their data requests, some companies will fail to respond. Additionally, numbers are aggregated in an effort to maintain confidentiality, and a number cannot be reported when fewer than three companies contribute to the total. For these reasons, the GOGLA sales data can only provide a partial view of the sector as a whole but can, in some cases, provide some limited insight and indicate broad trends in the market.



3. PUE Sectors

The PUE and off-grid sectors have been emerging at a rapid pace in the past few years, already powering around 10 million medium and small enterprises, including those involving smallholder farmers with more than 190,000 farms currently using solar irrigation systems worldwide, according to the latest World Bank *Off-Grid Solar Market Trends Report 2022*. In addition, approximately $7.7 million out of $10 million in grants globally in the off-grid sector went to PUE in 2021.[1] Solar water pumping and solar refrigeration were classified in 2020 as "emerging technologies" and have now evolved to "near-to-market."

Figure 1. Classification of PUE Appliances.



From World Bank. *Off-Grid Solar Market Trends Report 2022*, (p. 137)

[1] World Bank. Off-Grid Solar Market Trends Report 2022, 137.
https://documents1.worldbank.org/curated/en/099235110062231022/pdf/P175150063801e0860928f00e7131b132de.pdf

The sectors featured more prominently in the terms of reference for the following report coincide with the ones that interviewees and reviewed reports highlighted as the most important areas of focus. They are organized as follows in this section:

- Agriculture
  - Solar water pumping
  - Cold storage
  - Agricultural processing
- E-mobility
- Mini-grid/on-grid appliances
- Health facility electrification

The general availability of these technologies in the broader market in sub-Saharan Africa is briefly described along with a more in-depth characterization of each sector based on the information and insights gathered from interviews and key reports.

The following table summarizes general product descriptions and indicative, sample prices adapted from the ESMAP *Off-Grid Solar Market Trends Report 2022*[2] and for e-mobility and HFE offerings from other sources. Pricing varies widely and depends on sizing, quality, and other factors, and the ranges below should not be taken as definitive.

Table 1. PUE Prices from ESMAP Off-Grid Solar Market Trends Report 2022

Productive use appliances			
Product Category	**Application**	**Indicative Price Range ($)**	**Example**
Solar water pumps (up to 2 kW)	Solar water pumps improve irrigation and extend the growing season for rural smallholder farmers.	$107 - $7,630	 *Photo credit: Futurepump* Futurepump SF2 Solar pump
Refrigeration units (up to 300 L capacity)	Off-grid refrigeration units reduce the risk of food contamination and preserve perishable produce and beverages for both households and small shops in rural, remote communities.	$72 - $1,817	 *Photo credit: Koolboks* Koolboks Refrigerator
Cold-storage solutions (>300 L capacity)	Solar-powered cold-storage solutions enable larger scale preservation of produce, meat, and dairy products, targeted mostly as small businesses.	$3,456 - $150,000+	 *Photo credit: Ecozen* Ecozen Eco Frost

[2] Ibid., page 150.

Productive use appliances			
Product Category	**Application**	**Indicative Price Range ($)**	**Example**
Agro-processing equipment	The most common agro-processing application is solar-powered grain milling, given the importance of the maize value chain in sub-Saharan African markets.	$660 - $1,310	 *Photo credit: Agsol* Agsol Solar Powered Mill
E-mobility	Electric vehicles, from motorbikes to buses, can be cheaper to operate and more environmentally friendly.	$1,000 - $40,000	 *Photo: Ampersand* Ampersand Electric Motorbike
Health Facility Electrification	Solar-powered energy solutions enable enhanced services for small health posts to large district hospitals.	$3,000 - $80,000	 *Photo: Adobe Stock* *Power* HFE Solutions

Although there are linkages between PUE and clean cooking, the technology was left out of scope of this report as Nefco and Sida have another activity dedicated to it with the Modern Cooking Facility for Africa (MCFA). Customers purchasing electric appliances, especially women who often do most of meal preparation, reported monetary savings through cheaper fuel costs compared to charcoal (especially using electric pressure cookers) or time savings that allowed for income-generating or other useful activities. In this sense, cooking with electric appliances could be considered productive.

A few key companies manufacturing, distributing, and selling a range of PUE products are also profiled throughout the section where relevant, as outlined in Table 2. The companies were selected based on their financial maturity and potential to absorb an RBF and other financing instruments such as guarantees; others were recommended by Sida country missions, Nefco, and other donors and stakeholders that referenced them during interviews.

Table 2. Key PUE Companies Profiled for the Assessment

Company Name	PUE Sector	Key Countries of Operation
SunCulture	Solar water pumps	Kenya, Uganda, Togo, Zambia, Ethiopia, Senegal, and Cote d'Ivoire
Simusolar	Solar water pumps	Uganda, Tanzania
SureChill	Solar fridges	DRC, Ethiopia, Kenya, Mali, South Sudan, Malawi, Zambia, Zimbabwe
InspiraFarms	Solar cold rooms	Kenya, Zimbabwe
Agsol	Solar milling	Kenya
Ampersand	E-mobility	Rwanda, Kenya
Mobile Power	Battery Swapping	Sierra Leone, Liberia, Nigeria, Uganda, Zambia, Gambia
Energrow	Appliance financing	Uganda, Kenya
E-Longlife	Solar Standalone and Appliances	Mali, Chad, Niger
Differ	Health facility electrification	Malawi, Zambia, Kenya

Subsidy levels vary significantly depending on geography and even within the same country, unit economics can drastically change depending on the region. For example, the water table depth could double or triple the price of the pump or a drought-resistant crop can drastically cut the cost, making the unit viable again. As reported in later sections, governments such as Rwanda, Uganda and Togo have opted for high subsidies between 75 percent and 90 percent of the cost of the system for irrigation while donor-funded programs such as CLASP rely on reverse auctions and smaller level grants that include not only product deployment but also support through R&D subsidies and other basic market research. These interventions are discussed in Section 3.1 of the report.

3.1 AGRICULTURE

Challenges

- Business models may need to be adjusted across **different value chains**.
- Financing schemes can only work if the farmer successfully grows and brings **products to market**, with potential for problems along each step of the way.
- **Customer acquisition** takes significant effort.
  - PUE companies must **raise awareness** of their technologies and convince risk-averse farmers that buying the equipment or service will ultimately lead to an increase in income.
  - Farmers that can **afford** the PUE equipment may be difficult to find.

- The farmer should have the **knowledge and expertise** to choose the right crops, implement good agricultural practices to maximize yield, and conduct post-harvest processing.
- If applicable, the farmer may need to **learn how to use the equipment** properly. Technical assistance is often needed.
- The farmer must be able to **access the market** to sell the product.
- **Harvest timing** and therefore source of income could be spaced too far apart for repayments structured for PAYGO or other financing models, particularly for unbanked farmers.

Market Size

- The PULSE report estimates the **addressable market in pumping, cooling, and processing** to be about **$11 billion in Sub-Saharan Africa**. Factoring in affordability, the **serviceable market** drops to around **$700 million**.[3] With financing, that number increases, but even smaller payments over time are often still unaffordable for many farmers.
- The serviceable market should grow as prices of equipment drop due to economies of scale and technology development and rising farmer incomes due to general economic growth.

3.1.1 SOLAR WATER PUMPING

Challenges

- Solar water pumping is arguably **the most mature of the PUE sectors** considered in this report. However, there is still a **massive unserved population** and significant challenges to bringing the technology to scale.
- **Awareness** is cited as one of the top barriers that needs to be overcome before a farmer will consider purchasing a solar water pump.
- Once awareness has been raised, the product is often **unaffordable,** and **financing is required**. **Credit risk assessment is difficult** even for experienced solar home system (SHS) PAYGO providers entering the SWP market due to payment variability (e.g., harvest cycle) and uncertainty concerning the capability of end users to increase their income.
- **Technical assistance is often required** to ensure that customers can pay back the cost of the equipment.
- Potential rural customers are geographically dispersed, resulting in **increased distribution costs**.
- All of the factors above result in **high customer acquisition costs**, exacerbating the affordability problem.

Market Size

- According to analysis from the PULSE report,[4] the total **addressable market in Sub-Saharan Africa for solar water pumps is 5.4 million farmers** with about **700,000 as the serviceable**

[3] World Bank Group. Lighting Global. The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa. https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf

[4] Ibid.

market when affordability is considered. The **total serviceable market is expected to grow by about 12 percent per year** due to technology advancements and rising income levels.

- **Top players are approaching 25,000 total pumps sold at rates of up to ~8,000 pumps/year** when RBFs are present. Top players include some of the companies interviewed such as SunCulture and FuturePump as well as last-mile distributors like Simusolar, among others.

Business Models

- Business models vary depending on multiple factors, including existing ecosystem, status of the company within the value chain, and type of services, but the most prominent for smallholder farmers include **PAYGO, leasing, asset loans, off-taker structures as well as cash with operations and maintenance (O&M) services.**
  - Some solar water pump **manufacturers that are vertically integrated** serve customers directly through the **PAYGO** model when a **conducive environment is present.** This includes:
    - high penetration of mobile money and connectivity
    - subsidies, both fiscal and non-fiscal, e.g., results-based financing (RBF)
    - higher disposable incomes
    - proximity to headquarters, e.g., call centers, common language.

  However, these circumstances are difficult to replicate across geographies.

- Non–vertically integrated manufacturers rely on the typical business-to-business (**B2B**)**, partnership working with last-mile distributors** who have better knowledge of their customers and the country's socio-political circumstances, allowing them to operate within a complex ecosystem across multiple agricultural value chains while building the income-generating capacity of their own customers.
- **Last-mile distributors** often have multiple sales model approaches and **could implement PAYGO as well as cash sales** with agricultural services. Given their in-country presence and better knowledge of the local environment, they also can implement stronger **partnerships for asset financing** through microfinance institutions (MFIs), savings and credit cooperatives (SACCOs), or local banks. They are also better suited to implement **off-taker agreements through larger agricultural cooperatives.**

Recommendations

- **Manufacturers can absorb larger RBF ticket sizes**, but they may need to claim across multiple geographies. Thus, a regional RBF might make more sense until markets are more developed.
- **Loan guarantee products could be better suited for manufacturers** at this moment in the sector as they attract larger equity and debt ticket sizes compared to distributors. Typical guarantees of smaller ticket sizes range from $1 million to $5 million with most of them not willing to consider transactions under $5 million (e.g., GuarantCo, DFC, Sida). African Guarantee Fund allows for smaller ticket sizes of $500,000 to $1 million, making it the most suitable for the market.
- For **last-mile distributors**, ability to raise capital is limited, so they **need upfront grants**.
- **R&D and testing of business models** are still common in the sector and require **grant support, generally non-reimbursable,** as products continue to evolve and customer acquisition is fragmented by value chains and geography.

Photo credit: SunCulture

SUNCULTURE
COMPANY PROFILE

Product and Innovation

- SunCulture designs, sells, finances, installs, and provides after-sale service of Internet of Things (IoT)-enabled solar-powered irrigation solutions. The products are coupled with Africa's first carbon credits for irrigation, which will be used to reduce the cost of the products for end users.
- SunCulture is the first to commercialize asset financing for solar-powered irrigation in Africa and the largest company in the smallholder farmer irrigation segment with 30,000+ pumps sold as of the end of 2022.
- Despite its position in the market, SunCulture still has a need to conduct R&D to improve and expand the range of its solar irrigation systems. Supply chain challenges have both increased costs and delayed the rollout of new products significantly.
- SunCulture was planning for multiple product releases in 2022, but due to supply chain challenges, mainly around printed circuit board (PCB) components (semiconductors, computer chips, etc.), these releases have been delayed. Increases in lithium prices due to demand from electric vehicles are also driving up the cost of battery powered products, thus making them less accessible for smallholder farmers.

Business Model

- SunCulture operates directly in Kenya, has recently launched in Uganda, and has a joint venture with EDF in Côte d'Ivoire. It also has distribution partners in Togo, Zambia, Ethiopia, and Uganda, with ambitious expansion plans in the next few years.
- SunCulture offers financing through its Pay-As-You-Grow (PAYGrow) platform and provides both tailored advice and value-added services to its farmers.
- The company’s products allow for easy troubleshooting, correlation of customer repayment with usage, and collection of customer data that can be used to upsell. The IoT data can also be used to support verification for RBF and carbon credits.

Financing

- SunCulture has received support from donor programs in the past, which has allowed it to scale to the point where it closed its Series A at $14 million in 2020 and secured an $11 million debt facility with SunFunder. SunCulture also recently closed a $10 million mezzanine loan facility. SunCulture is planning for its Series B, which will finance its ambitious expansion plans.
- SunCulture has participated in RBF programs, including the CIZO program run by the Government of Togo, the Global LEAP program, AECF REACT RBF, and EnDev's Sustainable Energy for Smallholder Farmers (SEFFA).
- SunCulture is actively exploring the carbon credit market with the first carbon credit solar irrigation project in Africa which recently was approved by Verra for the Kenya market. Due to the high upfront cost of country project approval, it only makes financial sense for their larger markets. Grant funding for carbon validation would help reduce this barrier.

Conclusions

- SunCulture cited awareness, affordability, and the need for technical assistance as key barriers for the company and the sector more broadly.
- SunCulture is a strong advocate of RBF programs because they do not divert from its core business and allow it to scale up more quickly.
    - RBF mechanisms should be automated like the Togo CIZO program to significantly reduce the administrative burden that ultimately leads to higher prices for the end user.
    - RBF should operate on a rolling basis since planning around donor program time frames is often difficult for companies.
- Aside from RBF, there is a funding gap for small to midsize potential distributors who want to expand their portfolio with productive use products, which are more expensive and therefore harder and risker to finance. There is also a need for grant funds for market expansion.
- SunCulture expressed a desire for grant support to reduce the validation and transaction costs and increase the speed of entering the carbon market, which will reduce the cost of reaching more smallholder farmers.

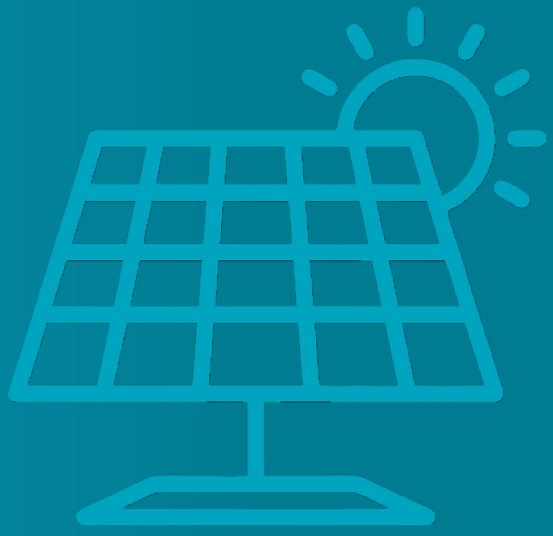


Photo credit: Simusolar

SIMUSOLAR
COMPANY PROFILE

Product R&D and Innovation

- Simusolar sells solar water pumps from different suppliers as its main product in Tanzania and Uganda.
- They have their own proprietary hardware and digital platform that remotely monitors and controls the equipment, collects customer data, and tracks payments.

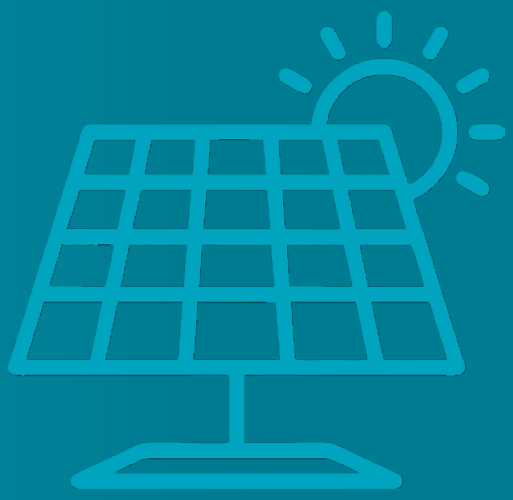
Business Model

- Simusolar sells cash upfront or on monthly installment plans with deposit. Most of their customers cannot afford the upfront cost or obtain loans and over two-thirds fall below the poverty line.
- They always do custom designs tailored to the needs of the farmer or livestock keeper, made scalable by their proprietary design application.
- They are currently focused on building customer concentrations and communities of practice, which accelerate adoption and reduce customer acquisition and servicing cost.
- Simusolar is approaching profitability in 2023 and focused on positive cash flow from operations.

Conclusions

- Simusolar noted very low awareness levels and the need to provide technical assistance to the farmers, which sometimes requires partnerships with other organizations and leads to high customer acquisition costs.
- In Uganda, they have tried several value chains, but the ones that worked were mostly horticulture and livestock.
- Donor programs do not usually cover boreholes, which makes pumps inaccessible to some farmers. Environmental impact assessments, where required by government, can also increase costs. However, there are large, addressable markets of farmers that have access to water or for whom these issues are not constraints.
- Technology R&D and experimentation with distribution models is still ongoing, building on the success they have had. There is no single, silver-bullet approach, but rather a combination of strategies depending on the target audience.

- They were cautious about subsidies that are less than four years, as the market is still in the early stages of awareness and adoption. They also emphasized having a plan for transitioning to commercial pricing. In addition, customers must be personally invested if the willingness to pay off the asset is to be assured. Currently, over 90 percent of Simusolar's clients purchase on commercial terms without a subsidy of any kind.
- They noted that grants are often restrictive, inflexible, and administratively burdensome and that results-based financing, in theory, has fewer of these problems. Reporting requirements are sometimes spontaneous or inconsistent and insensitive to the operational burden they create.
- They mentioned that longer time frames for donor programs and slow approval periods must take into account a dynamic landscape and market feedback. Flexibility is essential in program design.
- Upfront grants are needed for organizations beyond seed stage and even up to Series A, including for market development, which goes beyond R&D and should support evaluating distribution strategies. Similarly, equity and patient capital are needed for the sector to have a chance to become viable.



3.1.2 COLD STORAGE

Challenges

- The **market for cold storage technologies is not as well developed** as the solar water pumping market.
- Cold storage often **needs to run constantly**, increasing the cost compared to other technologies like pumps that only run part of the day.
- As with other PUE equipment, **affordability** is an issue, and **financing is a challenge** that comes with the risk of the entrepreneur failing to generate sufficient income.
- **Distribution is costly** and a challenge in disperse, sparsely populated areas.
- For agricultural applications, any **gaps along the cold chain** from farm to market can mean that the product does not reach markets. **Aggregation** of products at the cooling site is sometimes necessary, creating an extra challenge.
- **Import duty and value-added tax (VAT)** is high in many countries.

Market Size

- According to analysis from the PULSE report,[5] the total **addressable market size in Sub-Saharan Africa for cooling and refrigeration is around 6.5 million farmers,** with **about 225,000 farmers as the serviceable market size** when affordability is considered.
- The serviceable market has the **potential to grow by about 17 percent per year,** driven by smaller refrigerators for commercial use rather than walk-in cold rooms.

Business Models

- There are significant distinctions between the technologies and business models of the various subsectors within the cooling sector.
- Both **lease-to-own and cooling-as-a-service models are challenging** in many of the same ways as seen in the solar irrigation sector, and often exacerbated by the fact that cooling technologies are often **more expensive** than pumps.

Refrigerators/Freezers

- In a survey by 60 Decibels, most people who purchased a solar-powered refrigerator **used it to generate income.**[6] However, most were not used for agricultural purposes but rather for **light commercial purposes**, such as selling fast-moving consumer goods (FMCG).
- Fridges used for this purpose **could be a viable market** for distributors that are willing to provide some form of financing, though **payback periods can be long**, and some of the common challenges in selling PUE equipment can still persist.
- **Agricultural pilots** on the value chains for produce, dairy, and fisheries concluded that there is **not yet a viable market** for refrigeration in these sectors, at least in the countries studied.[7]
- However, additional piloting is needed to see if it can work under other conditions, including with larger or multiple units for cooperatives.

[5] Ibid.
[6] Mogono, Dennis. Efficiency for Access. Groundbreaking 60 Decibels and Efficiency for Access Study Reveals Key Long-Term Benefits of Off-Grid Refrigerators for Low-Income Users. September 6, 2022. https://efficiencyforaccess.org/updates/groundbreaking-60-decibels-and-efficiency-for-access-study-reveals-key-long-term-benefits-of-off-grid-refrigerators-for-low-income-users
[7] Efficiency for Access. Lessons Learned from IFAD Technologies Project. https://efficiencyforaccess.org/publications/lessons-learned-from-ifad-green-technologies-project

- The major barriers to adoption for farmers are, as expected, affordability and ability to generate enough increased income to pay for the financed asset.

Walk-in cold rooms

- High capital costs of walk-in cold rooms means that companies generally have only figured out how to make a profit by working with **medium-sized or larger enterprises** that are already operating successfully and often exporting.
- The impact of these larger projects on smallholder farmers is limited, though there could be positive benefits through job creation.
- The **costs** associated with working at the **smallholder level are high** and the amount of **income they can generate is often too low**.

Recommendations

- For **RBF purposes**, the market segment that is mostly likely to generate enough sales volume for the refrigeration/freezer technology is **fast-moving consumer goods**. However, the market is still nascent, and **grants may be more suitable** for further testing of business models.
- The refrigeration/freezer segment within the agricultural value chains, including dairy and fisheries, requires larger cold chain development, consumer behavior change, and awareness campaigns, among other factors in order to achieve scale for an RBF program.
- **Walk-in cold rooms are working for medium-sized or larger businesses** that are already successful. Models that involve **smallholder farmers have been difficult** to make profitable, including those that involve cooperatives or associations.

Photo credit: SureChill

SURECHILL
COMPANY PROFILE

Product R&D and Innovation

- SureChill has developed a unique cooling technology concept that was first applied in vaccine refrigeration. Their vaccine fridges were designed to work for up to 12 days without power. They have operated in this space for 11 years, providing fridges on behalf of the World Health Organization (WHO), UNICEF, Pan American Health Organization, Ministries of Health, and other NGOs
- They have sold over 25,000 vaccine fridges that have provided over 71 million vaccines in between 70 to 80 countries globally.
- Vaccines must be kept between a narrow temperature range of 2˚C to 8˚C, and fridges should meet standards set by WHO.
- SureChill vaccine fridges are available in both grid and solar direct drive formats and keep the temperature stable by using their unique, patented technology.
- SureChill refrigerators are different from conventional fridges and use a unique method of cooling allows a constantly stable temperature, with or without power.
- Being established in the vaccine sector gives them credibility to their customers in other sectors.
- In addition to the vaccine fridges, SureChill now has a smaller home and business fridge model. This is a 65-liter fridge that can offer consistent and continuous cooling 24 hours a day without the need for a battery or any other form of power. Its PAYGO functionality allows customers to access the fridge in an affordable way.

Business Model

- Outside of the vaccine space, SureChill is beginning to target small businesses, mostly retailers selling fast-moving consumer goods (FMCG) and perishable goods such as fish and milk.
- The SureChill team works with last mile FMCG retailers to identify customers that would benefit from having access to a fridge.
- SureChill then signs up the customer and carries out the installation.
- They have also seen an increasing interest from pharmacies and private medical centers (those not supported by the Ministry of Health and therefore not eligible for a vaccine fridge). These are usually based in rural communities and supply medicines such as insulin and antibiotics but not vaccines.
- The business fridge currently only comes in a solar version.
- They are providing a cooling-as-a-service rental model so that customers don't have the pressure of making regular payments to buy the fridge.
- The SureChill cooling-as-a-service (CaaS) model is designed to bring access to cooling to people who previously had no means to purchase an off-grid solar fridge due to inability to access finance or credit.

- Customers can rent a fridge at an affordable price on a no-commitment basis and pay Surechill via the built-in PAYGO functionality.
- Customers can opt to keep the fridge for as long as they want, and they don't have to worry about costly repairs or service costs as this is all included as part of the CaaS model. Surechill have a network of repair centers that can fix problems with the fridge within 72 hours.
- •If returned, the unit can then move from customer to customer based on current needs and ability to pay.
- They provide bonuses for long-term rentals and referrals and if the customer is a long-term renter with a good payment term, they may be gifted the fridge after 135 weeks of rental.
- The CaaS model offers more flexibility to the customer and removes some of the barriers that have prevented fridge ownership previously. It is a pioneering scheme that allows people to have access to essential cooling and can earn a decent living by becoming profitable businesses.

Conclusions

- They have sold about 1,000 units so far, and entrepreneurs who have purchased the fridge have seen increased sales.
- They are starting to partner with and sell through solar home system companies.
- Their home and small business fridges are often too small for larger scale productive users such large-scale farming. However, the vaccine fridges could serve cooperatives who want to keep animal vaccines safe.
- SureChill utilize grants to run pilots to test new ideas and business models such as the ones above.

Photo credit: InspiraFarms

INSPIRAFARMS
COMPANY PROFILE

Product R&D and Innovation

- InspiraFarms was established to reduce post-harvest losses within the agriculture sector and not originally focused on cooling.
- They design bespoke systems for each customer using building blocks from a menu of small, standardized solar cooling units costing from $20,000 to $200,000 depending on project size.

Business Model

- InspiraFarms has worked in several countries but now focuses on Kenya and Zimbabwe.
- Their main customer segments are large agricultural producers and commercial farms who are generally exporting as these are currently the most commercially viable. But domestic applications should grow as locally grown crops replace imports.
- As a result of a SunFunder loan, they now offer end users a five-year financing plan for 80 percent of the invoice value with flexible repayments timed with the harvest.

Conclusions

- While the positive impacts on smallholder farmers is smaller for larger projects, they claim significant impacts on livelihoods due to employment, which has ripple effects beyond the person with the job.
- They have tried to work with smallholder farmers, but it does not generally work from a commercial perspective given the cost of the system. It is too complex and logistically difficult, and subsidies are needed.
- However, they are considering working with an aggregator who collects crops for export from 300 smallholder farmers by driving to each of them on bad roads twice per week, forcing them to harvest a specific day.
- InspiraFarms would like to build a hub-and-spoke system instead, with units at centralized collection hubs that can be collected from when they are full, allowing farmers to harvest daily and increase yields.

3.1.3 AGRICULTURAL PROCESSING

Challenges

- The agricultural mechanization sector is still at a relatively early stage with very few companies active, limited investment, and a range of barriers. It is further from commercial viability than other technologies due to the following factors:
  - Solar-powered processing equipment is often **more expensive upfront** than the diesel alternative and is generally lower output.
  - With sparsely populated rural areas, potentially long distances between villages, and only the need for one or two pieces of equipment per village, **distribution and after-sales costs are high** for each sale.
  - Awareness is low and **customer acquisition costs are high**. Finding suitable entrepreneurs is time-consuming as is training on operation of machinery.
  - Ensuring **sufficient utilization** so that the entrepreneur makes a return on investment can be challenging, especially since units are often not mobile and therefore cannot be rented.

Market Size

- According to analysis from the PULSE report,[8] the total **addressable market size for agro-processing is around 940,000 units** with **about 54,000 units as the serviceable market size** when affordability is considered. The report notes that group or shared ownership and aggregation would expand the market size.
- The serviceable market has the **potential to grow by about 14 percent per year**.

Business Models

- The agro-processing sector is the **least mature** of the three agricultural technologies highlighted.
- **Imara Tech** in Tanzania sells solar-powered **multi-crop threshers** that increase the quality of the output and are mobile to allow for use as service provision and additional income generation.
  - Entrepreneurs can potentially **recover their investment after one season**.
  - However, attempts to scale have encountered challenges that are similar to the ones listed above and have prevented them from growing.
- **Agsol** in Kenya has **spent years conducting R&D** and refining their PAYGO mill.
  - Initial versions were **too costly** compared to diesel mills, and the product needed to be made more efficient and streamlined.
  - They now have a product called the **MicroMill** whose unit **economics potentially work**, according to preliminary assessment by A2EI.
  - They currently have 100 units they plan to sell but will **need to scale to at least 1,000** in the next phase.
  - It is **unclear** whether this kind of innovation through iteration is possible with **other types of processing**.

[8] World Bank Group. Lighting Global. The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa. https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf

- Other applications, such as solar dryers and egg incubators, are relatively niche compared to milling, which is the most advanced, though still at a very early stage.

Recommendations

- **Grant and TA support** is needed to encourage the few companies in this sector to **continue to conduct R&D, improve their product, and test business models**.
- This market segment is generally not yet ready for an RBF.

AGSOL
COMPANY PROFILE

Agsol is the leading innovator in the off-grid agricultural processing sector with a focus on milling grains such as maize, sorghum, and millet. They say their business is positioned similarly to where leading solar pump companies were five years ago. Key takeaways from the interview are summarized

Product R&D and Innovation

- Unlike many productive use of energy (PUE) technologies that focus on high-value products (horticulture, dairy, meat), Agsol's focus is on low-value grain milling where margins are low but demand is ubiquitous in rural areas across the continent. The cost and efficiency of the equipment are therefore critical.
- The incumbent technology is a diesel mill that weighs over 250 kilograms (kg). Off-grid technology that can compete is nonexistent and must be developed from scratch.
- Agsol's original mill was 60 kg with a 1.2-kilowatt (kW) motor that processed 35 kg/hour, but it needed to be more efficient to be viable.
- The newest iteration is the small and compact MicroMill, which weighs 6.5 kg with an 800-watt (W) motor that processes 60 kg/hour. Importantly the MicroMill is 2.5 times more efficient than its nearest competition and in solar format is more affordable than a new diesel mill.

Business Model

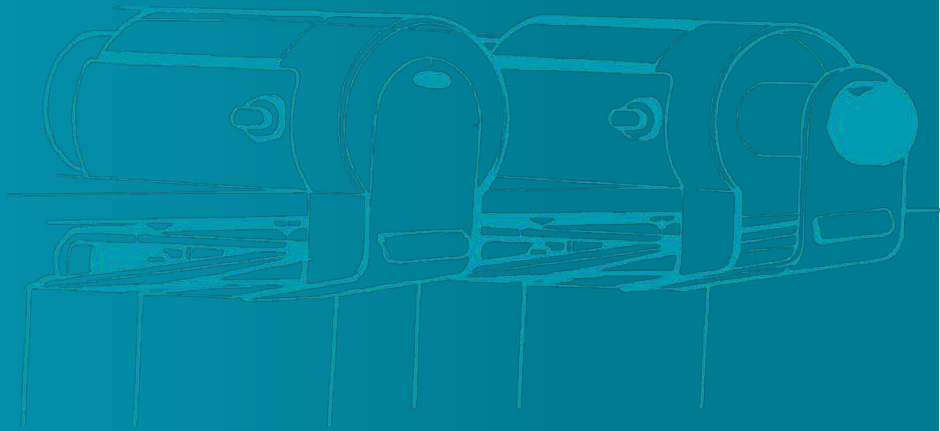
- Agsol is not trying to create a new market but rather transition businesses away from diesel mills. This is a technology transfer play, akin to solar lamps replacing kerosene lamps.
- The market size for off-grid processing is significant with high demand if the right product is available. At least 400 million people in sub-Saharan Africa depend on diesel mills today.
- The cost of milling with diesel has doubled due to the recent increases in price of fuel.
- The solar version sells for $1,300, which is roughly the cost of a 10-horsepower diesel mill. It runs at half the speed of the diesel mill but is twice as profitable due to lower operating costs with a potential payback period of one to two years.
- The AC version is equivalent to a 2.2 kW AC power mill and sells for $700 but is more than twice as efficient.
- Agsol does not provide in-house financing but is developing partnerships with distributors and financial institutions to do so.
- They have manufactured and sold 100 proof-of-concept units in 2022 but need to scale manufacturing to at least 1,000 units in 2023 for the unit economics to work.

Financing

- Agsol has been dependent on grants so far but plans to raise a first seed round in 2023.
- They are at the end of the hardware innovation phase, which is fully funded.
- They need funds to support further piloting and testing of customer segments of their current first batch of 100 units.
- They would like to have a temporary subsidy of roughly $150 per unit for their next batch of 1,000 MicroMills.

Conclusions

- They do not believe that RBF is appropriate for nascent sectors like agro-processing.
- They relied on grants for R&D and product development previously, and other companies will require the same.
- They believe that if the MicroMill succeeds as a proof of concept, it will show others that off-grid agro-processing can be a viable business and spur other entrants into the sector.



3.2 E-MOBILITY

Challenges

- The biggest challenge for the e-mobility sector, like most other PUE technologies, is the **higher upfront cost** of the vehicles, in particular the **battery costs**, which are often a significant proportion of the capital expenditure (capex).
- A **charging network** needs to be put in place at the same time as the roll-out of electric vehicles, which requires significant investment.
- The e-mobility sector is competing against **incumbent fossil fuel technologies**, which are already well entrenched, established, and funded.
- **Supply chain** shortages are a challenge and cause significant delays.
- In addition, there are many potential **policy and regulatory challenges**, including on taxes and duties, preferential tariffs, and incentives for local assembly that would help make an e-mobility business viable.

Market Size

- Currently, there about 20 to 30 companies in the e-mobility space in Sub-Saharan Africa, mostly focused on **two-wheelers**. The largest companies have several hundred bikes on the road.
- There is significant opportunity given the **5 million motorbikes in East Africa to replace by 2030**, which will require $3 billion in financing through debt, equity, grants, and carbon credits. The region spends **$6 billion on fuel and $12 billion on motorbikes** annually.
- **Carbon finance** could play a catalytic role and increase the size of the serviceable market but will depend on pricing in the voluntary and compulsory markets.

Business Models

- To date, most companies in Africa are focused on **smaller vehicles** like motorbikes as the **capital cost** is lower and can be **recovered through lower operational expenditures (opex) more quickly**, especially if used commercially.
- Electric vehicles have **lower maintenance costs**, which helps either the company or the end user depending on who is the owner in the business model.
- Batteries can either be owned by a company that provides **swapping as a service** or by the end user who pays to charge it at home or elsewhere.
- Some companies are shifting to or focusing entirely on **battery swapping for powering a range of different types of devices, equipment, or vehicles**.
- E-mobility is currently receiving the most attention, but applying the **battery-as-a-service** model beyond vehicles is a noteworthy and promising development.
- Some private sector companies, like Mobility for Africa in Zimbabwe or OX in Rwanda, are testing the viability of using **electric vehicles to serve rural populations**.

Recommendations

- **Grants are still needed** by many companies in this nascent sector. Even more mature companies that have raised millions of dollars are still doing significant R&D, and grants would help them scale faster.

AMPERSAND
COMPANY PROFILE

Photo credit: Ampersand

Product R&D and Innovation

- Ampersand developed Africa's first electric motorbike powered by a swappable lithium battery. First commercial sales were in 2019.
- Batteries are rented to drivers from a network of battery swap stations, where an attendant swaps a battery in about two minutes. They are targeting motorcycle taxi and delivery motorcycles with high utilization rates.
- The motorcycles cost about the same to acquire as the traditional ones and around 50 percent less to maintain and operate, yet they have more power. The cost savings translates to around $1,000 per annum at present.
- Their unique, heavy-duty battery pack and fleet software backend were developed by Ampersand, and the batteries are built by Ampersand in Rwanda.
- They have battery charging and swapping stations around Kigali and Nairobi and have assembly lines for both the bikes and the batteries.
- There are still significant R&D opportunities, including on software development, battery development and management, and optimization of battery networks.
- Supply chain shortages are still a challenge, and they are investing in vertical integration to address this issue.

Business Model

- Light vehicles are potentially easy wins, particularly when used commercially where costs can be recovered more quickly through high asset utilization (2-3 cycles per battery each day), and have lower development costs than larger vehicles, e.g., small trucks.
- They are currently mostly in Kigali but now starting up in Nairobi. They have about 750 electric motorbikes on the road in Rwanda and 60 in Nairobi. They are performing around 20,000 battery swaps per week from 19 stations, and their motorbikes traveled 20 million kilometers in 2022. They are aiming for 5,000 motorbikes on the road by end of 2023.
- Their long-term vision is primarily as an energy business, powering motorcycles from existing major international motorcycle brands via its network of swap stations.
- The batteries are owned by Ampersand, and the drivers own the bike, typically financed by a third party.
- Their drivers report increased higher monthly net earnings, and demand is high with long waitlists.

Financing

- In 2021, Ampersand received $3.5 million in venture capital from the Ecosystem Integrity Fund, and $500,000 from TotalEnergies. In November 2021, they also raised $9 million in debt from the U.S. Development Finance Corporation's relatively new innovation-focused "Pi-Squared" facility. Of this $9 million, Ampersand has drawn down $5 million so far. In 2022, they raised a further $3 million in equity capital from Ecosystem Integrity Fund, TotalEnergies, and Alphamundi, a venture capital (VC) fund. They are focusing on Series B now.
- Of around $16 million raised and drawn down by Ampersand to date, $8 million has been as equity, $5 million as debt, and $2 million as grants. The Shell Foundation has been the largest source of grant funding ($1 million). Other sources include USAID-DIV ($500,000), UKAID ($120,000), the Rwanda Green Fund (Fonerwa) ($220,000), New Zealand Government ($50,000), and UN Habitat ($50,000).
- They still have R&D needs for battery and software development, and grants would be useful. Serious tech VCs based in Europe and the United States have a high-risk perception for Africa, and grants can offset that risk perception.
- East Africa VCs tend to be more focused on revenue figures and positive in terms of earnings before interest, taxes, depreciation, and amortization (EBIDTA), especially in the current climate. East African VCs generally have less understanding and patience for tech and R&D costs. They are also wary of hardware startups due to the poor performance of solar home system companies and tend to focus on historical revenues for the purposes of valuation. This approach limits the total capital a company can raise according to the previous revenue, rather than focusing on other factors, such as customer waitlist, market size and positioning, climate change needs, and strategic partnerships.
- Ampersand is exploring carbon finance, but current prices on the purely voluntary market are not high enough to supply more than a small fraction of Ampersand's capital needs.

Conclusions

- Grants are important as they can help equity investors prevent their capital from being diluted beyond acceptable limits and provide confidence that due diligence has been carried out.
- However, grants often take too long to be worthwhile, and most entrepreneurs are not able to survive 12 to 18 months without funds, especially local entrepreneurs. Three of Ampersand's grants took well over 14 months to receive from initial application. Ampersand feels the time taken and process complexity in most grants is also inappropriate in the context of urgent climate crisis timelines. Recent emphasis on technical assistance by many donors also fails to supply the necessary capital.
- Timelines appear to be long partially due to aversion to risk by grant funders compared to the "portfolio approach" taken by commercial investors (placing several aggressive bets and considering it a success if one or two do very well). Ampersand cites UKAID's Frontier Technology Livestreaming grant as a successful example of the latter approach by a donor.

- On the debt side, they are interested in guarantees such as Guarantco, which Sida supports. These could unlock commercial debt from regional commercial banks (e.g., Bank of Kigali, Equity Bank, I&M, and Absa).
- They are open to exploring options for carbon finance, including with the Swedish Energy Agency. Light vehicles present the easiest target, particularly those used commercially, as they recover costs through opex savings. Batteries are already tracked in real time, so power consumption per kilometer traveled can be easily recorded. At prices around $80 per ton, Ampersand estimates they could secure around 20 percent of their total capital needs this decade via carbon finance.
- In countries with significant thermal power production, better data on current and projected grid carbon intensity (tons of $CO2_e$ per megawatt-hour produced) would help to secure better carbon pricing.

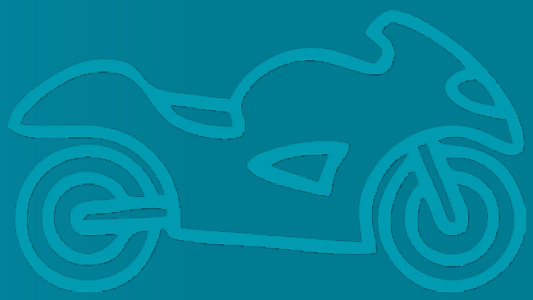


Photo credit: Mobile Power

MOBILE POWER
COMPANY PROFILE

While not exclusively an e-mobility company, Mobile Power has a business model based on expanding battery as a service beyond vehicles that is worth highlighting.

Product R&D and Innovation

- Mobile Power produces MOPO Batteries that are charged by solar-powered MOPO Hubs.
- The MOPO50 supports lower power applications like lights, phone charging, radios, and TVs.
- The MOPOMax is capable of powering motorbikes and tuk tuks as well as fridges and other larger household or business appliances.
- The company operates its own extensive networks of MOPO Hubs in Nigeria, Sierra Leone, Liberia, and soon the Democratic Republic of Congo (DRC).
- In addition, the battery rental model has been piloted with Winch mini-grids in Sierra Leone and Uganda, PowerGen mini-grids in Sierra Leone, and with a new partner soon in Chad. Mini-grid developers have used the model as a way of expanding the reach of their services to peripheral, unconnected clients.

Business Model

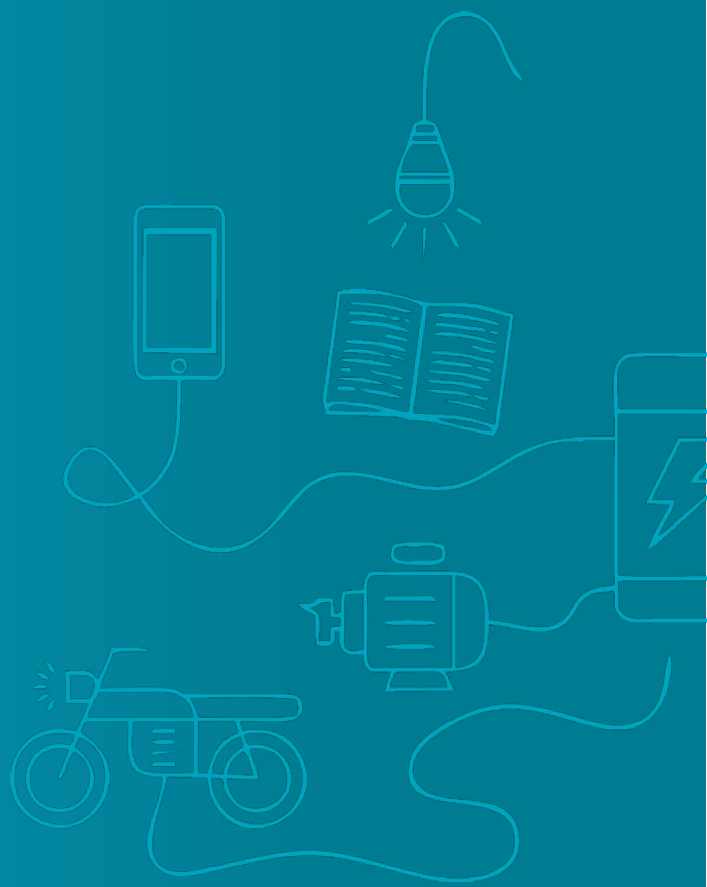
- Customers rent the batteries in 24-hour increments, providing them with flexibility to buy power only when they need it.
- There are no fixed payments, long-term commitments, or debt, which allows them to serve lower-income populations that can truly pay only when they are able.
- Payments can be made either in cash or with mobile money via a MOPO Agent.
- The MOPO Hub provides ongoing customer support, and batteries are monitored and removed from circulation at the end of their lifespan.
- For e-mobility, Mobile Power conducts battery swaps and partners with others who can finance motorbikes.

Financing

- Mobile Power's current investors consist of both private and public organizations including All-On and Camco-REPP .
- The company has received loans from Innovate UK, DEG, and Social Investment Managers and Advisors (SIMA).
- The company has received grants from the Beyond the Grid Fund for Africa (BGFA), Energy Catalyst, IKEA Foundation, Swedish International Development Cooperation Agency (SIDA), NEFCO, and the UK Foreign Commonwealth and Development Office (FCDO).
- Mobile Power is in a strong financial position, having deployed over £10 million, with a further £6.5 million in available funds. They are raising a Series B to increase the rate of growth and unlock the value that they see in the MOPOMax.

Conclusions

- Many of their lower-income customers rent irregularly and only utilize the service periodically. RBF and grant eligibility rules should have a way to count the service of an entire community rather than individual households of a specific tier, which ends up favoring wealthier consumers with the ability to pay with some regularity.
- They are seeking $12 million in equity for their Series B which will be further leveraged with grant and debt opportunities.



3.3 MINI-GRID/ON-GRID APPLIANCES

Challenges

- Financing appliances comes with similar risks as those powered by off-grid standalone solar.
- **Business support and financial literacy training** are often needed for new entrepreneurs to run successful enterprises.
- Their **products must reach markets,** and their **services must be in demand** for them to generate income to pay off the asset.
- Unfortunately, there are not yet any entities financing PUE appliances at scale for rural customers of mini-grids or the national grid.

Market Size

- The increasing number of households and businesses accessing electricity through mini-grids and on-grid utilities brings new opportunities for **economic growth** through PUE. Stimulating PUE also benefits utilities through **increased demand**.
- Power availability is higher than typical SHS, which expands the range of viable PUE applications. However, **appliance financing** is often necessary.
- Some mini-grid developers would prefer to leave PUE appliance financing to third parties while others choose to engage in it directly.
- A few **national utilities are starting to partner with entities that provide appliance financing** to grow demand and could consider providing financing themselves in the future.
- **Utility-led financing** of appliances has been a successful model implemented around the world for almost a hundred years but has not been adopted widely yet across the continent.

Recommendations

- For mini-grids, **opex subsidies that directly lower the tariff** can reduce the risk for those financing appliances.
    - There are decades of data that show that lower tariffs broadly result in **increased electricity consumption**, which leads to an **increase in income**.
    - Mini-grid developers submit customer consumption records periodically to receive the subsidy as an RBF while the donor monitors for trends.
    - **Administrative burdens** for both the developer and donors are **relatively low** compared to other mechanisms, which further translates to lowers the cost for consumers.
    - The need for opex subsidies should reduce over time as economy grows.
- Otherwise, donors can **directly support entities to provide appliance financing**, including mini-grid developers, suppliers, and MFIs. Support could come in the form of:
    - **Grants** to encourage suppliers to begin offering appliance financing or to enter more rural areas where mini-grids are located.
    - **Subsidies**, including RBFs, to lower the price of the appliance and make it easier to sell and increase repayment rates.
    - **Loan portfolio Guarantees** (first loss) to microfinance institutions to reduce the risk of lending to end users (75% or above coverage).

Photo credit: EnerGrow

ENERGROW
COMPANY PROFILE

Company Philosophy

- EnerGrow's objective is to help rewrite the economics of rural electrification by being a productive use service provider to rural electrification companies.
- EnerGrow's pilot has shown that they simultaneously increase local incomes of communities as well as revenues for energy companies.
- EnerGrow believes that off-the-shelf productive use of energy (PUE) equipment is generally suitable for the needs of on-grid and mini-grid customers.
- The major barriers are distribution and affordability, not technology.
- Most PUE companies focus on a single technology such as irrigation or refrigeration. As a result, they can only sell a few units per village, and it becomes costly to scale in sparsely populated rural areas.
- Rather than having many companies to fulfill the PUE needs of a single village, all with distribution costs that increase the price of the product, fewer distributors and aggregators should sell multiple appliances.

Business Model

- EnerGrow partners with mini-grids and the national utility in Uganda to sell PUE appliances to their customers. It acts as a microfinance institution (MFI) and provides financing to end users for fridges, power tools, sewing machines, agro-processing machinery, and electric pressure cookers.
- They use digital credit scoring from data sources such as prior electricity consumption patterns, which they can obtain through their partnerships with the mini-grid and on-grid utilities.
- They provide working capital, financial literacy training, and business support to their customers.

Successes/Results

- During EnerGrow's pilot, customers' incomes increased by over 50 percent.
- In newly connected communities, six months of work by EnerGrow led to energy consumption levels only seen after six years in untreated communities.
- This equates to a 400 percent increase in lifetime customer value for energy companies, with further increases and improvements likely as EnerGrow learns, evolves, and improves its model and service offering.

Challenges

- EnerGrow's early customers are mostly urban, but they are actively building out pathways to serve rural areas profitably. Low population densities and higher costs of servicing remote geographies make this a challenge.
    - EnerGrow is developing partnerships on distribution, sales, and marketing to reduce costs and build pathways to scale.
    - Equipment will require maintenance and repair, and it is costly to provide after-sales service for dispersed populations across large areas. Training local technicians on repairs and maintenance will help create skilled jobs in rural areas and address this issue.
- Traditionally, PUE funding has been project-related and not aimed at systemic change or at funding broad PUE distribution. Hence, fitting into existing PUE funding streams has been a challenge.
- Because EnerGrow is not a technology company but rather a microfinance and rural distribution company, they have found fundraising in the energy access community challenging because they do not fit into traditional energy investor buckets, which mostly focus on connections and kilowatts. The microfinance investor space has also proven challenging as they do not understand or prioritize the co-benefits EnerGrow provides to the mini-grid sector.

Conclusions

- Real potential exists for PUE companies to emerge as partners and service providers to energy companies, benefiting them by removing the burden to fundraise for both energy infrastructure and PUE appliances and allowing them to focus on their core work.
- While substantial attention is focused on productive uses as a solution to the economic challenges in the energy access space, funding has not caught up to match this realization.
    - PUE is often an afterthought allocated to only a small percentage of mini-grid grants.
    - Donors focus on specific technologies, which does not fit the market need for a broad selection of PUE tools and appliances that each community needs and does not address the need to support distribution and delivery of these technologies to communities.
    - Some funders focus on PAYGO only, which EnerGrow does not see as technology that can or should be integrated into every piece of PUE equipment.
- RBF should be used to draw companies into underserved markets and not for nascent markets. RBS mechanisms are simple, flexible, fast, and proven to work in delivering new approaches and technologies to underserved markets. Equity must be available, however, to allow companies to realistically access these mechanisms.
- Because the PUE sector is extremely nascent, the initial goal of any PUE support program should not be on the number of appliances sold, but rather on building sustainable businesses that can grow and deliver substantial numbers once a solid foundation has been built.

Photo credit: E-Longlife

E-LONGLIFE
COMPANY PROFILE

While not powered by mini-grids or the national grid, another model reminiscent of Energrow's includes a suite of technologies rather than a singular focus on one technology and deserves highlighting here.

Product R&D and innovation

- E-Longlife rents and sells standalone solar home systems (SHS) that power a range of productive use of energy (PUE) appliances, including pumps, fridges, freezers, mills, sewing machines, carpentry kits, hairdresser kits, printers, computers, microscopes, and centrifuges.
- They sell pico-solar kits of long lifespan and offer 20-year payment plans on their large SHS kits.

Business Model

- They rent their kits on an energy-as-a-service basis in Chad, Mali, and Niger with extremely long payment plans of up to 20 years, and they sell their productive tools and appliances on a rent-to-own basis with payment plans over two to three years.
- They have sold or rented over 10,000 large kits combined with appliances and hundreds of pumps and have provided power to more than 50 public institutions.
- Their credit risk assessment procedure generally results in very low default rates.

Financing

- In 2019, In 2019, the U.S. International Development Finance Corporation (DFC) provided a $10 million loan to E-Longlife for its operations in Chad.
- In 2020, ElectriFi provided a €4 million loan to E-Longlife for its operations in Niger and Mali.

Conclusions

- E-Longlife believes that results-based financing (RBF) should allow companies to provide SHS pico-solar kits with three lights without PAYGO, which should be reserved for more expensive systems beyond the most basic kit. RBF that covers 50 percent of the cost of the basic kit should be sufficient for this purpose and will accelerate access to electricity and free up additional household budgets to purchase PUE appliances.
- They believe awareness raising is still needed and that donors and governments should fund these activities.
- RBFs should allow both AC and DC equipment and come with technical assistance to help end users successfully generate income.

3.4 HEALTH FACILITY ELECTRIFICATION (HFE)

There has recently been significant interest in ensuring that health facilities throughout sub-Saharan Africa (SSA) have an adequate source of electricity, particularly following the COVID-19 pandemic. However, the potential **challenges and business models are unique** because they are social institutions, and initiatives often **involve government more heavily**.

Challenges

- **Off-grid health facilities** tend to be in rural areas that are **difficult to reach**, making them more costly to electrify with either solar or grid.
- They often **do not have critical medical equipment** that also needs to be supplied.
- Many donor and government initiatives have tried to electrify off-grid health facilities using solar, but have **neglected to fully address O&M**, leading to countless reported incidents of nonfunctioning systems.
- Rural health facilities often **lack the ability to pay** for electricity. For public facilities, **payments from governments are often too unreliable** for companies to bring off-grid solar solutions, and other interventions like grants and guarantees are needed to make private sector involvement viable.
- **Coordination between the ministries** that cover energy and health is often lacking.

Market Size

- There are about **100,000 health facilities** in SSA.[9]
- **About 25 percent of health facilities in SSA have no access to electricity,** and **only 28 percent have reliable access**,[10] but these are just estimates as government data can sometimes be unreliable or nonexistent.
- An upfront cost of about $500 million is needed to connect unelectrified health facilities with solar according to one source,[11] though higher estimates have also been suggested.

Business Models

- In the past, most health facilities were connected to the grid or electrified through standalone solar systems funded and installed by government, NGO, and donor programs.
- These systems have typically been implemented without a comprehensive business model, with nonexistent or limited operations and maintenance plans.
- Most donors now understand that **O&M is critical** and are **piloting new business models** with greater involvement of private sector companies, though no systematic approach as emerged.
- Most companies work on electrification of social institutions only as one part of their business, since **HFE initiatives are not yet at scale**.

[9] Maina, J., Ouma, P.O., Macharia, P.M. *et al.* A spatial database of health facilities managed by the public health sector in sub Saharan Africa. *Sci Data* **6**, 134 (2019). https://doi.org/10.1038/s41597-019-0142-2 https://www.nature.com/articles/s41597-019-0142-2

[10] Sustainable Energy for All (SEforALL) and the Energy Sector Management Assistance Program (ESMAP). From Procurement to Performance: Toward a private sector-led service-based model to scale up sustainable electrification of public institutions. November 2021. https://www.seforall.org/system/files/2021-12/Procurement-to-Performance-SEforALL.pdf

[11] Moner-Girona et al., Joule 5, 2687–2714 October 20, 2021. Published by Elsevier Inc. https://doi.org/10.1016/j.joule.2021.09.010

Recommendations

- Ensure any initiatives build in **provision of O&M for a minimum of ten years, preferably longer**.
- Initiatives should **bundle multiple sites** to unlock economies of scale and reduce transaction costs.
- Consider a project finance structure that works the same way as for an independent power producer (IPP) that has a **power purchase agreement (PPA)** with the government, backed by **guarantees**.
- Some level of **subsidy for the upfront cost** is generally needed for HFE projects. **RBF for the capex** could be part of the structure of a PPA.
- Carbon finance could be explored, but it is unclear if enough credits can be generated to make a significant difference.
- Multiple **donors and governments are starting to look at models that bundle other public buildings such as in the education and water sectors** to bundle together with health as they could require similar approaches.

Photo credit: DCP

DIFFER COMMUNITY POWER
COMPANY PROFILE

Product R&D and Innovation

- Differ Community Power (DCP) offers complete solar solutions for health facilities, including financing and O&M services enabled through remote monitoring and data management.
- They have standardized packages depending on the size of the health facility and can offer appliances and connections to nearby staff houses at extra cost.
- DCP currently operates more than 100 sites in Kenya, Malawi, the Philippines, and Zambia.

Project Financing

- Differ Community Power, together with World Resources Institute and Population Services Kenya, is piloting a lease-to-own model in Kenya through bundling of private health facilities into one financing vehicle funded by equity and debt.
- Standardization, automation, and digitalization reduce overhead costs and allow more reasonable financing to be provided to the health facilities.
- DCP enters into long-term power purchase agreements with governments using a project finance structure like those used by utility-scale independent power producers. These must be backed by guarantees and other measures to make the projects bankable.
- Their systems have the potential to power additional productive use of energy (PUE) with any excess power or could be oversized for planned PUE

Conclusions

- Upfront grants or results-based financing to reduce the capex or opex, respectively, would lower the price for governments and private facilities and thereby reduce the risk of default.
- Appropriately designed guarantees will generally be needed, especially when public facilities are involved.

4. Analysis

This section focuses on general findings from interviews and literature review organized thematically by donor support, finance, policy and regulation, and technical assistance. Overall trends and key takeaways are presented to lay the groundwork for the recommendations that follow in the next section.

4.1 DONOR PROGRAMS

The subsection contains information collected from literature review and interviews of multiple donor programs in operation or under design across the continent. The private sector also provided opinions on advantages and challenges of the existing programs during interviews.

Below is an overview of key donor support initiatives that operate across multiple countries, although this list in not exhaustive. Some programs that have ended or run out of funding and are currently fundraising are generally not included, though some are listed if they are particularly relevant to the PUE sector.

Table 3. Overview of Key Donor Support Programs

Program Name	Description
Productive Use Appliance Financing Facility	• Bulk procurement RBF and consumer financing fund • Pumps, fridges/freezers, cold rooms, mills, fans, electric pressure cookers • Kenya, Uganda, Ethiopia, Nigeria, Sierra Leone, DRC
Universal Energy Facility (UEF)	• RBF • Mini-grids in Madagascar, Sierra Leone, Benin • Standalone solar for productive use in Nigeria
Beyond the Grid Fund for Africa (BGFA)	• RBF • SHS, Mini-grids, PUE • Burkina Faso, DRC, Liberia, Mozambique, Uganda, and Zambia

Program Name	Description
Water and Energy for Food (WE4F)	• Grants and technical assistance • Agricultural PUE • 28 countries, including Kenya, Uganda, Rwanda, Somalia, Ethiopia, Tanzania, DRC, Mozambique, Zambia, Zimbabwe, Mali, Burkina Faso
Africa Enterprise Challenge Fund (AECF)	• Grants, RBF, and technical assistance • Agriculture, energy, and climate • 26 countries, including all 15 Sida countries
Energy and Environment Partnership (EEP)	• Early-stage grants • Range of clean energy businesses • 15 countries across Southern and East Africa
Powering Renewable Energy Opportunities (PREO)	• Grants and technical assistance • Range of PUE • SSA excluding South Africa
Sustainable Energy for Smallholder Farmers (SEFFA)	• Grants, RBF, and technical assistance • PUE for smallholder farmers • Kenya, Uganda, Ethiopia

Productive Use Appliance Financing Facility

- Global Energy Alliance for People and Planet (GEAPP), led by the Rockefeller Foundation, is supporting the development of a **PUE appliance financing facility implemented by CLASP and Nithio**:
  - For **solar water pumps, mills, walk-in cold storage, fridges, fans, and electric pressure cookers**.
  - Initially in **Kenya, Uganda, Ethiopia, Nigeria, and Sierra Leone, and DRC**.
- It will consist of two main components to address affordability issues with $6.5 million in funding, and will run for four years:
  - **Bulk procurement subsidies** in the form of an RBF, implemented by CLASP.
  - **Consumer financing fund**, implemented by Nithio, to provide loans for distributors at concessional rates to enable them to provide cheaper end-user financing.
- The facility expects to support the sale of over **160,000 PUE appliances and over 42,000 businesses**.
- It also has a **small fund** of $800,000 for **grants of $10,000–$20,000** for companies to put toward any costs they are struggling to cover, including training, warehouse costs, vehicles, or short-term consultants.
- The facility is **designed to be as flexible as possible** since this was a key lesson learned from previous rounds of the Global LEAP RBF.
  - The first round of the RBF had all aspects pre-defined, including incentive amounts, and it did not work well for the companies.
  - Subsequent rounds were more flexible with wide technology scope and eligibility criteria. Flexibility during implementation was also made possible.
    - Incentives were increased and disbursement schedules were modified due to the pandemic.

        - Funding can be reallocated away from companies that are not performing.
    - This round was designed to be as flexible as possible in terms of technologies and geographies. The approach is to be open and **see where the funding flows to determine where the viable markets are located**.
- It is designed with the intention that **other donors can contribute additional funds** to expand it geographically or in other ways. Notably, Nithio is aiming for a $100 million fund over five years.

Universal Energy Facility (UEF)

- The $50 million Universal Energy Facility, with a target of $100 million by the end of 2023, is funded and supported by a number of donors and partners led by Rockefeller Foundation and GEAPP.
- The UEF launched in 2020 with **$8 million** for an **RBF for mini-grid development** in Madagascar, Sierra Leone, and Benin with a target of **14,000 connections**. It announced its first 542 connections in Madagascar in 2022.
    - Results took longer than expected due to a number of challenges that included the pandemic, supply chain challenges, and lengthy administrative processes.
- The second **RBF window** is focused on **stand-alone solar for productive use** and recently launched in Nigeria.
    - The goal is to **address the upfront cost** for small and medium enterprises (SMEs) to acquire solar and to **de-risk expansion** into new markets for solar companies.
    - It is expected that many of the SMEs will purchase the solar to **replace polluting sources of energy such as diesel**.
    - The program will support systems between 100 W and 5 kW installed with lithium batteries and pay **40 percent of the capex** for each unit up to a maximum limit.
    - Upon installation, 30 percent of the capex is paid with the remaining 10 percent paid after 18 months to help ensure proper after-sales servicing.
- The UEF is actively looking to expand both windows into other countries and during our interview has flagged DRC as a potential country for the stand alone solar for productive use model.

Beyond the Grid Fund for Africa (BGFA)

- The Nordic Green Bank which is the facility manager of the Beyond the Grid Fund for Africa and the Swedish International Development Cooperation Agency (Sida)commissioned this report
- BGFA provides funding in the form of **RBF for companies** selling **SHS** and developing **mini-grids**, including those that incorporate **PUE appliances and applications** into their portfolios.
- It has **over €126 million**, to support projects in **Burkina Faso, DRC, Liberia, Mozambique, Uganda, and Zambia**. The Governments of Sweden, Denmark, Norway and Germany (via KfW) are also contributing to the fund.
- As of December 2022, BGFA has signed contracts with thirteen projects that expect to provide over **953,000 connections.**
- BGFA has signed with one pure-play PUE company, Tulima Solar in Uganda, and at least **six other portfolio companies incorporate PUE into their products**, including solar water pumps, fridges, and freezers. Three of these companies are using over 60 percent of RBF for PUE.
- BGFA provides TA for the sector, including advocacy for **policy, regulation, and fiscal incentives** as well as a program of TA to portfolio companies.

Africa Enterprise Challenge Fund (AECF)

- AECF has a range of funders, including Sida, and has raised almost $400 million.
- AECF REACT SSA provides **matching grants and technical assistance to early-stage, high-risk companies** working in **agriculture, energy, and climate**.
  - It has a **policy and advocacy** component to promote a positive enabling environment for these companies.
  - It has a component called the Innovation Fund that funds even earlier stage companies with **smaller grants without milestones**.
  - In Kenya, there is a component that offers **RBF** for those companies that graduated from the matching grants program.
  - In 2021, **only 2.3 percent** of beneficiaries reached were **PUE businesses**.
- They have supported over **375 businesses** in 26 countries impacting over **30 million lives**.
- Financing comes in the form of **grants, zero-interest loans, guarantees, and working capital**.
- **Technical assistance** includes business advisory services and helping companies access finance by linking them with appropriate investors.
- **Underserved countries and regions continue to be a challenge** even for flexible instruments like AECF. For example, Sudan and South Sudan are eligible countries with no deployment of funding in the PUE space or off-grid altogether. Most of these markets are served by EPCs, often without O&M or after-sales service.
- AECF funding has allowed some early-stage companies to **mature to a level where they have subsequently absorbed RBFs**, e.g., in Liberia.

Water and Energy for Food (WE4F)

- WE4F provides **grants and technical assistance to early-stage companies** operating in the **energy-water-food nexus**.
- The program is an initiative of BMZ, EU, Sida, the Government of the Netherlands, and USAID with **$65 million** in funding.
- The program works to improve the **enabling environment** through policy dialogues and government engagement, including on standards, import duty and taxes.
- Support is also offered to **support MFIs to provide financing for PUE**, including the development of loan products and internal digital systems.
- WE4F also **conducts research** such as market assessments to benefit the sector.
- This program is a follow-on to the Powering Agriculture and Securing Water and Energy for Food worldwide grand challenges that were implemented nearly a decade ago. The purpose of WE4F is to support companies to reach scale rather than early-stage pilots. However, the private sector is still less developed in PUE than expected, particularly in underserved regions (e.g., southern and central Africa), and the successful applications were largely from early-stage companies.

Energy and Environment Partnership (EEP)

- The EEP facility hosted and managed by the Nordic Development Fund (NDF) with funding from Austria, Denmark, Finland, Iceland, NDF and Switzerland
- It provides **grants and technical assistance to early-stage companies** in 12 different clean energy sector technologies, including PUE.

- TA support includes business development support, investment facilitation, knowledge exchange.
- It has invested about **$50 million in 250 projects** resulting in **5 million people** with enhanced energy access and over **8,000 jobs created**.

Powering Renewable Energy Opportunities (PREO)

- The PREO program provides **funding and technical assistance to high-risk projects deploying PUE services** to grow local economies. It has **€10.9 million** from by IKEA Foundation and UK Aid.
- It has supported **30 projects** in multiple sectors such as agriculture, health, and transport with the goal of creating **3500 jobs** and benefiting **11,000 households**.
- The program provides **grants up to €300,000** are available and **tailored technical assistance** depending on project needs.

Sustainable Energy for Smallholder Farmers (SEFFA)

- The **€8 million** SEFFA project funded by IKEA Foundation and implemented by Energising Development (EnDev) is supporting **solar irrigation, cooling, and drying** applications in Uganda, Kenya, and Ethiopia.
- The project will initially target **750 farmers for pumping, six cooperatives for cooling, four for drying, and one for grinding**.
- In addition to enabling environment and research activities, it has established an **RBF facility for solar water pump distributors in Kenya**.
- It has an **innovation fund** that provides small grants of up to **€25,000 for four companies in each country**.

4.2 FINANCE

Overview

From a financing standpoint, the **PUE asset class** is a tier above SHS, which has traditionally been focused on small capacity units and low-income households. On the one hand, PUE **provides new opportunities** for investors: larger capex, higher capital requirements, more **income generation**, more sophisticated end clients, and diverse impacts in the form of **job creation and economic growth** in addition to energy access. On the other hand, PUE finance is typically associated with **higher risks**: **supply chains** are immature and complex, there is less standardization, systems are much **more expensive**, small business/farmers/SMEs tend to show **poor repayment** behavior, and collection and repossession are more challenging. A combination of better data access to quantify the risk and downside protection to limit the expected loss can help boost investments in the sector, especially for companies that are reaching maturity.

Capital Needs

- Though estimates vary widely, PREO estimates the PUE market opportunity at $120 billion per annum from 2020 to 2030 in Sub-Saharan Africa, split between equipment and appliances and the solar systems needed to power them.
- Over 200 million businesses in SSA would access PUE products with this investment, creating jobs and growing the economy.

- Regardless of the accuracy of these estimates and even taking into account the smaller size of the actual serviceable market, the **need for financing is significant**.

Existing PUE Funding

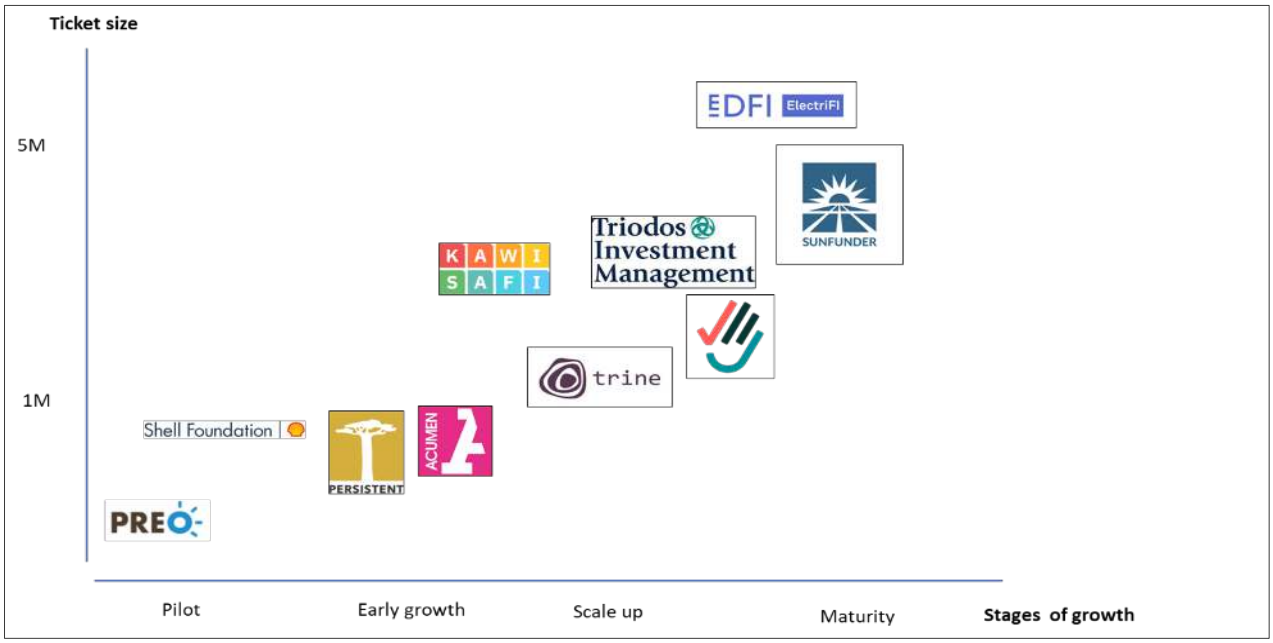
The nascency of the PUE appliance and equipment segment means that the supply chain has not reached the level of scale and efficiency that supports low-cost production. **Most PUE companies have not reached the series B stage**, and funding is coming largely from high-risk capital and grants, although specialized debt is becoming possible.

Existing Investors

Investors have shown high interest in the PUE asset class, and they can be broadly split into two categories.

- **Impact investors** who have been traditionally involved with financial inclusion, agricultural finance, or energy access. They have leveraged their network and their knowledge of the local SME finance market to gradually build an exposure to PUE business models and PUE asset financing.
  - DFIs are notably involved directly, e.g., DFC in Ampersand, or indirectly through DFI-supported funds. ElectriFI and Infraco, for instance, were created by DFIs as investment funds mainly focused on energy production but are now found as early supporters of PUE companies such as Simusolar, Zembo, and Bonergie.
  - Sunfunder has traditionally focused on SHS models but is currently closing a $500 million fund that will have significant exposure to PUE companies, and Acumen has launched a fund solely dedicated to PUE.
- **Strategic investors**, mostly in health electrification and e-mobility. Examples include Toyota's Health54 and Mobility54 that fund early-stage companies in Africa active in these sectors. EDF has also supported SunCulture as an early shareholder in 2018.

Figure 2. Examples of PUE Funders



Equity

- Equity is **critical for product development, business setup and operation, and debt fundraising**, when possible, through leverage.
- As with any nascent sector, at least 50 percent of the required capital should be equity.
- Various equity players have supported PUE initiatives, although ticket sizes rarely exceed $5 million. A few indicative examples include:
  - KawiSafi Ventures, who invested in InspiraFarms for solar walk-in cold rooms;
  - InfraCo Africa, who invested in Zembo for e-mobility; and
  - ElectriFI and Acumen, who invested in Simusolar for solar water pumps.
- Some investors, such as Persistent Energy Capital, combine their equity investments with significant technical assistance and "venture building."
  - Ticket sizes typically range from $200,000 to $1 million in seed round or Series A investments.
  - Unlike conventional venture capitalists, they invest human and financial resources into their portfolio companies to compensate for the lack of ecosystem support that entrepreneurs typically access in developed countries.
  - Their human resource investments enables them to intervene earlier in special situations that arise in their investee companies.

Working Capital and Inventory Finance

- This type of funding is **crucial to ensure a good level of liquidity and to support PUE companies in their complex supply operations**.
- Specialized funds like SIMA and Sunfunder are the most prominent players, with some increasing involvement from crowdfunding platforms like Lendahand.
- Working capital loans are typically between $50,000 and $5 million over two to four years. Some transactions are scaling up and exceeding $10 million, such as the syndicated debt transaction to SunCulture in December 2021.

Grants and RBF

- Grants are **crucial to fund pilots, facilitate market entry, and improve the affordability and the economics of PUE solutions**, especially at this early stage of market development.
- RBFs are **effective in bringing companies into underserved markets** that are difficult to operate in profitably.
- Some examples are described in the Donor Programs section of this report.

Consumer Finance

- Most PUE end-user finance is provided by PUE distributors through leasing or PAYGO solutions.
- However, more **efforts are needed to stimulate local financing through MFIs and banks** for small businesses and farmers to acquire PUE solutions. These efforts could include capacity building to financial institutions, transaction support, and establishing securities such as guarantees or green credit lines that can reduce collateral requirements and interest rates.

Carbon Finance

- Carbon finance comes with **high transaction costs** and is therefore only viable for companies that have sufficiently large number of sales and if the quantity of emissions avoided is high enough.
- Carbon prices **are volatile** and expected to go down in the short term given a global decrease in energy consumption due to higher prices and recession fears. Carbon credit futures prices under the European Union (EU) cap and trade regimes already have decreased by 30 percent since August 2022.
- However, **some of the more mature companies are beginning to explore options** and could potentially require support, including:
  - Modeling of potential carbon-related income and assessments of viability
  - Assistance with the lengthy process of preparing project documents and standard selection
  - Guidance on broker selection and buyer origination.

Conclusions

Based on our discussions with investors, key barriers to the scale-up of their exposure to the PUE asset class are summarized in the table below.

Table 4. PUE Investment Barriers and Solutions

PUE Investment Barriers	Potential Solutions
High-risk clients with seasonal income, making it difficult to provide consumer financing	• Data aggregation and analysis through PAYGO platforms • Piloting of credit solutions such as PAYGO and leasing that are adapted to farmers and SMEs, potentially with grace periods and accounting for seasonality • B2B platforms to connect PUE players and provide better market intelligence to inform decisions • Pilots to better understand the economics of PUE and give confidence to investors
Lack of maturity and track record, making it difficult to obtain affordable corporate debt	• Blended finance solutions • Grants for early-stage companies
High macro risks, making investors reluctant to support local companies	• Hedging solutions • Political guarantees

To further increase flows of capital to companies, guarantees are another instrument that could be deployed. While most donors have only engaged with financial intermediaries, there are other types of guarantees that would unlock additional financing to allow PUE companies to scale even faster.

Table 5. Guarantee Options to Scale Up PUE

Guarantee Options to Scale Up PUE	Benefits	Risks
Private Equity/Debt Funds: guaranteeing portfolios or bilateral deals	Encourage more and faster exposure to the sector, facilitating the availability of institutional capital for scalable PUE companies	Market distortion vis-à-vis other funders
Manufacturers: guaranteeing supplier credits to local distributors	Improving the liquidity and growth of local distributors	Structure too complex for large manufacturers
Local Banks: guaranteeing PUE lending by local banks and SMEs	Stimulating needed local funding for PUE growth	Lack of knowledge and technical assistance needed
In-House/Receivables: guaranteeing receivables generated by in-house PAYGO and leasing of PUE	Stimulating in-house financing and supporting receivable-based borrowing from local and international lenders	High loss considering typically high defaults

4.3 POLICY AND REGULATION

The following policy and regulatory interventions should be supported by multiple donors in the sector. there should be active collaboration among technical assistance facilities that have a mandate to improve the enabling environment. Both financial and capacity building support to national renewable energy associations is needed to stablish long term advocacy capacity as policies and regulations will continue to fluctuate past the life of the RBF.

Policies and Strategies

- Government can play a critical role in **raising awareness** of the benefits of PUE appliances and equipment, which is a significant barrier in the adoption of these technologies.
- Coordination is imperative for ministries across multiple sectors, including agriculture, health, and transportation.
- Policies and strategies can be **strong indicators of government support** to the private sector and compel line ministries, implementing agencies, and regulators to fulfill the vision that is laid out in them.
- **Subsidy programs** can significantly increase uptake of PUE, especially when supported by the government, though care should be used in their design to avoid unintended negative consequences.
- Industry associations should advocate for **coordination between relevant ministries** in the development of appropriate policies and regulations that enable PUE to scale.

Fiscal Incentives

- Ideally, PUE appliances and equipment would have **exemptions from VAT and customs duties** to encourage their adoption and stimulate economic growth.
- In most cases, these exemptions are not in place.

- **Application of duties and taxes is often inconsistent**, leading to unpredictability and delays during dispute resolution.
- Corporate tax holidays and other tax benefits would also reduce prices for the end user and address affordability issues.
- **Industry associations** and other stakeholders should **advocate to government** for fiscal incentives that support the PUE sector, a **revision of Harmonized System (HS) codes** when necessary, and **clarity and uniform application of customs procedures**.

Quality Standards

- **Quality standards are generally not in place** for PUE appliances and equipment.
- As a result, **market spoilage** is seen in some sectors when low-quality products fail and there is no warranty or after-sales service.
- **Verasol** has long played a critical role in SHS standards and is more recently attempting to fill the gap by conducting **appliance testing** and generating publicly available **performance data** on solar water pumps, fridges, TVs, fans, and electric pressure cookers.
- Ideally, international standards such as those of the International Electrotechnical Commission (IEC) would be established eventually. In the meantime, Verasol testing and data along with the development of **voluntary standards** are an important stopgap measure.
- Note that for PUE products that are still undergoing significant R&D, mandatory standards could stifle innovation and place unnecessary burdens on early-stage companies.

PUE-INCLUSIVE POLICIES AND REGULATIONS: LIBERIA CASE STUDY

Policy and Fiscal incentives:

- Many types of PUE equipment are listed under the recently signed Presidential Executive Order #107, which waives the import duty on quality certified solar products.
- Implementation of the Executive Order is tied to the final approval of the draft regulations.

Technical Regulation:

- Liberia recently developed their Draft Technical Regulations for solar products, including PUE, which have been submitted to the Electricity Regulatory Commission for adoption while the importation guidelines are also awaiting the signature of the Minister of Commerce and Industry
- These importation guidelines will inform the products to be exempted under Executive Order #107.

Standards:

- The Draft Technical Regulations includes a list of solar products with associated international standards and Verasol certificates.
- Larger PUE equipment will be covered by existing international standards for component-based solar systems.

4.4 TECHNICAL ASSISTANCE (TA)

TA is Critical

- **Private sector and donors repeatedly highlighted the importance of TA** to support the increased uptake of various PUE technologies.
- Some donor programs are providing TA to support the PUE companies they are funding, including BGFA, WE4F, AECF, and PREO who provide a range of tailored TA to each of their innovators to help them overcome specific market barriers.

TA Should be Tailored

- PUE companies have a **broad range of TA needs** depending on a range of factors such as the countries in which they are operating, their level of maturity, and the PUE technologies being deployed.
- The range of potential TA is broad and **should be tailored** to the needs of each company. Potential support could include sales and marketing, financial management, training of staff, and talent recruitment, especially for experienced managers.
- TA **needs to be high quality**, with providers having appropriate experience and local context.

TA Depends on Maturity of Technologies and Companies

- For **less mature PUE technologies**, such as solar milling and drying, TA is still required on the **development of the technology and testing different business models**, in addition to grant financing.
- **Earlier stage** companies tend to need more high-level TA on **strategic plans, investment pitch decks, and partnerships.**
- For **more mature PUE technologies**, such as solar water pumps and cold storage, the TA could be more focused on scaling up the business model by developing **strategic partnerships**, testing **consumer finance models,** and strengthening **financial systems** to help raise finance. Although grants are still required, they can be more focused on supporting companies to build their financial systems to leverage other forms of funding.
- **Mature companies** need more in-depth and detailed support in specific areas, such as **credit risk mitigation plans, adjusting financial models, and reviewing sales and marketing processes** to make them leaner and more efficient.

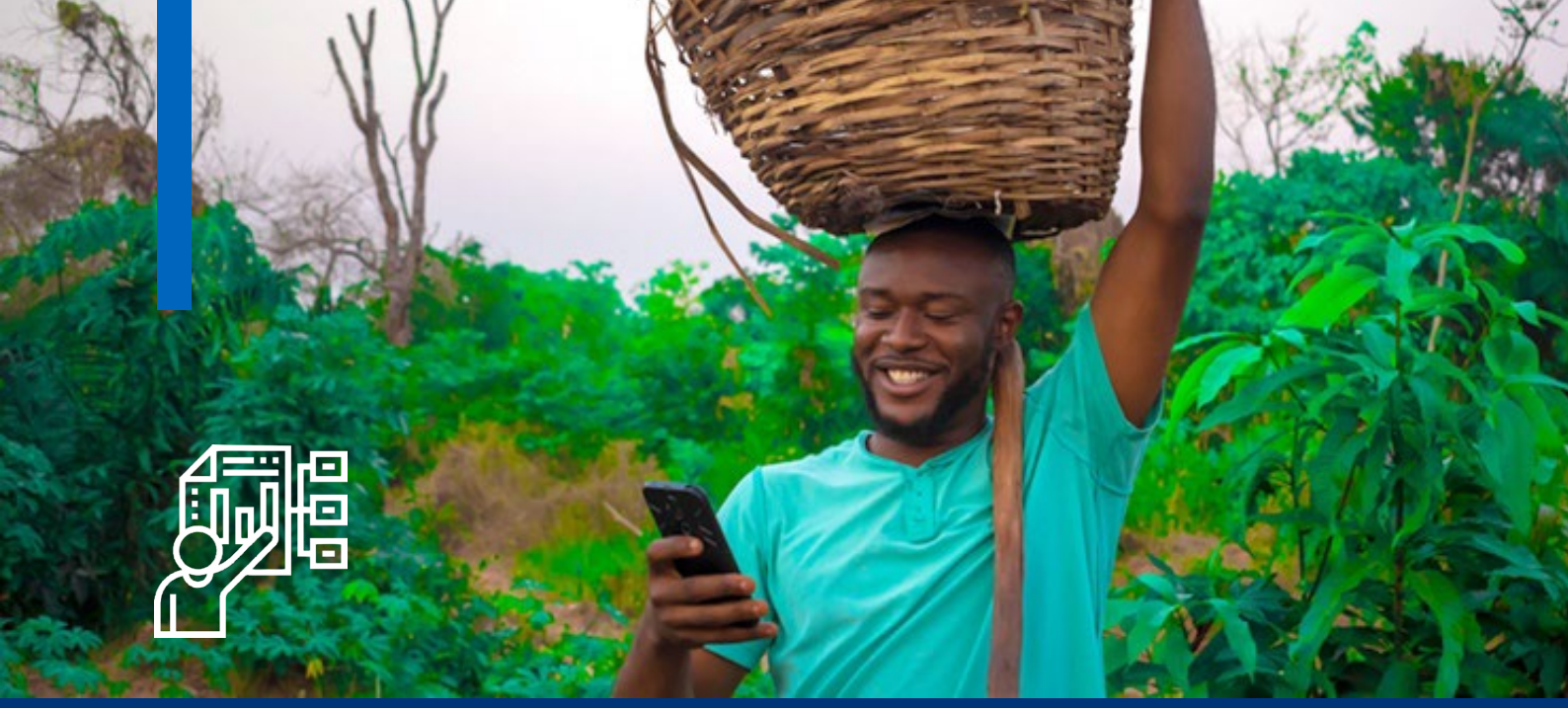
TA Can Be Short or Long Term

- TA can be **short-term** support to overcome specific barriers, such as **identifying new partners**, preparing **applications for funding,** or reviewing of monitoring and evaluation indicators.
- **Longer-term** engagements include embedding an advisor such as a **part-time chief financial officer** to help companies develop their fundraising capabilities or supporting the private sector broadly to engage governments in the development of **tax and duty exemptions or quality standards** in a particular country.

INDICATIVE EXAMPLES OF TA NEEDS

Based on feedback from companies and support programs, some of the TA priority areas for PUE companies are as follows:

- Support to reach customers, in particular rural farmers, by building **strategic partnerships** with agricultural input suppliers, farmers associations, and other supply chain companies that have a close relationship with large numbers of smallholder or commercial farmers.
- Support on getting relevant **information on good agricultural practices** to farmers, including which crop to grow, how to preserve or process crops post-harvest, and the most efficient and cost-effective methods of getting agricultural products to the markets with the best prices. Similarly **good business practice trainings are needed for non-agricultural SMEs.**
- Support on community **awareness campaigns** to build knowledge of the benefits of a range of PUE products, including their potential to generate additional revenue in the long run despite the cost of the equipment. Nexus coordination is imperative to successfully implement PUE awareness campaign including coordination with existing off-grid SHS campaigns.
- Support on **consumer finance strategies** to overcome the high upfront cost of PUE, including structuring low-risk PAYGO services and partnerships with other consumer finance providers such as MFIs and local banks.
- Support on **R&D for product refinement** of various technologies to bring down their cost, increase their quality and reliability, and provide additional services in rural and agricultural settings.



5. Conclusions and Recommendations

The PUE and off-grid sector has been emerging at a rapid pace in the past few years and is already powering around 10 million medium and small enterprises, including those involving smallholder farmers with more than 190,000 farms currently using solar irrigation systems worldwide, according to the latest ESMAP *Off-Grid Solar Market Trends Report 2022*. In addition, approximately $7.7 million out of $10 million in grants globally in the off-grid sector went to PUE in 2021. Solar water pumping and solar refrigeration were classified two years ago as "emerging technologies" and have now evolved to "near-to-market." Even though there has been progress in the PUE space, key challenges still remain as the sector evolves.

End-User and Distributor Financing

- The PUE sector faces many challenges that are different from those experienced by the SHS sector. A few stem purely from the fact that **PUE equipment generally comes with a higher cost**.
  - **Affordability** challenges are amplified.
  - There is **greater need for financing** by distributors and end users to cover the upfront cost of the equipment.
  - There is **higher risk** to the distributor in providing **end-user financing** for a higher cost product.
  - **Credit assessment is more difficult** since assessing farmer's ability to generate income is complex.
  - Higher risk leads to **higher cost of financing**, whether provided by a third party or the PUE company itself, or **financing is simply unavailable.**
- **Loans** to distributors also comes at a **high cost** for distributors or are **unavailable** because financial institutions are not willing to provide sufficiently small loans.
- Companies **struggle to pre-finance activities** under results-based financing.
- Typical **PAYGO approaches may not be suitable** for PUE equipment, especially for agricultural income that is tied to harvest season.
- **Financial institutions will generally require TA** if they are to be convinced to enter the sector.

Customer Acquisition

- **Identifying capable entrepreneurs** that can successfully generate income with the PUE equipment is not always simple. Often, significant TA must be provided.
- It takes **effort to convince farmers** to take on the risk of paying for or taking a loan for high-cost PUE equipment when increased income is not guaranteed.
- Customers have concerns about **product quality and after-sales service**.

Equipment and Distribution

- Off-the-shelf equipment is often **not suitable for rural PUE applications,** and new products need to be developed. In addition, **customization** of these products for specific customers is sometimes necessary.
- PUE powered by solar often **competes with incumbent technologies** that have lower upfront costs, such as diesel and lead acid batteries.
- Distribution can be made more difficult and costly by the **size and weight of the equipment**.
- Some equipment, such as pumps, fridges, and mills, can serve multiple people, resulting in **fewer sales opportunities per village**.
- If villages are dispersed in **sparsely populated rural areas** and only a few sales are possible per village, the **marketing, distribution, and after-sales servicing costs are high**.
- **After-sales servicing is often more complex and needed more frequently** compared to SHS.
- More complex equipment means **supply chain disruptions** are more common and difficult to manage.
- PUE **market requirements vary widely by sector and value chain** and due to location-specific circumstances and differing policies and regulations.

Challenges Facing Private sector

The table below summarizes key challenges from interviews and the literature review, which were common themes across sectors, technologies, and regions.

Table 6. Key Challenges Facing Private Sector

Key Challenges Facing Private Sector	

Affordability	• Equipment cost is higher than SHS means:
	  ○ Greater need for both distributor and end user financing
	  ○ Higher risk for distributors providing financing to the end user, which leads to more complexity in assessing credit risk

Awareness	• Potential customers unaware of the technology • Even if aware, unsure whether investing in expensive equipment will earn them additional income
Knowledge and Skills	• Getting a product or service to market requires significant TA along multiple steps in the value chain

Customer Acquisition	• Costs of acquiring customers that can pay back the cost of the asset is high due to:
	  ○ Lack of awareness
	  ○ Need for financing

Key Challenges Facing Private Sector	
	○ Difficulty in finding capable entrepreneurs with the necessary skills and knowledge to generate sufficient income
Distribution	• Distributing a few, large pieces of equipment per village in sparsely populated rural areas is costly
Supply Chain	• Supply chains can be more difficult to manage, especially for equipment that is custom designed

Challenges Facing Grants and RBF Programs

RBF facilities and grant programs for PUE have been deployed in multiple countries and allowed the sector to develop solutions with the potential to scale. However, private sector, donors, and implementers have highlighted a few challenges with both current and previous initiatives:

Table 7. Key Challenges Facing Grants and RBF Programs

Key Challenges Facing Support Programs	
Long Timelines	• Procurement timelines can mean that the company is in a very different situation at approval than application submission
Lack of Flexibility	• Focus of the grant program can divert companies from their core business • Inability of programs to adjust to changing circumstances on the ground can be problematic • Programs can be too rigid on requirements and constraints on how funding can be spent
Administrative Burdens	• Reporting requirements can be time consuming • Monitoring and verification can take significant company resources
Market Distortion	• Grants and RBFs can overlook or leave out existing market players, putting them at an unfair disadvantage

Summary of Conclusions

Based on the challenges previously summarized, the recommendations below are generally applicable to most markets and technologies under consideration. However, the PUE sector is complex and multiple context-specific factors should be taken into account when designing interventions.

Table 8. Key Interventions and Applicable Situations

Key Interventions	Applicable Situations
Challenge Funds or Traditional Milestone-Based Grants (Seeding and Acceleration)	• **Grants** are crucial to fund **pilots**, facilitate **market entry**, and improve the **affordability** and the economics of PUE solutions, especially at this **early stage** of market development. • **R&D, technological improvement of equipment, refinement of customer acquisition strategies, and testing of business**

Key Interventions	Applicable Situations
	models is routine and a constant in the sector, even amongst the most mature companies. The activities above are often **fragmented by value chains and geography** and need to be tailored accordingly. • **Even companies that have reached scale in other sectors require R&D funding** when entering the PUE space to adapt their sales strategy, train staff, conduct marketing campaigns, and other aspects of their business model. • Grants for these activities will reduce costs for companies, **address affordability and reduce the time for companies to scale**. • Ticket sizes for challenge funds **range widely between $50,000 to $1 million** as early-stage companies generally cannot absorb more. • Geographically, the **PUE sector generally grows with the SHS sector**. However, even countries with high penetration of SHS have underserved markets that will require early stage funding.
Results-Based Financing (Acceleration and Scale)	• RBFs are **effective in bringing companies into underserved markets** that are difficult to operate in profitably. • **Solar water pumping and solar refrigeration** are the two PUE technologies with the most potential reach scale under an RBF instrument. • **Manufacturers are currently more likely to absorb larger RBF ticket sizes**, but they may need to claim across multiple geographies. • For **last-mile distributors**, ability to raise capital is limited, so an RBF may need to provide some **funding upfront in advance.** • RBFs should consider **partnering with donors** that can provide financial support at an earlier stage to make companies ready for investment by an RBF. • Companies have expressed that **reporting requirements for PUE grants and RBFs can be burdensome** and suggest that donors fund external consultants to provide this service to reduce private sector burden. • For mini-grids, **opex subsidies** (through an RBF based on customer payments) to **lower the end-user tariff** can reduce the risk for those financing appliances and **increase demand for PUE**. • Donors can also **directly support entities to provide appliance financing**, including mini-grid developers, suppliers, and MFIs.

Key Interventions	Applicable Situations
	• RBFs should consider allowing for **greater flexibility in design,** including admissions on a **rolling basis** any time during the lifetime of the project, **co-creation** with companies, and relaxed requirements for prior grantees.
Guarantees (Scale and Maturity)	• **Guarantees can be useful for more mature companies** seeking loans of larger ticket sizes. • PUE could be **integrated within existing renewable energy loan portfolio guarantees** already in the market. • Guaranteeing portfolios or bilateral deals with **private equity/debt funds** encourages more and faster exposure to the sector and increases the **availability of institutional capital** for scalable PUE companies. • Guarantees can also be considered for suppliers to provide **credit to distributors and receivables financing**. • Guarantees for **local banks and MFIs** could also provide another source of financing depending on the context. • An **external entity responsible for donor reporting requirements** funded by the guarantee provider would **reduce administrative burden** and could provide better PUE impact metrics data collection and analysis. • Ticket sizes for **guarantees should start low**, if possible at $500,000 or lower, to support lending to the PUE sector from more risk-averse institutions. • **Guaranteeing manufacturers who provide supplier credits** to local distributors could Improve their liquidity and growth. • **Guaranteeing receivables** generated by in-house PAYGO and leasing of PUE stimulates receivables-based borrowing from local and international lenders. • **The African Guarantee Fund,** supported by Sida, has relevant guarantee products for the sector, starting with small ticket sizes, multiple existing facilities with local financial institutions, and low-cost, pan-African coverage with the ability to co-guarantee up to 75 percent with long tenors up to ten years.
Policy and Regulation	• Governments can play a critical role in **raising awareness.** • They can strongly **signal support** for PUE, especially through **subsidy programs.** • **Exemptions from VAT and customs duties** can encourage adoption of PUE.

Key Interventions	Applicable Situations
	• But they must be **clear and applied consistently.** • **Quality standards** can **prevent market spoilage.** • However, they **could stifle innovation** if applied to markets that are too early stage. • Both financial and capacity building support to **national renewable energy associations** is needed to stablish long-term **advocacy capacity** as policies and regulations will continue to shift after donor programs end.
Technical Assistance	• **A significant range of skills and competencies need to be developed** in order to ensure the success of a PUE company and its financiers and end users. • **Needs assessments** should be conducted to determine appropriate interventions for the sector broadly. • Companies expressed a desire for **high-quality, tailored, and adapted** TA that is specific to the needs of the company. • Needs span a **broad range of potential interventions**, including awareness raising, business model refinement, access to finance, partnerships, policy and regulation, and technology development. • Companies have expressed **interest in carbon finance**, and TA can help them understand whether the value of the credits make a significant difference in their business model. • **Financial institutions will generally require TA** if they are to be convinced to enter the sector. • Donors can develop **B2B platforms** that connect PUE players and provide better market intelligence to inform decisions by all stakeholders. • **Donor program coordination** is required to enhance **knowledge management** and harness lessons learned.

6. Country Profiles

6.1 BURKINA FASO

GOGLA has not reported any data on solar water pumps due to lack of sales or reporting by companies. For refrigeration units, no data has been reported with the exception of about 60 sold during one six-month period in 2020.

Security concerns and political instability still remain barriers for development in general in the country.

Government

- The $168 million Solar Energy and Access Project funded by the World Bank has a component that aims to build out mini-grids, including productive uses. A smaller activity as part of the project will focus on consumer education to promote PUE.
- The Yeleen Rural Electrification Project, funded by donors through the Green Climate Fund, will provide 3,300 PUE connections as part of its effort to connect 150,000 customers through mini-grids and SHS. A guarantee of €2.8 million will cover PUE equipment loans.

Development Partners

- BGFA is supporting two companies over the next four years to deploy SHS, mini-grids, and PUE equipment. More funding rounds are anticipated.
- AECF is providing grants to companies that provide productive use solutions as part of their portfolios. The number of grantees involved with PUE is notably higher than other countries considered in this report.
- The Africa Mini-grids Program run by the GEF provides TA to the sector and support for PUE pilots.
- The Regional Off-Grid Electricity Access Project (ROGEAP) covers Burkina Faso as one of the 19 countries eligible for the project, which includes a $209 million line of credit through BOAD (West Africa Development Bank) for standalone solar, including both SHS and PUE for businesses. The

project also has a grant facility of $67 million for financial institutions as well as a $30 million grant facility for standalone solar companies. The project is expected to have a fund manager for the grant facility at beginning of 2023.[12]

- The World Bank conducted a study[13] in 2021 on the potential for e-mobility in Ouagadougou, where more than two-thirds of vehicles on the road are two-wheelers. The most promising use cases were focused on electric scooters or bicycles and more for the public sector. More than 70 percent of grid electricity is generated from non-renewable sources,[14] which makes charging electric vehicles less beneficial from a climate change perspective.
- In 2021, Siemens awarded five e-mobility startup grants of €10,000-50,000, one of which went to BEAM in Burkina Faso who produces mobile solar-powered agricultural PUE solutions.

Private Sector

Table 9. Key PUE Companies and Payment Models—Burkina Faso

Company Name	Products/Services	Business Model
Oolu	• Fridges, freezers	• PAYGO
ARESS	• Solar water pumps, fridges, kits for businesses	• PAYGO
Africa Energie Solaire	• Solar water pumps, fridges, freezers	• PAYGO
Solafrique	• Solar water pumps	• PAYGO
Green Engineering Services	• Solar water pumps, fridges, mills	• PAYGO
Sahelia Solar	• Mini-grids	• Fee for service

- Oolu offers PAYGO SHS, fridges, and freezers and aims to sell over 28,000 products under the BGFA RBF announced in 2022, including larger solar installations for over 500 businesses. The project value is at least €5 million with BGFA contributing €2.5 million.
- ARESS sells PAYGO SHS, pumps, fridges, and larger installations for businesses and aims to deploy solar solutions for 19,000 households and 2,000 businesses under the BGFA RBF awarded in 2022. In 2021, they closed a €3 million Series A with ElectriFI, Gaia Impact Fund, and Triodos.
- Africa Energy Solaire has received grants from both AECF and WE4F and offer flexible payment plans for solar solutions such as water pumps, fridges, and freezers.
- Solafrique has a WE4F grant and offers drilling services in addition to PAYGO solar water pumping.
- Green Engineering Services has received grants from AECF and USADF to pilot solar milling. They also offer pumps and fridges.

[12] World Bank Group. Lighting Africa. Regional Off-Grid Electricity Access Project (ROGEAP). https://www.lightingafrica.org/wp-content/uploads/2017/12/ROGEAP-1-Pager-Mar-2021.pdf
[13] World Bank. Pathways to Electric Mobility in the Sahel: Two and three-wheelers in Bamako and Ouagadougou. 2021. https://openknowledge.worldbank.org/bitstream/handle/10986/37046/P174592012d6e100d09f6f0c1fd37ad2d16.pdf
[14] IRENA. Energy Profile Burkina Faso. https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Africa/Burkina%20Faso_Africa_RE_SP.pdf

- Sahelia Solar has received grants from AECF and USADF for mini-grids and community energy provision.
- Though not a primary focus of this report, in the commercial and industrial space, companies such as Sahelia, Yandalux, SolarX, and Solar23 are providing larger PUE installations for farming applications up to a megawatt.

Recommendations

- There are a significant number of promising early-stage companies in the sector, though perhaps not quite yet ready for RBF exclusively for PUE.
- Political risk guarantees could be needed in the sector given the recent instability, particularly for RBFs as companies would need to pre-finance with debt or equity and reassure international investors concerned about the current political environment.
- Given the potential difficulty in accessing international debt and equity, local financial institutions could fill the gap if guarantees were in place and technical assistance were provided to help them better understand the sector.

6.2 DEMOCRATIC REPUBLIC OF CONGO

Although still nascent, DRC is one of the fastest growing off-grid markets on the continent with enormous potential given its low electrification rate. It is one of the most populous countries in the continent with at least 85 million people. However, GOGLA has not reported any data on solar water pumps due to lack of sales or reporting by companies. For refrigeration units, about 200 were sold in the two six-month periods where enough companies reported in order for numbers to be published.

Previous RBFs through donor and government funding were focused on SHS and mini-grids. However, several related PUE initiatives have emerged, including the Mwinda Fund co-funded by the presidency, the launch of the BGFA window that includes PUE, and WE4F grant and TA support. Other initiatives under development include the Productive Use Appliance Financing Facility funded by GEAPP and the SE4ALL Universal Energy Facility for Standalone Solar for Productive Use, which is considering DRC as a country for future inclusion.

Government

- The National Agency for Electrification and Energy (ANSER) is fundraising for the national renewable energy Mwinda Fund, which currently has a commitment of $5 million from the presidency. The fund is aiming to raise $500 million in investment by 2024 to reach 400,000 connections in 55 territories through end-user subsidies for decentralized energy solutions. Mwinda will fund SHS, mini-grids, solar water pumping, HFE, and clean cooking. ANSER has thus far been able to convince donors to pledge a total of $122 million, including BGFA activities in DRC.
- The planned Electricity & Water Access and Governance Project and the ongoing Electricity Access and Service Expansion Project are both funded by the World Bank and provide support for the deployment of SHS and mini-grids. The latter is not explicit on productive uses, but the former mentions potential support for PUE involving agriculture and the cold chain.

- In 2022, the USAID Tanganyika Conflict Mitigation and Reconciliation launched together with ANSER an Off-Grid Energy Challenge that includes grants for the provision of PUE and HFE.
  - For HFE, solar water pumping is part of the mandate. The program will subsidize capex costs while the company will cover opex through sales of water to the surrounding communities.
  - For PUE, grants will cover 40 percent of capex costs with the remaining to be paid by the customer over time.
  - ANSER is looking forward to the results of this collaboration to replicate as well as co-fund and partner with other donor-funded activities such as the Garamba Alliance Biodiversity Program.

Development Partners

- WE4F aims to scale private sector innovations to increase the sustainability of agricultural food value chains in developing countries and emerging markets. DRC is included as a priority country under its Southern and Central Africa Regional Hub. In the first call for proposals, one application from DRC was successful.
- BGFA launched a call for proposals for DRC in 2022 and received a significant number of applications. Evaluation of the applications is currently underway.
- EnDev DRC has two components, one of which started in 2022 and is focused on PUE. It will help 80 business on Idjwi Island with business TA, access to finance, and purchase of appliances.
- GEAPP, led by the Rockefeller Foundation, is supporting the development of a PUE appliance financing facility implemented by CLASP and Nithio for solar water pumps, mills, walk-in cold storage, fridges, fans, and electric pressure cookers. DRC is one of six focus countries for GEAPP.
- GEAPP is also leading the effort to mobilize $1 billion in funding for the development of 25 metro-grids that will power 4 million people and 30,000 businesses. Guarantees for investors and developers are being considered to protect them for end-user repayment failure.
- The SE4ALL Universal Energy Facility is considering adding DRC to its mini-grid and standalone PUE windows.

Private Sector

Table 10. Key PUE Companies and Payment Models—DRC

Key Companies	Products/Services	Business Model
Africa Solaire	• Solar water pumps • Solar fridges	• Cash
Dev Solaire	• Solar water pumps • Solar fridges and freezers	• Cash
DGridEnergy	• Solar cold rooms	• Cash
GoShop	• Solar water pumps • Solar cold rooms	• Cash
Weast Energie	• Solar water pumps • Solar cold rooms	• Cash, cooperation with MFIs
Apalia24	• Solar water pumps	• PAYGO

	• Solar fridges	
Mobile Power	• Battery swapping • E-bikes	• PAYGO
Mopepe	• E-bikes	• Rent
Equatorial Power	• Mini-grid, ice makers • Small businesses	• On-bill financing

Solar Water Pumping and Cold Storage

- ❖ With relatively decent rainfall, irrigation assets are idle more often than in other countries, making PAYGO challenging. Assets that have potential for year-round utilization such as solar sheds or mini-grids that supply energy for mills, carpentry, cold storage, and solar sprayers could be more viable.
- ❖ Most companies selling PUE equipment are doing so on a cash basis, and PAYGO is nascent.
- ❖ GoShop does EPC and after-sales servicing and has implemented projects with Equatorial Power, Bboxx, and Nuru. They have sold more than 1,000 solar water pumps in 2021 and expect to sell 1,500 in 2022.
- ❖ Dev Solaire is specializing in the sale, installation, and maintenance of solar equipment, including solar pumps, freezers, refrigerators, and cold storage systems.

E-Mobility

- ❖ Given its proximity to East Africa and its inclusion in the EAC, companies that are involved with e-mobility or battery swapping could be interested in entering the DRC market.
- ❖ The sector holds promise, as indicated by the recent entry of Mobile Power.
- ❖ Mopepe is an e-mobility company that has secured $1.3 million in financing from Rawbank and Vodacom to assemble electric motorcycles and train drivers over the next two years. It promises to create over 1,000 green jobs during this period of time.[15]

Recommendations

- ❖ Donor coordination is imperative to ensure complementarity given the significant amount of grant and RBF funding entering the country across multiple sectors, including for standalone solar, mini-grids, metro-grids, and PUE.
- ❖ Technical assistance to develop partnerships is needed to strengthen the nexus between energy and other sectors.
- ❖ Given the nascency of the market, grant funding is generally the most appropriate instrument for DRC. In addition, early-stage companies still need significant technical assistance on their business operations, as in other countries.

[15] Wansi, Benoit-Ivan. Afrik21. DRC: Eco Ride to train 1,000 youth in electric mobility in 2 years. March 14, 2022. https://www.afrik21.africa/en/drc-eco-ride-to-train-1000-youth-in-electric-mobility-in-2-years/

6.3 ETHIOPIA

The private sector faces a number of unique challenges in Ethiopia. Limited foreign exchange (forex) is a serious issue, and financial regulations can be onerous for PAYGO companies. Foreign companies are only allowed to operate in Ethiopia through a formal partnership with a local company or through local manufacturing. Unclear tax and duty requirements for solar products and appliances are limiting the potential growth of PUE markets, and regulation and enforcement are needed to control the informal importation of low-quality equipment that is untaxed, putting legitimately imported goods at a disadvantage. The ongoing civil conflict also creates uncertainty.

As a result of these and other barriers, there are very few PUE-based off-grid sector companies operating in Ethiopia, and end-user prices of PUE solutions are among the highest in the region. Since 2019, however, the government has been engaging in a series of policy reforms aimed at improving the enabling environment for private enterprises.

GOGLA has not reported any data on solar water pumps or refrigeration units in Ethiopia due to lack of sales or reporting by companies.

Government

- Given the high cost of extending grid access to many rural areas and the desire to create economic opportunities for rural communities, the government has made a commitment to power at least 35 percent of its unelectrified population using off-grid technologies.
- The Government of Ethiopia provides tax exemptions on agricultural imports, and irrigation equipment is duty free. Assemblers and manufacturers are provided with tax holidays.
- The Government of Ethiopia implements the $500 million Access to Distributed Electricity and Lighting in Ethiopia (ADELE) project funded by the World Bank. ADELE includes $50.5 million for SHS, including PUE, and $55 million for stand-alone systems for health and education facilities. To help address the forex issue, the project will also make foreign currency available to importers of quality-certified systems. It will also provide local currency financing to address affordability issues.
- The Government of Ethiopia plans to introduce 4,800 electric buses and 148,000 electric automobiles in the next ten years. They have partnered with the private sector to introduce 60 electric vehicles and 40 charging stations as a pilot. Electric vehicles are also exempt from a range of taxes, including VAT and excise, and customs duty is zero for those fully assembled locally, 5 percent for those partially assembled, and 15 percent for those imported fully assembled.

Development Partners

- The Distributed Renewable Energy-Agriculture Modalities (DREAM) project is funded by GEAPP in partnership with AfDB Sustainable Energy Fund for Africa, Agricultural Transformation Agency, Ministry of Water and Energy, Veritas, Odyssey, and SNV. It invites private companies to develop and operate mini-grids that power farmer-based Agricultural Commercial Clusters, including PUE equipment such as solar water pumps, agricultural processing equipment, and electric vehicles.
- Ethiopia is also one of the countries under the Sustainable Energy for Smallholder Farmers project funded by EnDev and the IKEA Foundation, which aims to support PUE companies with grants in the dairy and horticultural value chains.

- WE4F aims to scale private sector innovations to increase the sustainability of agricultural food value chains in developing countries and emerging markets. Ethiopia is included as a priority country under its East Africa Regional Hub.
- AECF provides grants to early-stage companies, including those that offer PUE equipment.
- Funded by the Shell Foundation, the Ministry of Irrigation and Lowlands launched a Solar Appliance Manufacturing (SAM) initiative to enable local manufacturing and scaling of solar pumps for smallholder irrigation and solar home systems.

Private Sector

Table 11. Key PUE Companies and Payment Models—Ethiopia

Company Name	Products/Services	Business Model
Rensys Engineering	• Solar water pumps • Solar fridges	• PAYGO • Pay as you store and lease to own
Lydetco	• Solar water pumps • Solar fridges	• PAYGO
Acme Engineering	• Solar water pumps	• PAYGO
Grundfos	• Solar water pumps	• Cash

Solar water pumps

- Rensys Engineering has received grants from AECF and USAID Feed the Future to enable them to sell SunCulture pumps on a PAYGO basis. The grants have helped Rensys to develop a credit algorithm, provide market linkages, and promote awareness.
- Grundfos is a supplier of solar water pumps to Ethiopian distributors. They recently opened a training lab in Ethiopia to train youth install and operate solar water pumps.
- Lydetco and Acme Engineering are AECF grantees that sells various PAYGO solar products, including solar pumps and fridges.
- Mini-grids developed under DREAM will exclusively hybridize large diesel irrigation pumps, and a number of companies have been shortlisted for multiple tenders. However, some developers may decide not to develop the sites because of sanctions as well as the political risk due to nearby conflict.

Cold storage

- Through Feed the Future, Rensys has also imported cold storage units and now provides services to local fisherman with the option to own the equipment through a lease-to-own arrangement. Early success with this model has led Rensys to diversify the productive uses it offers and is now exploring establishing a fee-for-service cold room for smallholder horticulture farmers. This service will enable small-scale farmers to store their perishable produce and gain bargaining power when selling their harvest. Farmers will be charged based on the volume and length of storage.

Recommendations

- Forex availability must be addressed in order for companies to viably scale.
- Grants are needed for early-stage companies to operate in a challenging sector.
- The ADELE program could help address the above barriers. It will also potentially include an RBF that includes PUE, which could be a test of whether the sector is ready for such a mechanism.
- Political guarantees could be needed to support site development in fragile areas.

6.4 KENYA

While Kenya is the most developed off-grid PUE market in the region, the National Electrification Strategy does not adopt productive use in its current version. The strategy is being updated, but there is no clarity whether it will acknowledge PUE as a priority in addition to grid extension, mini-grids, and SHS. The National Energy Efficiency and Conservation Strategy does address PUE by offering a set of recommendations for the use of solar in the agricultural and transport sectors.

For solar water pumps and refrigeration units, East Africa has between 60 percent and 80 percent of the reported sales across sub-Saharan Africa, and sales in Kenya are between 60 percent and 80 percent of the East African market. For the past two years, pump sales have been on an upward trend, ranging from about 3,300 to 5,500, while refrigeration sales have been declining from roughly 1,300 to 400. The numbers above include both cash and PAYGO sales since not enough affiliates generally report PAYGO sales for GOGLA to publish disaggregated data.

Government

- The Government of Kenya is generally supportive of PUE, but there has not been concrete prioritization of the sector.
- The Kenya Off-Grid Solar Access Project involves the development of mini-grids as part of its mandate but no explicit support for PUE.
- Off-grid PUE appliances generally attract VAT and import duty. Companies report lack of consistency in awarding such exemptions.

Development Partners

- In December 2020, AECF launched an RBF window for Kenyan companies providing access to electricity, including PUE appliances.

- The Global LEAP RBF has been a major driver of PUE sales for a few years and a new facility is under design with GEAPP to scale up the previous program. However, some companies expressed serious concerns about the administrative burden associated with reporting and verification.
- A number of donors have provided grants over the past few years to support the PUE sector. Programs and development partners that have been involved include WE4F, EEP, EnDev, Shell Foundation, GDC, PREO, CrossBoundary, DOEN, and LEIA, to name a few.
- Current active PUE RBFs include the EnDev Sustainable Energy for Smallholder Farmers project and the Productive Use Appliance Finance Facility funded by the Global Energy Alliance for People and Planet. For more details see the Donor Programs section:
  - GEAPP, led by the Rockefeller Foundation, is supporting the development of a PUE appliance financing facility implemented by CLASP and Nithio for solar water pumps, mills, walk-in cold storage, fridges, fans, and electric pressure cookers. Kenya is one of the focus countries.
  - Kenya is also one of the countries under the SEFFA program funded by EnDev and the IKEA Foundation. The program aims to support PUE companies with grants in the dairy and horticultural value chains.

Private Sector

Table 12. Key PUE Companies and Payment Models—Kenya

Key Companies	Products/Services	Business Model
SunCulture	• Solar water pumps	• Cash, PAYGO-enabled for distributors
Futurepump	• Solar water pumps	• Cash, PAYGO-enabled for distributors
Davis & Shirtliff	• Solar water pumps and main distributor of Grundfos	• Cash, PAYGO-enabled through distributors
Sollatek	• Solar water pumps • Solar fridges	• PAYGO, MFI partnerships
InspiraFarms	• Walk-in cold rooms	• 5-year repayment plan, cash
SokoFresh	• Walk-in cold rooms	• Cooling as a service
Agsol	• Solar mills	• Cash, PAYGO-enabled for distributors
Mwezi	• Hair clippers and salon kits • Piloting OVO solar egg incubators and Agsol solar mills	• PAYGO
Asobo	• Electric fishing boats	• Electric propulsion as a service
Ampersand	• Battery swapping for e-mobility	• Fee for service
Roam (Opibus) & M-KOPA	• Battery swapping for e-mobility	• Fee for service

- In a 2021 study, EnDev reports that there are over 100 active PUE companies in the country with 41 of them in the solar water pumping space, 26 in cold storage, and 15 in e-mobility.[16]
- Market segments include plug and play, component based, mini-grid and captive power, and business models include cash sales, rental/lease to own, and service provision.
- A significant number of companies that are profiled throughout the PUE Sectors section operate in Kenya. Please see that section for more details.
- Solar pumping models serving the poor and scaling in Kenya are for systems under 1 kW installed on a standalone basis not requiring EIA. Cold storage walk-in rooms require EIA and a generation license.

Recommendations

- Since the market in Kenya spans nearly the entire spectrum of the PUE sector, recommendations here reflect those that apply generally to the sector.

Solar Pumping

- Manufacturers can absorb larger RBF ticket sizes, but they may need to claim across multiple geographies.
- Loan guarantee products could be better suited for manufacturers as they attract larger equity and debt ticket sizes compared to distributors.
- For last-mile distributors, ability to raise capital is limited, and upfront grants are generally needed.
- R&D and testing of business models are still common in the sector and require grant support as products continue to evolve and customer acquisition is fragmented by value chains and geography.

Cold storage

- For RBF purposes, the market segment that is mostly likely to generate enough sales volume for the refrigeration/freezer technology is fast-moving consumer goods. However, the market is still nascent, and grants may be more suitable for further testing of business models.
- The refrigeration/freezer segment within agricultural value chains, including dairy and fisheries, requires more cold chain development, consumer behavior change, and awareness campaigns, among other interventions in order to achieve scale for an RBF program.
- Walk-in cold rooms are working for medium-sized or larger businesses that are already successful. Models that involve smallholder farmers have been difficult to make profitable.

E-mobility

- Grants are still needed by many companies in this nascent sector. Even more mature companies that have raised millions of dollars are still doing significant R&D. Grants

[16] EnDev/SNV. The Market for Productive Uses of Solar Energy in Kenya: A Status Report. 2021. https://snv.org/assets/explore/download/The%20Market%20for%20Productive%20Uses%20of%20Solar%20Energy%20in%20Kenya-Status%20Report%202021_web%20%28002%29.pdf

would help them scale faster, provide confidence to investors, and accelerate the fundraising process.
- Guarantees can be useful for more mature companies seeking loans of larger ticket sizes.
- RBF could work for a few companies, though the number would be relatively low, and programs may need to be multi-country or regional.

6.5 LIBERIA

In Liberia, solar pumping for irrigation is the most common PUE application while other markets are still very early stage, though some companies have begun moving towards cold storage. There are several challenges hindering marketing and distribution efforts, including lack of financing capabilities and poor infrastructure for transportation of products to areas that are harder to reach. Few companies have begun testing the PAYGO model.

GOGLA has not been able to report any data on solar water pumps or refrigeration units in Liberia due to lack of sales or reporting by companies.

Government

- PUE has not been a focus of government energy policies, which address traditional generation and access issues.
- In 2022, the Government of Liberia exempted quality certified solar equipment and appliances from import duty, though appliances will still attract VAT. Development of the regulations that will guide the importation of these products is underway.
- The Electricity Sector Strengthening and Access Project and the Renewable Energy Access Project, both funded by the World Bank, have off-grid components to support the deployment of SHS and mini-grids. However, while the importance of PUE is acknowledged and awareness raising of productive use will be implemented, there is no dedicated focus on or direct support for PUE with the exception of some health facility electrification activities.

Development Partners

- BGFA is providing RBF to four companies in Liberia. More rounds are anticipated.
- AECF has provided a number of grants to early-stage companies that have PUE as part of their portfolio.
- Power Africa has an ongoing request for proposals to provide grants of up to $150,000 to companies that undertake PUE activities, including for mini-grids, the agricultural value chain, and for small businesses. Companies have been shortlisted and announcements will be made soon.
- The Regional Off-Grid Electricity Access Project (ROGEAP) covers Liberia as one of the 19 countries eligible for the project, which includes a $209 million line of credit through BOAD (West Africa Development Bank) for standalone solar, including both SHS and PUE for businesses. The project also has a grant facility of $67 million for financial institutions as well as a $30 million grant facility

for standalone solar companies. The project is expected to have a fund manager for the grant facility in early 2023.[17]

Private Sector

Table 13. Key PUE Companies and Payment Models—Liberia

Key Companies	Products/Services	Business Model
Mobile Power	• Battery swapping	• Fee for service
Easy Solar Liberia	• Solar water pumps • Solar freezers	• PAYGO
Energicity	• Mini-grids	• Fee for service
LIB Solar	• Solar fridges	• PAYGO
EcoPower Liberia	• Solar water pumps • Solar food dryers	• Cash

- ❖ Mobile Power is a BGFA beneficiary that provides battery swapping service for multiple applications. They will partner with EcoPower Liberia to establish their charging hubs. See the E-mobility section for a company profile.
- ❖ LIB Solar and Easy Solar, both BGFA awardees, will provide solar solutions to tens of thousands of additional customers over four years, including for PUE applications such as solar water pumping and cooling.
- ❖ Energicity will use BGFA funding to establish up to 30 solar mini-grids over four years that will power both households and businesses.

Recommendations

- ❖ With significant BGFA funding flowing to a few more mature companies, others that are earlier stage will need startup grants to reach the same level.

6.6 MALI

Mali ranked fifth on GOGLA's list of countries with most solar water pumps sold in the last half of 2021. However, no number is available since fewer than three affiliates reported. In fact, since GOGLA started collecting data in 2018, it has not been able to report any data on solar water pumps or refrigeration units in Mali due to lack of sales or reporting by companies.

Government

- ❖ The $200 million Mali Electricity System Reinforcement and Access Expansion project funded by the World Bank includes an off-grid component on SHS, mini-grids, and broad PUE activities that include agriculture and electrification of social institutions.

[17] World Bank Group. Lighting Africa. Regional Off-Grid Electricity Access Project (ROGEAP). https://www.lightingafrica.org/wp-content/uploads/2017/12/ROGEAP-1-Pager-Mar-2021.pdf

- The €46.2 million Mali Solar Rural Electrification Project financed by the Green Climate Fund includes support for solar water pumping, fridges, mills, power tools, and health facility electrification through guarantees and lending by local financial institutions.
- Mali is one of the nineteen countries under the Regional Off-Grid Electricity Access Project, which includes support for the entire range of PUE applications.
- Mali and Senegal have the largest number of mini-grids in West Africa due to long-term concessions offered through government programs, though these have mixed levels of success. With the appropriate enabling environment, government and development partners could create programs that roll out large numbers of mini-grids.

Development Partners

- Sida supports the non-profit organization Geres, which establishes Green Business Areas that provide off-grid electricity to small rural businesses. These energy hubs could potentially be run as social enterprises, allowing them to scale up in a more sustainable manner. Geres is also involved with health facility electrification efforts.
- The World Bank conducted a study[18] in 2021 on the potential for e-mobility in Bamako, where an estimated two-thirds of vehicles are two-wheelers. Electric motorbike taxis were selected as one of four use cases that could, in one to three years, begin to demonstrate the uptake of e-mobility in the city. However, the sector is currently nonexistent.
- The Regional Off-Grid Electricity Access Project (ROGEAP) covers Mali as one of the 19 countries eligible for the project, which includes a $209 million line of credit through BOAD (West Africa Development Bank) for standalone solar, including both SHS and PUE for businesses. The project also has a grant facility of $67 million for financial institutions as well as a $30 million grant facility for standalone solar companies. The project is expected to have a fund manager for the grant facility at beginning of 2023.[19]
- Mali is an eligible country under the AECF and WE4F programs.
- The USAID-funded Innovation Lab for Small Scale Irrigation (ILSSI) conducts research to identify the best approach to promoting irrigation, including with private sector companies.
- EnDev Mali implements a demand-based approach to deploy SHS and mini-grids that support PUE applications. The program also provides funding for health facility electrification.

Private Sector

Table 14. Key PUE Companies and Payment Models—Mali

Key Companies	Products/Services	Business Model
E-Longlife	• Range of PUE appliances	• Rent to own
EMICOM	• Solar water pumps	• PAYGO
EcoTech	• Solar water pumps	• PAYGO

[18] World Bank. Pathways to Electric Mobility in the Sahel: Two and three-wheelers in Bamako and Ouagadougou. 2021. https://openknowledge.worldbank.org/bitstream/handle/10986/37046/P174592012d6e100d09f6f0c1fd37ad2d16.pdf

[19] World Bank Group. Lighting Africa. Regional Off-Grid Electricity Access Project (ROGEAP). https://www.lightingafrica.org/wp-content/uploads/2017/12/ROGEAP-1-Pager-Mar-2021.pdf

Key Companies	Products/Services	Business Model
Access SA	• Mini-grid	• Fee for service
Africa GreenTec Mali	• Mini-grid	• Fee for service
SEECO Mali	• Mini-grid	• Fee for service
FlexGrid Mali	• Mini-grid	• Fee for service

- E-Longlife provides a large range of PUE equipment on a rent-to-own basis, including electrification of public institutions. Under certain conditions, they will offer financing over many years. Please see the Mini-Grid/On-Grid Appliances section for a profile of the company.
- EMICOM and EcoTech are being supported by the ILSSI to develop their business model and use PAYGO to finance farmers for the purchase of solar water pumps. The program is also linking farmers to markets through off-takers.
- Access SA is an AECF grantee that develops mini-grids with a mix of public and private funding.
- Africa GreenTec, an AECF grantee, develops mini-grids and supplies PUE equipment. When needed, funding is partially sourced from crowdfunding.
- SEECO Mali is an AECF grantee that develops mini-grids, including ones that replace diesel-powered plants.
- FlexGrid Mali, an AECF grantee, aims to electrify 50 villages through their modular, decentralized mini-grids.
- Though not a primary focus of this report, in the commercial and industrial space, companies such as Yandalux, SolarX, Tysilio, and Solar23 are providing larger installations for PUE for farming applications up to a megawatt.

Recommendations

- Given that the companies providing end-user finance for PUE equipment are still early stage, upfront grants are still needed for them to scale their businesses.

6.7 MOZAMBIQUE

Natural disasters, conflict, and the pandemic have made Mozambique a challenging country for the private sector to do business. Nevertheless, multiple donor-funded programs have sparked a positive outlook resulting in solar home systems sales peaking at 76,000 according to the last GOGLA report. This represents 143 percent growth over the previous reporting period. Similarly, the appliance market which includes TVs, refrigeration units, and solar water pumping has peaked at 3,000 per reporting period—a growth rate of 138 percent. However, these sales are likely mostly TVs. Since GOGLA started collecting data in 2018, it has not been able to report any data on solar water pumps due to lack of sales or reporting by companies and was only able to report about 15 refrigeration units sold during one six-month period in 2020.

A recent GIZ analysis of the solar irrigation pumping market surveyed 25 private sector companies who reported sales of more than 700 solar pumps[20] and a 10 percent increase each year for the last three consecutive years. Available brands include Lorentz, Grundfos, Solartech, Futurepump, Shakti, and Jain, among others. Manufacturers such as SunCulture and Dayliff are not in the market but have expressed interest in entering. Others like Ennos are known to have a presence. Only 10 percent of the companies reported not providing after-sales service.

Government

General

- Policy and regulation for the off-grid sector benefits mainly mini-grid companies, including through fiscal incentives that include import duty exemption.[21] Although policies and regulations specifically call for the development of PUE activities, there are no direct benefits currently extended towards stand-alone PUE companies.
- The World Bank has launched a $26 million grant facility through Mozambique's Energy Fund,[22] FUNAE, that will benefit SHS, mini-grids, and clean cooking companies. PUE is mentioned for potential consideration in the future, but a timeline is not given, and the current grant facility does not cover it.
- FUNAE has been supportive of the PUE sector in the past. FUNAE previously deployed 60 solar irrigation systems, and the government has included solar irrigation as an area of support in their Strategic Plan on Agricultural Development 2010-2020.
- Also funded by the World Bank, the Government of Mozambique is targeting 400 PUE on-grid customers by the end of 2024 through the Mozambique Energy for All project, known as ProEnergia.

Development Partners

- The Fund for Sustainable Access to Renewable Energy (FASER) is an ongoing RBF program funded by BMZ through Green People's Energy (GBE) and implemented by GIZ through EnDev. The RBF includes PUE and social infrastructure and has deployed 160 PUE systems and powered 62 social infrastructure projects benefitting more than 2.3 million people with a target to reach 100 on-grid and off-grid areas[23].
- Toward Sustainable Energy for All Mozambique, implemented by UNIDO and funded by GEF, launched a guarantee fund in 2020 that provides a three-year $1 million PUE credit line with a 7.5 percent interest rate.[24]
- AECF provides grants in Mozambique.

[20] GIZ Green People's Energy Programme Mozambique. Solar Irrigation Market Analysis in Mozambique. 2021. https://energypedia.info/images/0/08/Solar_Irrigation_Study_Mozambique_2021.pdf
[21] BR_239._SÉRIE_2021. December 10, 2021. https://www.lerenovaveis.org/contents/lerpublication/decreto-93-2021_regulamento-de-acesso-a-energia-nas-zonas-fora-da-rede_6586.pdf https://www.lerenovaveis.org/contents/lerpublication/decreto-93-2021_regulamento-de-acesso-a-energia-nas-zonas-fora-da-rede_6586.pdf
[22] FUNAE. Terms of Reference for the selection of the manager for the off-grid energy finance facility. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Ffunae.co.mz%2Fwp-content%2Fuploads%2F2022%2F08%2FTerms-of-Reference-ToR-for-the-selection-of-the-Manager-for-the-Off-Grid-Energy-Finance-Facility-1.docx&wdOrigin=BROWSELINK
[23] ALER. The new regulation for energy access in off-grid areas in Mozambique webinar. https://www.youtube.com/watch?v=9vSfyRkD1Kc
[24] Towards Sustainable Energy for All Mozambique. UNIDO partners with BCI to finance renewable energy systems for productive uses in rural Mozambique. https://www.tse4allm.org.mz/index.php/en/midia/a-unido-em-parceria-com-o-bci-financia-sistemas-de-energia-renovavel-para-usos-produtivos-na-zona-rural-de-mocambique

- ❖ BGFA operates in Mozambique but is currently on hold due to pending mini-grid regulations.

Private Sector

Table 15. Key PUE Companies and Payment Models—Mozambique

Key Companies	Products/Services	Business Model
SolarWorks	• Fridges (piloting) • Sewing machines (selling) • Solar water pumping (selling)	• Cash and PAYGO
Engie	• Refrigerators • Piloting solar water pumping	• PAYGO
Epsilon Energia	• Cold storage for fisheries	• Cash
RVE.SOL	• Conceptualizing cold storage for fishing	• Mini-grid PUE as anchor

SolarWorks in a recent interview[25] with the Global Distributors Collective outlined lessons learned and strategies they are implementing to better understand how to deploy PUE devices profitably.

Solar Pumping

- ❖ To design a PAYGO model, they spent significant time understanding what and how farmers produced and their budgets, including incomes and expenditure on basic needs.
- ❖ Even with PAYGO, subsidies are needed to make irrigation affordable for farmers.
- ❖ Payments need to be scheduled around the harvest schedule and not on a monthly basis.
- ❖ It takes time to train staff to be able to fully service the pumps.
- ❖ They provide informal advice on accessing markets but not systematically.

Solar fridges

- ❖ They started selling fridges on a cash basis but are starting to experiment with PAYGO using grants.
- ❖ Building the technical capacity to service fridges takes significant effort.
- ❖ They are trying to figure out a way to determine when servicing can be done onsite rather than transporting the fridge to a distant, centralized service center.

Health Electrification

- ❖ In 2021, SolarWorks received a $320,000 grant from USAID Power Africa to electrify more than 90 facilities on a PAYGO basis with the goal to develop a business model that will generate income for the system for long-term O&M.

Recommendations

- ❖ The PUE sector needs support developing sustainable business models beyond EPCs. Companies are currently selling about 700 solar pumps per year and are ready to scale but

[25] Global Distributors' Collective. Selling Productive Use of Energy Products to Last Mile Consumers. https://infohub.practicalaction.org/bitstream/handle/11283/622928/GDC_Selling%20PUE%20products%20to%20last%20mile%20consumers_Lessons%20learned_July2022.pdf

need an incentive to move away from the EPC approach and towards provision of end-user financing. An RBF could be considered for this purpose.

- ❖ HFE appears promising given the more than 90 units deployed on a PAYGO basis by SolarWorks, and an RBF could be explored. However, HFE generally requires government involvement and the development of a PPP approach for long-term maintenance beyond the repayment period.
- ❖ Fiscal incentives such as import duty exemptions are in place for mini-grid appliances, making RBFs and grants more effective at increasing uptake. However, support is still needed resolve pending mini-grid regulations in order for the sector to scale.

6.8 RWANDA

With a population of 12 to 13 million, about 72 percent of the working population is employed in agriculture, which contributes 33 percent of the GDP.[26] As is the case across the region, there is a significant need for PUE solutions like pumps and cold storage since less than 10 percent of potential irrigation areas are irrigated,[27] and the cold chain is largely nonexistent. It should be noted, however, that opportunities for PUE powered by mini-grids are limited since the National Electrification Plan allocates only about a hundred sites for mini-grid projects.

GOGLA has not reported any sales of solar water pumps or refrigeration units in Rwanda due to lack of sales or reporting by companies.

Government

Solar Water Pumping

- ❖ The Small-Scale Irrigation Technology (SSIT) program run by the Rwanda Agriculture and Animal Resources Development Board (RAB) under the Ministry of Agriculture and funded by the World Bank provides a 50 percent subsidy for irrigation equipment sold.
  - On occasion, RAB has offered higher levels of subsidy for poorer farmers.
  - Private sector companies have complained about the inconsistency in the program from district to district, with some not allocating any budget for the program. Significant delays in payment to the companies is also a serious issue.

Cold Storage

- ❖ The Government of Rwanda released a National Cooling Strategy in 2018 and launched the Africa Centre of Excellence for Sustainable Cooling and Cold Chain, which will conduct research, develop and test technologies, collaborate with industry, and build capacity and skills.

[26] Food and Agriculture Organization of the United Nations. Rwanda at a Glance. https://www.fao.org/rwanda/our-office-in-rwanda/rwanda-at-a-glance/en/

[27] Nzeyimana, Innocent. Water Global Practice Case Study. Farmer-Led Irrigation Development in Rwanda. 2021. https://openknowledge.worldbank.org/bitstream/handle/10986/35798/Assessment-of-Farmer-Led-Irrigation-Development-in-Rwanda.pdf?sequence=1&isAllowed=y

- There are few off-grid cold chain facilities in Rwanda and almost all of them are developed by the government, including ten cold storage rooms designed by InspiraFarms.

E-Mobility

- The Government of Rwanda is providing a number of incentives for the e-mobility sector.
  - Fiscal incentives include a preferential tariff and a reduced off-peak tariff for charging stations, exemption from import and excise duty and VAT zero-rating for electric vehicles, spare parts, batteries and charging station equipment, and exemption from withholding tax.
  - Government will also provide land for charging stations rent-free.
  - Companies that are assembling or manufacturing are given a 15 percent preferential corporate income tax and a seven-year corporate income tax holiday.

Development Partners

There is currently little support from development partners on PUE in Rwanda. A few programs that have ended were noteworthy and follow-on funding should be explored.

Solar Water Pumping

- From 2018-2020, Energy 4 Impact ran the Solar Irrigation Rwanda (SIR) program with $1 million in funding from the OPEC Fund for International Development. The program supported the development of almost a hundred systems benefiting over 1,450 farmers.
  - The program supported mobile and stationary solar-powered irrigation pumping systems through subsidies and technical assistance to help farmers form groups, choose appropriate pumps, access markets, and obtain loans.
  - Awareness, affordability, ability to access finance, and availability of quality pumps were all issues that the program faced. Note that it was necessary for the program to provide subsidies on top of those provided by the government SSIT program, highlighting the affordability challenge.
  - In addition, the program only initially found three distributors that were capable of working with solar water pumps, and due to lack of consistency with two of them, mostly worked with Ignite Power who provided most of the installations.
- Another program that ran from 2017-2022 called Hinga Weze, funded by USAID Feed the Future, had a component that supported installation of solar irrigation systems. The program provided irrigation for 300 hectares that benefited over 1,200 smallholder farmers.
  - Initially, the program focused on larger installations that covered up to 10 hectares each but eventually moved toward smaller, mobile pumps.
  - Like SIR, the program provided technical assistance and subsidies in addition to SSIT, and it also faced challenges similar to those listed above.

Cold Storage

- USADF has provided three grants that have included productive use and two grants for mini-grids.
- WE4F is providing a grant to local company Munyax Eco to deploy solar-powered fridges.

- ❖ Energising Development is currently conducting a small pilot to test the pay-as-you-store model with a local company called Izuba Energy, who plan to install four walk-in storage units cooled by SelfChill solar-powered cooling units.
- ❖ From 2018-2021, under an IFAD program, SunDanzer piloted 50-liter and 165-liter PAYGO-enabled solar fridges for the dairy sector and concluded that there was not a sustainable market for this application.

Health Facility Electrification

- ❖ In partnership with the Government of Rwanda, the United Nations Population Fund (UNFPA) and the United Nations Development Programme (UNDP) are beginning implementation of a $8-9 million program to support the creation or upgrading of a thousand privately-run health posts, some of which will be off-grid.
  - While most of the funding will support non-energy activities, a few million dollars will be set aside to support solarization of the facilities in need of electricity.
  - The program envisions a heavy subsidy for the equipment with solar companies providing long-term maintenance that is partly financed by the private health post operators who will have increased income through additional services made possible by electricity access.

Private Sector

Table 16. Key PUE Companies and Payment Models—Rwanda

Key Companies	Products/Services	Business Model
Ignite Power	• Solar water pumps	• Cash, considering PAYGO
Davis & Shirtliff	• Solar water pumps • Solar fridges	• Cash, considering PAYGO
One Acre Fund	• Solar water pumps	• Piloting rental model
Munyax Eco	• Solar fridges • Solar cold rooms	• Cash, including through MFI • Installments
Dassy Enterprise	• Solar water pumps • Solar fridges	• Cash
NESELTEC	• Solar water pumps • Solar fridges	• Cash, but considering PAYGO
OX	• Transportation of goods	• Fee for service
Ampersand	• Battery swapping for e-mobility	• Fee for service

Solar Water Pumping

- ❖ Ignite Power is the leading distributor of solar water pumps in Rwanda and possibly the only one actively seeking out smallholder farmers as end users, but they have sold less than 200 pumps to date with a number of these under the SIR program.

- One Acre Fund planned to begin a small pilot in 2022 to rent solar water pumps to its beneficiaries.
- Davis & Shirtliff are a well-known supplier of solar-powered pumps and fridges but are not actively working in poorer rural areas.
- Dassy Enterprise and NESELTEC sell solar water pumps and are both recipients of USADF grants.

Cold Storage

Only a few companies provide solar-powered equipment for cold storage. As above, GOGLA reported few refrigeration units sold in Rwanda in the second half of 2021.

- Munyax Eco, Dassy Enterprise, Davis & Shirtliff sell fridges in small quantities in addition to other products.
- DGridEnergy announced in August 2022 a partnership with PULSE Rwanda Ltd, who run centers that support businesses, to pilot five walk-in cold storage facilities.

E-Mobility & Cold Storage

- In 2021, a British company called OX began operating a truck specifically designed to transport goods to and from rural areas.
  - It weighs half as much as a standard pickup truck but can transport twice the weight.
  - Customers rent space in the truck for produce to be transported to markets, and demand is high even though OX charges higher rates than transport by bicycle.
  - The second version of the vehicle will be electric and optionally will come with a solar-powered refrigeration unit.

E-Mobility

- Ampersand is perhaps the leading electric motorbike company in East Africa with over 500 motorbikes on the road at present.
  - The company works with taxi drivers who get financing for the cost of the bike from a third party.
  - The batteries are owned by Ampersand and swapped when depleted.
  - They report that their drivers increase their income by over 40 percent. Demand is high, and waitlists are long.
  - They have had bikes on the road for more than three years, with project profitability in 2022, and appear ready to scale.
  - In 2021, they received $3.5 million in venture capital from the Ecosystem Integrity Fund and $9 million in debt from the U.S. DFC.

Recommendations

- Programs that provide grants and TA are needed across the board.
- Even though the PUE sector for agriculture is still nascent and potentially too early stage for RBFs, the Government of Rwanda has experience implementing them for SHS and irrigation, with programs currently running in both sectors. Providing funding through the government on a rolling basis over the long term could catalyze more patient capital to enter the sector

and allow the market to mature. However, technical assistance similar to what was provided under the SIR program would also be required to support all stakeholders involved.

- A regional or multi-country RBF like the Global LEAP RBF, in which Ignite Power has participated in the past, could capture a few of the more experienced players like Bboxx, Engie, and One Acre Fund.
- Regarding e-mobility, Ampersand could take advantage of an RBF.
  - However, they also have needs that would be better addressed by grants such as for R&D on battery technology and software.
  - Repayable grants would prevent their debt-to-equity ratio from getting too high.
  - Guarantees could help as they raise debt.

6.9 SOMALIA

Political instability in Somalia has made it difficult for the population to access basic services with only about 40 percent with access to electricity. Diesel-powered mini-grids operated by private energy service providers supply about 90 percent of the electricity in the country. There is significant need for solar water pumping for the agriculture sector and fridges and freezers for fisheries. Donor engagement with the private sector is limited to areas that are more stable, such as Somaliland and Puntland.

GOGLA has not reported any sales of solar water pumps or refrigeration units in Somalia due to lack of sales or reporting by companies.

Government

- The Somalia Electricity Access Project has over $7 million in funding from the World Bank to support the deployment of SHS and mini-grids. About $3 million is allocated for results-based financing for SHS companies to electrify of households and businesses, an additional $1.0 million will facilitate analytical work to enable the development of solar-powered hybrid mini-grids, and $3.2 million is reserved for TA and capacity building.
  - The Japan Policy and Human Resources Development Fund provided seed grants to smaller or less-experienced local companies to help them build inventory for the SHS RBF.
  - The project has supported the deployment of over 18,000 SHS as of May 2022.
- The Somali Business Catalytic Fund (SBCF) is a $13 million matching grant program under the World Bank-supported Somali Core Economic Institutions and Opportunities Project (SCORE).[28]
  - SBCF provides matching grants to businesses to catalyze private sector investment and incentivize productivity, including for companies supplying PUE equipment.

Development Partners

- AECF and PREO both provide grants to early-stage companies in Somalia.
- AECF runs the €4.5 million Finance for Inclusive Growth Somalia (FIG Somalia) program, which provides support to financial intermediaries through a revolving loan and guarantee scheme as well as TA. FIG Somalia supports small businesses in the agriculture sector to receive loans they would not otherwise be able to access.

[28] The World Bank. Somalia's Businesses Tap Solar Energy to Expand, Boosting Economic Growth. May 6, 2021. https://www.worldbank.org/en/news/feature/2021/05/06/somalia-s-businesses-tap-solar-energy-to-expand-boosting-economic-growth

- The USAID Growth, Enterprise, Employment & Livelihoods (GEEL) has supported the integration of solar technology into the agriculture, fisheries, and dairy sectors, albeit through tender processes.

Private Sector

Table 17. Key PUE Companies and Payment Models—Somalia

Key Companies	Products/Services	Business Model
SolarGen	• Solar water pumps • Solar fridges • EPC for mini-grids • Solar systems	• PAYGO
SECCCO	• Solar fridges/freezers • Solar water pumps	• PAYGO
ClearSky Power	• Solar irrigation systems • Solar fridges	• Financed by local banks
Phaesun	• Solar cooling and freezing kits	• Cash

- SolarGen received $75,000 from the SBCF, which they matched with $75,000 of their own funds. The grant allowed them to provide solar systems and appliances like fridges to households and businesses through a new lease-to-own scheme, overcoming the hurdle of high upfront costs, with some entrepreneurs reporting increased income.
- SECCCO is one of the main recipients in Somalia of donor and private finance for PUE. They have an AECF grant to sell solar water pumps and freezers with a focus on agriculture and fisheries. They often fulfill tenders by donors to supply and install PUE equipment.
- ClearSky Power has a PREO grant to deploy solar-power drip irrigation systems on 10 farms. The farmers will take out loans from local banks who will contract ClearSky Power to provide maintenance of the system during the repayment period.
- Phaesun partners with local solar company Horn Renewable Energy Company to sell solar fridges and freezers in Somaliland.

Recommendations

- Due to the very limited number of PUE companies in Somalia, upfront grants to companies could help de-risk their entry into the region.

6.10 SOUTH SUDAN

Electricity from the grid in South Sudan is extremely expensive and unreliable, creating high demand for solar and diesel solutions in both grid-connected and off-grid areas. However, financing is difficult to obtain for end users.

GOGLA has not reported any sales of solar water pumps or refrigeration units in South Sudan due to lack of sales or reporting by companies.

Government

- The $50 million South Sudan Energy Access Project funded by the World Bank will support the development of mini-grids and standalone solar systems for households, productive use, and public institutions such as health facilities.
- An RBF mechanism along with grants are being considered for the deployment of the standalone solar systems.
- The project is yet to be approved by the World Bank and is in the design phase.

Development Partners

- Companies are eligible for AECF, but there are no grantees from South Sudan.

Private Sector

Table 18. Key PUE Companies and Payment Models—South Sudan

Key Companies	Products/Services	Business Model
PowerGen and SunGate Solar	• Mini-grids • Demand stimulation	• Fee for service

- Powergen and SunGate Solar have partnered to develop a mini-grid in Wanyjok in Aweil East County, the first in South Sudan. They have grants from the Norwegian government and Humanitarian Grand Challenges Canada and plan to do demand stimulation that will include PUE.

Recommendations

- The South Sudan Energy Access Project will provide much needed support to the sector when it is launched.
- The World Bank has expressed interest in having other donors to contribute additional funding to the project.

6.11 SUDAN

While a number of companies sell PUE equipment on a cash basis or respond to government and donor tenders, there do not appear to be many providing end-user financing. GOGLA has not reported any sales of solar water pumps or refrigeration units in Sudan due to lack of sales or reporting by companies.

Government

- The Sudan Energy Transition and Access Project (SETAP), funded by the World Bank, is still under design but will broadly support the energy sector, including off-grid access and PUE. Agriculture, dairy, and livestock applications as well as health facility electrification are being considered as part of the scope. An off-grid solar market assessment is currently underway as part of the design.
- The Government of Sudan, with funding from AfDB, is supporting the replacement of diesel-powered irrigation through the Solar PV Powered Pumping for Irrigation Project (Desert-to-Power Initiative) that will install 1,170 systems for farmers.
- The government is providing tax exemptions for solar equipment used for agriculture.

Development Partners

- From 2016-2019, UNDP and GEF provided $4.4 million for the Solar for Agriculture pilot to replace diesel-powered irrigation pumps with solar.
- Building from the pilot, UNDP and the Korea International Cooperation Agency (KOICA) in cooperation with the government are providing $7 million in funding to deploy solar water pumps for sustainable agriculture over a five-year period from 2019-2023.
- To make the above efforts sustainable, the National Solar Fund is also being established by UNDP with the support of the central bank and other donors to provide loans to end users for a range of solar applications, including agriculture and health.[29]
- UNDP is supporting the scale-up of electric tuk tuks, which are becoming popular due to recent fuel price increases.

Private Sector

Table 19. Key PUE Companies and Payment Models—Sudan

Key Companies	Products/Services	Business Model
Baridi	• Solar cold rooms	• Pay as you store
Empower	• Solar water pumps	• EPC and O&M
AEMIT	• Solar water pumps	• EPC and O&M

- The companies above were mentioned by development partners as companies of interest. However, only Baridi advertised itself as providing end-user financing, and its product is yet to be launched.

Recommendations

- Stakeholders should work through the existing government and donor mechanisms, especially SETAP when it launches, to build up the capacity of the private sector to sustainably sell and finance PUE products.

6.12 TANZANIA

GOGLA has not reported any sales of solar water pumps in Tanzania due to lack of sales or reporting by companies. They were able to report about 40 refrigeration units sold during one six-month period the last half of 2020.

However, there is strong interest in PUE equipment from potential customers. In 2021, 60 Decibels conducted a survey of the beneficiaries of the EnDev Green Economic Recovery Fund. Of the SHS customers, 64 percent were interested in buying a solar water pump, with 20 percent indicating it was the appliance they were most interested in owning.

[29] United Nations Development Programme. KOICA Partner in Project to Promote Solar-Powered Irrigation for Sustainable Agriculture in Sudan. May 21, 2019. https://www.undp.org/sudan/press-releases/undp-koica-partner-project-promote-solar-powered-irrigation-sustainable-agriculture-sudan

Government

- The $209 million Tanzania Rural Electrification Expansion Program (TREEP), funded by the World Bank and approved in 2016, supports access to on-grid and off-grid electricity for productive uses but not explicitly PUE appliances and equipment. TREEP received an additional $335 million in funding in 2022, which will include an RBF program for off-grid SHS and clean cooking, both implemented by the Rural Energy Agency (REA).
- There has previously been a lack of clarity regarding how the 2019 microfinance regulations affect PAYGO companies. Following extensive consultation with the Bank of Tanzania, PAYGO companies were informed that a new commodity microfinancing regulation will be required for companies that lease/sell micro assets. The Bank of Tanzania also informed the sector that regulatory oversight is not a priority at this time, and that they should continue to operate while adhering to existing policies and regulations.
- There is a general lack of clarity and consistency in duties and VAT being charged on standalone solar products.[30]
- In early 2021, the government suddenly forced all existing mini-grid projects to charge a tariff consistent with the national grid, making them unviable. Though progress has been slow, developers have confirmed that they have been working with the regulator on new tariffs, with three companies having cost-reflective tariffs announced. Changes in leadership have resulted in regulators regaining control of the tariff approval process, and developers can now negotiate reasonable pricing for existing and future sites.

Development Partners

- Support for PUE has largely come through funding for mini-grids in Tanzania.
- EEP and Energy 4 Impact have provided funding for mini-grid projects that have actively been supporting PUE applications.
- Companies in Tanzania are eligible for AECF grant funding and have been supported by the CLASP Global LEAP program.
- The Norwegian Embassy funds the Rural Electrification Densification Programme run by the Rural Energy Agency. A component of this program implemented by Energy 4 Impact[31] stimulates demand and uptake of PUE equipment in rural on-grid communities by creating awareness, providing TA, and helping entrepreneurs access finance.
- While a number of donor programs aim to electrify households and businesses, few explicitly support the deployment of PUE equipment.

[30] Africa Clean Energy Technical Assistance Facility. Stand Alone Solar Market Update Tanzania. March 2021. https://www.ace-taf.org/wp-content/uploads/2021/04/Stand-Alone-Solar-SAS-Market-Update-Tanzania.pdf

[31] Energy 4 Impact. Getting the Most Out of the Grid: It's Time to Make Investments Count. October 27, 2021. https://energy4impact.org/news/getting-most-out-grid-%E2%80%93-it-time-make-investments-count

Private Sector

Table 20. Key PUE Companies and Payment Models—Tanzania

Key Companies	Products/Services	Business Model
Simusolar	• Solar water pumps	• PAYGO
Imara Tech	• Solar thresher	• PAYGO
Agsol	• Solar mills	• Cash, PAYGO-enabled for distributors
Ensol	• Mini-grid developer	• Fee for service
PowerCorner	• Mini-grid developer	• Fee for service
JUMEME	• Mini-grid developer	• Fee for service
REDAVIA	• Mini-grid developer	• Fee for service

- ❖ Simusolar sells solar water pumps on a PAYGO basis and have received a number of grants to scale up its activities. The company also sells fishing lights and has started a pilot on refrigeration for dairy. See the Solar Water Pumping section for a profile of the company.
- ❖ Imara Tech sells multi-crop threshers and report that entrepreneurs can earn back the cost of the equipment in as little as one year. They have sold a few hundred and have been trying to scale for years. The company believes that it is close to profitability.
- ❖ Prior to the uniform tariff policy, there were a number of notable mini-grid developers active in Tanzania. Many received grants for projects that support a range of PUE activities.

Recommendations

- ❖ Upfront grants are ideal for companies selling, financing, and piloting PUE products in Tanzania. Companies such as Simusolar are already financing PUE products, but they are having difficulties scaling, piloting new products, training, and providing end-user financing to a growing customer base. The same can be said for mini-grid companies who are struggling to finance and pilot PUE appliances.
- ❖ Even though rural communities have gained significant access to financing over the last twenty years through group lending, there is little to no track record on local financing institutions working in the PUE space. MFIs have begun to express interest in financing solar water pumps, agro-processing, and cold storage products, but capacity building is required to pilot the business models.
- ❖ Guarantees for MFIs and local financial institutions could be useful to the sector, particularly due to the uncertainty in the effect of microfinance regulations on PAYGO.

6.13 UGANDA

Sales of solar water pumps reported by GOGLA appear to be on an upward trend, reaching roughly 800 in the most recent six-month reporting period. However, sales of refrigeration units peaked in 2020 at about 700 and have declined to less than 100 sold in the first half of 2022. Challenges facing the sector are

highlighted by the fact that SolarNow, one of the more successful SHS companies, has stopped providing end-user financing for its PUE appliances.

Regarding agro-processing, Power Africa is conducting a market study on SMEs in northern Uganda. Though not yet finalized, preliminary results indicate that solar PV with battery storage is not a profitable option for either off-grid or grid-connected businesses. Solar PV alone or solar-diesel hybrids are both viable solutions, but the former will not provide consistent reliable power and is not an ideal option.

With its high number of motorbike taxis, Uganda is one of the more ideal places to implement e-mobility. Early trials in several countries indicate that drivers can make additional income if a company is able to build out charging stations and provide battery swapping as a service, though there are significant challenges to doing so. Uganda has one of the more advanced e-mobility companies in the region, albeit still early stage.

Government

General

- International quality standards are in place for off-grid solar home systems and the government has worked on a quality assurance framework for component-based systems.
- Most solar appliances attract import duty and VAT, though solar fridges are exempt from VAT and solar water pumps and mills are exempt from import duty.
- Under the Electricity Access Scale-up Project running from 2022 to 2027, the World Bank has allocated $107 million to the Uganda Energy Credit Capitalisation Company to provide financial intermediation services.
  - One component of this fund is for the purpose of providing lines of credit and grants to financial institutions to lend to energy companies, including those that supply PUE equipment.

Solar Water Pumping

- The Ministry of Agriculture, Animal Industry, and Fisheries is currently providing a subsidy for solar irrigation pumps in 40 districts as part of the Micro-Scale Irrigation Program funded by the World Bank.
  - The program provides between 25 percent and 75 percent of the total cost of the irrigation equipment, though with a maximum cap per acre. Financial institutions are part of the program to provide lending as needed by the farmers for the remainder of the cost.
  - It is slated to run from 2020 to 2023 with a budget of about $40 million. About 3000 pumps have been installed and the program will expand to new districts in the next phase.

Development Partners

General

- In 2021, BGFA launched several RBF windows in 2021 totaling €20.7 million, including a window for mini-grids and two for standalone systems, one called “direct to scale” as a pure RBF and another called “launch to scale” for earlier stage companies that need more funding upfront.

- These windows set aside a portion of funding for PUE applications like earlier BGFA calls.

❖ The Sustainable Energy for Smallholder Farmers (SEFFA) project is providing small grants of about $20,000 for pilots that provide solar irrigation, cooling, and drying in Uganda, Kenya, and Ethiopia.
- The project was launched in 2022, funded by IKEA Foundation, implemented by EnDev.

❖ Water and Energy for Food also provides grants and TA to early-stage companies in Uganda working on productive use for agriculture.

❖ The GIZ Green People's Energy program has also supported PUE, including an idea competition that provided up to around $100,000 in grant funding.
- The program also previously provided a grant for promotion of solar home systems to provide schools with lighting, phone charging, and operation of energy-efficient information and communications technology equipment.

❖ As mentioned previously, there are two initiatives planned under GEAPP.
- CLASP plans to run a procurement subsidy RBF for several countries, including Uganda, that includes solar water pumps, fridges, walk-in cold storage, and mills.
- In parallel, Nithio will run an appliance financing platform that will allow companies to borrow at concessional rates for provision of consumer finance at lower rates than otherwise possible.

Mini-Grids

❖ The Promotion of Mini-Grids for Rural Electrification program, funded by the EU and BMZ and implemented by GIZ, plans to develop 40 mini-grid sites in Uganda with a budget of over $8 million.
- The first 25 in northern Uganda have already been tendered and commissioned in 2022 with 15 more to be launched at a later date, all developed by Winch Energy.
- The program contains a component that provides training and access to finance for PUE.

Private Sector

Table 21. Key PUE Companies and Payment Models—Uganda

Key Companies	Products/Services	Business Model
Energrow	• Multiple PUE appliances, including for on-grid	• Installments
Aptech	• Solar water pumps	• Fee for service
Simusolar	• Solar water pumps	• PAYGO
Winch Energy	• Mini-grid	• Partner with appliance finance providers
Equatorial Power	• Mini-grid	• Partner with appliance finance providers
Zembo	• Battery swapping for e-mobility	• Fee for service
Bodawerk	• Battery swapping for various applications	• Fee for service

General

- Energrow has a unique business model that provides multiple types of productive use appliances rather than focusing on a single technology like most companies.
  - They sell appliances for cold storage, agro-processing, clean cooking, tailoring, metalworking, and carpentry and are planning to pilot e-bikes.
  - They partner with energy companies, including the utility Umeme and mini-grid developers, to help them grow demand through appliance financing to address the affordability issue.
  - Their focus is largely urban at the moment, but their goal is to expand to more rural areas.
- Aptech is primarily a company that does EPC in Uganda, Liberia, DRC, Uganda, South Sudan, Niger, and Sierra Leone.
  - They have experience in stand-alone solar, mini-grids, and C&I. While their focus is on EPC, a number of their projects are outside of this space.
  - They have begun a pilot with almost 70 solar water pumps deployed and 50 more to be added soon. The model is water-as-a-service and farmers pay a subscription fee on a monthly basis. They acknowledged struggles in making the enterprise profitable and are trying to reduce default rates.
  - They are also piloting a solar hybrid charging station for an e-mobility company, testing a cold room demonstration site, and experimenting with lithium battery repurposing and assembly.

Solar Water Pumping

- Simusolar sells solar water pumps in Tanzania and Uganda.
  - Known as Tulima Solar in Uganda, about 85 percent of their customers are in either the horticulture or livestock value chains and less than half purchase the equipment on credit.
  - They are one of the most advanced companies in Uganda and have sold about 400 pumps to date.
  - They noted that awareness is low, after-sales servicing is a challenge due to remoteness of clients, and water availability is a challenge where surface water isn't available with boreholes costing up to $1000.

Mini-Grids

- Notable mini-grid developers in Uganda include Winch Energy and Equatorial Power. Mini-grids are an opportunity for appliance providers like Energrow, though currently only a few have been commissioned, and it is still a nascent market. However, the Promotion of Mini-Grids for Rural Electrification program mentioned above plans to tender more than 100 in 2022 on top of the 40 that it has already funded.

E-Mobility

- Zembo is an e-mobility company that has about 200 motorbikes on the road to date and are aiming to have 400 in total by the end of the year.
  - They have received grants from EEP and USAID Development Innovation Ventures (DIV) and secured $3.4 million in investment from Mobility 54, Toyota, DOB Equity, and Infraco.

- Boda taxi drivers buy or lease to own the bike while the batteries are owned by Zembo and are swapped as needed at charging stations.

Battery Technology for PUE

- Bodawerk is a battery company that is most known for its work on e-mobility but are making their batteries compatible with a wide range of applications.
  - They are aiming to power motorbikes, fishing boats, tractors, a range of agricultural applications, wheelchairs, and autoclaves.
  - They have about 70 motorbikes on the road and have received funding from PREO to develop their AgrE-Hub, which provides contract mechanization services.

Recommendations

- While being a relatively advanced market compared to other countries on the continent, there are still relatively few companies that would potentially be ready for an RBF, likely some of the ones listed above. Despite higher penetration of PUE products compared to most countries in the region, numbers are low, and companies are still early stage.
- Even though the PUE sector for agriculture is still somewhat nascent and possibly too early stage for RBFs, the Government of Uganda has experience implementing them for solar water pumps. Providing funding through the government on a rolling basis over the long term could catalyze more patient capital to enter the sector and allow the market to mature. However, technical assistance would also be required to ensure success of such an initiative.
- Even those that expressed openness to an RBF approach noted that funding is still needed upfront for research, technology development, and testing of business models. Some mentioned the possible need for loans or repayable grants if they were to be able to participate in an RBF or even a milestone-based grant.
- Stakeholders did note the positive aspects of RBFs, including less reporting and administrative burdens as well as not being constrained by the defined boundaries of the grant program or their own original grant proposal, which sometimes became unworkable due to changing circumstances on the ground. However, RBFs will often need to be paired with other support that addresses immediate needs for upfront funding.
- Support to the sector is needed to streamline mini-grid licensing and tariff approval, which continue to be challenges for the sector and barriers to scale.

6.14 ZAMBIA

The productive use sector in Zambia is very nascent. BGFA and WE4F are supporting companies on mostly early-stage attempts to enter the sector. Almost all of the main players are engaged in other lines of business, which can help them scale or allow them to sideline PUE if it becomes difficult or unprofitable. In addition, there has been some donor support for mini-grids, which provide opportunities for developers to directly engage in PUE or for appliance providers to sell their products now or when the number of projects start to scale. GOGLA has not reported any sales of solar water pumps or refrigeration units in Zambia due to lack of sales or reporting by companies.

Government

- While there are general government programs to support the agriculture sector and other sectors linked to it, there is little support directly for PUE.
- GOGLA mentions the Targeted Medium-Term Refinancing Facility under the Bank of Zambia, which offers financial service providers with liquidity for onward lending to households and businesses. However, it is not clear that PUE companies have access the facility and whether they would be deemed to satisfy the requirements after evaluation by the bank.
- The Government of Zambia released an action plan for the electrification of health facilities in 2022. It aims to map the electrification status and energy needs of health facilities, potential supply options and their cost, and the creation of a national multi-stakeholder coalition to ensure alignment and mobilization of resources.

Development Partners

- BGFA started as Beyond the Grid Fund for Zambia and have deployed RBF in the country since 2017. The second round has three windows and totals €17 million, with funds set aside for productive uses of energy.
- WE4F provides grants and TA to early-stage companies in Zambia working on productive use for agriculture.
- AECF has two grantees in Zambia, one of whom has PUE products in their portfolio.
- USADF provided a grant for a mini-grid to a company that also sells solar water pumps and fridges.
- GIZ Green People's Energy is supporting technical and vocational education and training of off-grid solar technology, including for PUE applications such as solar water pumping and milling. Curriculum development is done in coordination with the Technical Education, Vocational and Entrepreneurship Training Authority to align with needs of the local off-grid sector.

Private Sector

Table 22. Key PUE Companies and Payment Models—Zambia

Key Companies	Products/Services	Business Model
Vitalite	• Solar water pumps	• Cash, PAYGO • Employee deduction schemes
RDG	• Solar water pumps • Solar fridges	• PAYGO
Solar Village	• Batteries that power pesticide sprayers	• PAYGO
Muhanya Solar	• Solar water pumps • Solar fridges	• Cash
Engie PowerCorner	• Mini-grid	• Fee for service
Standard Microgrid	• Mini-grid	• Fee for service

Solar Water Pumping

- Vitalite, which has received RBF from BGFZ and BGFA as well as a grant from AECF, sells solar water pumps, of which they've sold about a hundred over three years. They are beginning to pilot other productive use equipment such as PAYGO egg incubators.
- RDG, a SHS company and also a BGFA RBF beneficiary, only just recently began selling PAYGO solar water pumps and fridges.

Solar Dryers

- Sylva Food Solutions is a WE4F grantee that provides a range of services to smallholder farmers. They organize famers into groups and train them on good agricultural practices and value addition, which includes the use of solar dryers that they have designed. When the final product is ready, Sylva purchases from the farmers and does further processing or packages for sale.

Pesticide Sprayers

- Solar Village, a WE4F grantee, works with cotton companies in multiple countries to provide their farmers with PAYGO batteries for their pesticide sprayers.
- They have over 55,000 farmers as customers.
- The batteries also power TVs, fans, lights, and phone charging. They noted that would prefer RBF but that eligibility criteria of many programs exclude their business model.

Mini-Grids

- Engie PowerCorner commissioned their first mini-grid in Zambia in 2019 and recently received RBF from BGFA to develop 11 more.
- Standard Microgrid is a leading mini-grid developer in Zambia. They have previously received RBF from BGFA and have investments of $3.5 million from Infraco and an undisclosed amount from EDF.

Multiple

- Muhanya Solar is a seller of solar water pumps and fridges and an installer of larger stand-alone solar systems. They received a grant from Power Africa to power seven rural health facilities in 2020 and was funded by USADF in 2017 to develop Zambia's first independently-owned mini-grid.

Recommendations

- BGFA beneficiaries have the opportunity to incorporate PUE appliances as part of the RBF. However, most other companies likely prefer upfront grant support.
- Solar Village could use an RBF, but it would have to be designed broadly in scope to include their product and business model.
- Any potential support for mini-grids or health facility electrification would follow models mentioned earlier in the sections on Sectors.
- The Sida mission in Zambia suggested exploring whether Nefco would be able to lend to the sector at concessional rates.

6.15 ZIMBABWE

GOGLA has never reported sales of refrigeration units due to lack of reporting by companies, but there was a one-year period where about 200 solar water pumps sales were recorded. One company estimated only about 3,000 to 4,000 solar water pumps currently in the country but reported that there is significant and increasing demand.

Market spoilage has been an issue due to low quality pumps and lack of after sales service. Many companies are not technically competent and not selecting the pumps with the right specifications for the situation. Affordability and awareness are issues as is the case across the region.

Aside from solar water pumps, there are few companies operating in other PUE sectors, though a few noteworthy ones are InspiraFarms, Mobility for Africa, and Lanforce Energy.

Government

- The Government of Zimbabwe announced in 2021 that for the next five years, solar equipment, including solar water pumps, will enter the country duty free. However, they are not exempt from VAT.[32]
- The Government of Zimbabwe worked over 18 months with other stakeholders, including the United Nations Environment Programme (UNEP), to produce a National E-Mobility Policy and Market Readiness Framework, a National E-Mobility Roadmap, and a Market Feasibility Study for Intracity E-buses, all released in 2022. The roadmap provides a pathway to decarbonize the transportation sector in Zimbabwe in the next ten years.[33]

Development Partners

- EEP has provided grants to companies in Zimbabwe for solar water pumps, e-mobility, solar walk-in cold rooms, and incubators.
- AECF has provided grants to two companies selling solar water pumps, one company for e-mobility, and two MFIs that provide loans for clean energy products.
- WE4F is providing a grant to one company selling solar water pumps and another selling biogas digesters with appliances in Zimbabwe.

Private Sector

Table 23. Key PUE Companies and Payment Models—Zimbabwe

Key Companies	Products/Services	Business Model
Zonful Energy	• Solar water pumps	• PAYGO
Celfre Energy	• Solar water pumps	• PAYGO
Natfort Energy	• Solar water pumps	• PAYGO
Powerlive Zimbabwe	• Solar water pumps • Food processing machines	• PAYGO

[32] Shetty, Sangita. Solar Quarter. Zimbabwe Announces Tax Exemption for Solar Energy Producers. May 15, 2021. https://solarquarter.com/2021/05/15/zimbabwe-announces-tax-exemption-for-solar-energy-producers-for-5-years/

[33] United Nations Environment Programme. Zimbabwe Ready to Transition to Electric Mobility. https://unepccc.org/zimbabwe-ready-to-transition-to-electric-mobility/

Key Companies	Products/Services	Business Model
Lanforce Energy	• Biogas digesters and appliances, including fridges and brooder heaters	• PAYGO
InspiraFarms	• Solar cold rooms	• Installments and cooling-as-a-service
Mobility for Africa	• E-mobility	• Fee for service

Solar Water Pumping

- Zonful sells SHS and solar water pumps and has received grants from EEP, AECF, and WE4F. They have sold about 65,000 SHS, 1,000 solar water pumps, and 500 biodigesters. While their pumps are PAYGO, it is counterproductive to switch off the pump and deprive farmers of water, so they have begun partnering with off-takers who can directly deduct from payments to farmers.
- Celfre Energy has an AECF and EEP grant to sell PAYGO solar water pumps.
- Natfort Energy sells PAYGO solar water pumps and has previously received AECF and USADF grants for SHS.
- Other companies providing solar water pumps are One Stop Solar, Solar Shack, Driptech, Satewave, Samansco, Electrosales, Felicity Solar, and Pristine Technologies Solar.[34]
- Powerlive Zimbabwe is a women-led enterprise that sells PAYGO SHS and solar water pumps. They have an EEP grant and have sold 4,000 SHS with half accompanied by PUE appliances, including pumps.

Biogas Digesters

- Lanforce Energy is a woman-led enterprise that sells portable biogas digesters that are used to power cold rooms and heat livestock brooders. They also sell a range of appliances that run on biogas, including fridges. They have a WE4F grant to scale their operations.

Cold Storage

- InspiraFarms has its main headquarters in Nairobi, but their main focus countries are Kenya and Zimbabwe. They have previously received support from EEP. See the Kenya section for more details.

E-Mobility

- Mobility for Africa is a rural last-mile e-mobility company. They produce low-cost electric tricycles and bicycles that are paid for on a rental basis and can travel 100 km with a 300-400 kg load. They also want to rent equipment that can be powered by the same batteries used for transport, including pumps, grinders, and drills. They also have a partnership with a dairy producer and is working with government to pilot a tricycle as an ambulance. They participated in the creation of and helped author the national e-mobility policy. They have received EEP and AECF grants.

[34] Africa Clean Energy Technical Assistance Facility. Stand Alone Solar Market Update Zimbabwe. April 2021. https://www.ace-taf.org/wp-content/uploads/2021/04/Stand-Alone-Solar-SAS-Market-Update-Tanzania.pdf https://www.ace-taf.org/wp-content/uploads/2021/03/Stand-Alone-Solar-SAS-Market-Update-Zimbabwe.pdf

Recommendations

- Most companies are too early stage for an RBF, so grants are generally more appropriate for the sector.
- One company noted that many companies selling solar water pumps are focusing on urban areas and that an RBF could draw them into more rural geographies.
- Walk-in cold rooms could be an opportunity given larger farm sizes in southern Africa and the success of companies like InspiraFarms.
- E-mobility has potential given the government's strong interest in promoting the sector, as witnessed by its effort to create the policy, framework, and roadmap mentioned above.

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APPENDIX A: LIST OF STAKEHOLDERS INTERVIEWED

No.	Organization
	Development Partners
1	Power Africa USAID
2	Power Africa Off-Grid Project - Finance Advisor
3	Power Africa Off-Grid Project - Policy and Regulatory Advisor
4	Power Africa Off-Grid Project - Market Dynamics Advisor
5	Power Africa Off-Grid Project - Health Electrification Advisor
6	Power Africa Off-Grid Project - East Africa Energy Agriculture Advisor
7	Power Africa Off-Grid Project - West Africa Energy Agriculture Advisor
8	Power Africa Off-Grid Project - East Africa Regional/Tanzania Advisor
9	Power Africa Off-Grid Project - West Africa Regional Advisor
10	Power Africa Off-Grid Project - Uganda
11	Power Africa Off-Grid Project - Ethiopia
12	Sida Burkina Faso
13	Sida Mozambique
14	Sida Tanzania
15	Sida Zambia
16	EU Tanzania
17	EnDev West Africa
18	WE4F USAID
19	WE4F Central Southern Africa Hub
20	WE4F East Africa Hub
21	WE4F West Africa Hub
22	CLASP
23	REEEP
24	GOGLA
25	SEforALL
26	AECF
27	Energy 4 Impact East Africa

28	Energy 4 Impact West Africa
29	Energy 4 impact Rwanda
30	AMDA
31	Feed the Future Innovation Lab for Small Scale Irrigation
32	World Bank - Sudan
33	World Bank - South Sudan
	Private Sector Companies
34	E-LongLife
35	ARESS
36	SunCulture
37	Agsol
38	Futurepump
39	InspiraFarms
40	EnerGrow
41	Simusolar
42	Simusolar Uganda
43	Ensol
44	Agricultural Transformation Agency
45	LIB Solar
46	Ecopower
47	GreenLight Africa
48	A2EI
49	EV Association Kenya
50	Davis & Shirtliff
51	OFGEN
52	Aptech Africa
53	Solar Village
54	RDG
55	Zonful
56	Mobility for Africa
57	Surechill
58	Differ Group

59	SunDanzer
60	Go Shop
61	OffgridBox
62	Dgrid
63	Practical Action West Africa
64	Zembo
65	Ampersand
66	SECCCO
67	Sylva Food Solutions
68	Vitalite
69	Rensys
70	Ignite Power
	Investors
71	Infraco
72	IKEA Foundation
73	Acumen
74	Lendahand
75	SunFunder
76	Rockefeller
77	CrossBoundary

APPENDIX B: LIST OF RELEVANT REPORTS REVIEWED

No.	Report Title	Organization/Author
1	Solar Appliance Technology Briefs and Snapshots	Efficiency for Access Coalition
2	Navigating Policy and Regulation in the Clean Energy-Agriculture Nexus: A Guide for Companies to Engage Policymakers	Tetra Tech, Powering Agriculture Support Task Order (PASTO)
3	Technology Case Study: Cold Storage	Tetra Tech (PASTO)
4	Technology Case Study: Clean Energy Agro-Processing	Tetra Tech (PASTO)
5	Technology Case Study: Micro-Grids and Productive Agricultural Uses	Tetra Tech (PASTO)
6	Technology Case Study: Clean Energy Agro-Processing	Tetra Tech (PASTO)
7	Access to Financing: For Early-Stage Innovators in the Clean Energy-Agriculture Nexus	Tetra Tech (PASTO)
8	Benefits and Risks of Solar-Powered Irrigation	Powering Agriculture
9	Solar Milling: Market Requirements to Close the Commercial Viability Gap	Efficiency for Access Coalition
10	Energy for Rural Industrialisation: Productive Use of Energy 2.0	GET.transform
11	Productive Use of Energy: Moving to Scalable Business Cases	EnDev
12	Standalone Solar Market Updates	ACE-TAF
13	Power Africa Off-Grid Solar Market Assessments	Power Africa
14	Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data	GOGLA
15	Transforming Energy Access Markets with Results-Based Financing	EnDev
16	Global LEAP+RBF final report for Powering Agriculture	CLASP

17	The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa	Lighting Global
18	Sustainable Expansion of Groundwater-based Solar Water Pumping for Smallholder Farmers in SSA	Efficiency for Access Coalition
19	Selling productive use of energy (PUE) products at the last mile: top tips and common pitfalls	Global Distributors Collective
20	Powering Productivity: Lessons in Green Growth from the EEP Africa Portfolio	Energy and Environment Partnership (EEP)
21	Capital Required to Maximise the Productive Use of Energy in Rural Sub-Saharan Africa	Powering Renewable Energy Opportunities (PREO)
22	Evaluation of Solar-Powered Agricultural Technologies for Productive Use Applications: A Modeling Approach	A2EI
23	Sustainable Energy for Smallholder Farmers (SEFFA) in Ethiopia, Kenya and Uganda: Baseline Study and Market Assessment	EnDev
24	Lessons Learned from IFAD Green Technologies Project	IFAD
25	Off-Grid Solar Market Trends Report: State of the Sector	Lighting Global/ESMAP