



# The market for productive uses of solar energy in Kenya: a status report

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# Acronyms and abbreviations

A2EI: Access 2 Energy Institute

AC: Alternating Current

ACE TAF: Africa Clean Energy Technical Assistance Facility

AECF: Africa Enterprise Challenge Fund

AEMDA: Association of Electric Mobility Developers of Africa

CBEA: Cross Boundary Energy Access

C&I: Commercial and Industrial

CLASP: Collaborative Labelling and Appliance Standards Program

COVID-19: Coronavirus Disease

DC: Direct Current

EnDev: Energising Development

EEP Africa: Energy and Environment Partnership Trust Fund

EPRA: Energy and Petroleum Regulatory Authority

ESMAP: Energy Sector Management Assistance Programme

FCDO: Foreign, Commonwealth and Development Office

GDC: Global Distributors Collective

Global LEAP: Global Lighting and Energy Access Partnership

GMG: Green Mini-Grid

GOGLA: Global Off-Grid Lighting Association

ICE: Internal combustion engines

IEC: International Electrotechnical Commission

IFC: International Finance Corporation

ISO: International Organisation for Standardisation

JKUAT: Jomo Kenyatta University of Agriculture and Technology

KEBS: Kenya Bureau of Standards

KEPSA: Kenya Private Sector Alliance

KEREA: Kenya Renewable Energy Association

KNES: Kenya National Electrification Strategy

kWh: kilo Watt hour

LEIA: Low energy inclusive appliances

LMD: Last-Mile Distributors

MFI: Microfinance Institution

MoA: Ministry of Agriculture

MoE: Ministry of Energy

MoEF: Ministry of Environment and Forestry

MolTED: Ministry of Industry, Trade and Economic Development

MSME: Micro-, Small- and Medium-Sized Enterprise

NGO: Non-Governmental Organisation

NEECS: National Energy Efficiency and Conservation Strategy

PAYGo: Pay-as-you-go

P&P: Plug and Play

PREO: Powering Renewable Energy Opportunities

PUE: Productive Use of Solar Energy

PV: Photovoltaic

RBF: Results Based Financing

SACCO: Savings and Credit Cooperative

SHS: Solar Home Systems

SERC: Strathmore Energy Research Centre

SIDA: Swedish International Development Cooperation Agency

SME: Small- and Medium-sized Enterprises

SWP: Solar water pump

TA: Technical Assistance

VAT: Value Added Tax

V: Volt

Wh: Watt hour

Wp: Watt peak

# Executive Summary

**The Energising Development (EnDev) programme recognises the positive impact the productive use of solar energy (PUE) can have** both on solar companies and their customers. In cooperation with the Kenya Renewable Energy Association (KEREAA) PUE Working Group (WG), the SNV Netherlands Development Organisation (SNV), as part of EnDev Kenya, commissioned this study of the Kenyan PUE market to give stakeholders an up-to-date view of the space and recommendations to support its growth. Research was conducted between April and July 2021 and included a survey of 16 Kenyan PUE companies and interviews with 45 stakeholders across the PUE ecosystem.

## Key take-aways

**About 100 specialist companies** are active in the Kenyan solar PUE space (see Figure 1), and many more electrical supply and hardware traders sell component-based systems with less visibility.

**Business models are difficult to scale, as the market is characterised by low-volume niche appliances.** The financial and logistical challenges of importing and warehousing low-volume products point to an increasingly important role for partnerships along the entire supply chain – such as for bulk procurements, import, warehousing, distribution and after-sales – as companies consolidate or specialise.

**Solar water pumping (SWP) and irrigation, cooling and electric mobility** are gaining attention and traction. Eighty-two per cent of specialist PUE companies in Kenya are working with one or more of these technologies (see Figure 2).

**Three market segments are evolving in parallel,** with some overlap:

- Plug and play (P&P)<sup>1</sup> PUE offer important entry technologies with pay-as-you-go (PAYGo) end user financing, though their smaller size limits value-addition.
- Component-based solar PUE systems dominate the market and capture more value for Kenyan suppliers and end users, but sales are severely constrained by lack of consumer financing.
- Solar mini-grid operators are actively testing PUE demand stimulation approaches, with the verdict still out on which business models will succeed.

**Seventeen per cent of component-based system suppliers and one-third of P&P suppliers are vertically integrated** – that is, manufacturers who have direct engagement with end users.

<sup>1</sup> Definitions and more detail regarding the scope of this report may be found in Section 1.2.

■ Mini-grid   
 ■ Component based system   
 ■ Plug and play

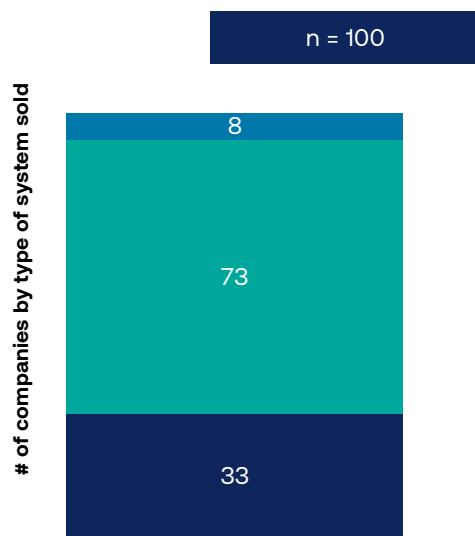


Figure 1: Companies active in the Kenyan PUE space.

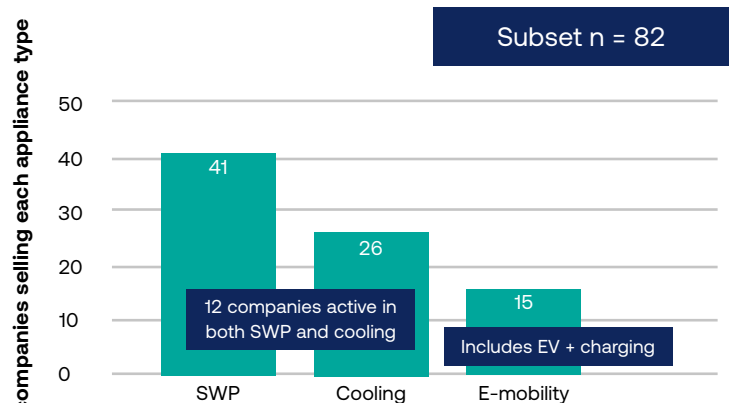


Figure 2: Subset of companies supplying three major PUE appliances.

N.B. Where companies are involved with more than one type of system/appliance, they are counted twice. As such, the totals are >n.

**Alongside, and in support of, the main value chain actors, a host of other parties are at work in the PUE ecosystem** (see Figure 3).

**The Kenyan government is supportive of PUE, but concrete action has been limited.** The regulatory environment is broadly conducive, with the exception of taxation of most solar and electric appliance components; a 2021 reinstatement of exemptions does not include most PUE appliances. There is little inter-ministerial coordination.

**Some Kenyan companies have accessed impact debt and early-stage equity**, but more is needed, including for non-PAYGo and component-based solar manufacturers and last-mile distributors (LMDs). Climate financing may become available for companies (or other actors) reducing carbon emissions, for example, by replacing fuel with solar electricity, or by irrigating using soil-preserving solar-drip technology.

**Consumer financing for mid-sized component-based PUE systems** is a major gap, and most customers pay cash up front. Enterprising fintech lenders may bypass traditional micro-finance institutions to reach these clients, but there remains a need for dedicated asset financing to the sector.

**Improved business practices as a consequence of the COVID pandemic** are strengthening companies' sophistication and evidence-based decision-making in ways that will enhance their attractiveness to investors. This includes an unprecedented level of digitisation.

As business models evolve, promising potential exists in:

- Expansion through non-solar sales channels. Though some LMDs sell through both solar and agricultural equipment supply chains, many do not.
- Service or rental business models, by which customers do not buy PUE appliances but rent them, or purchase the solar-powered service only. These address high equipment costs and can benefit from global lessons on sharing or rental economies.
- Horizontal consolidation, by which companies solve for more than one constraint in their customers' value chain, for example, selling farmers cold storage and cold transport.



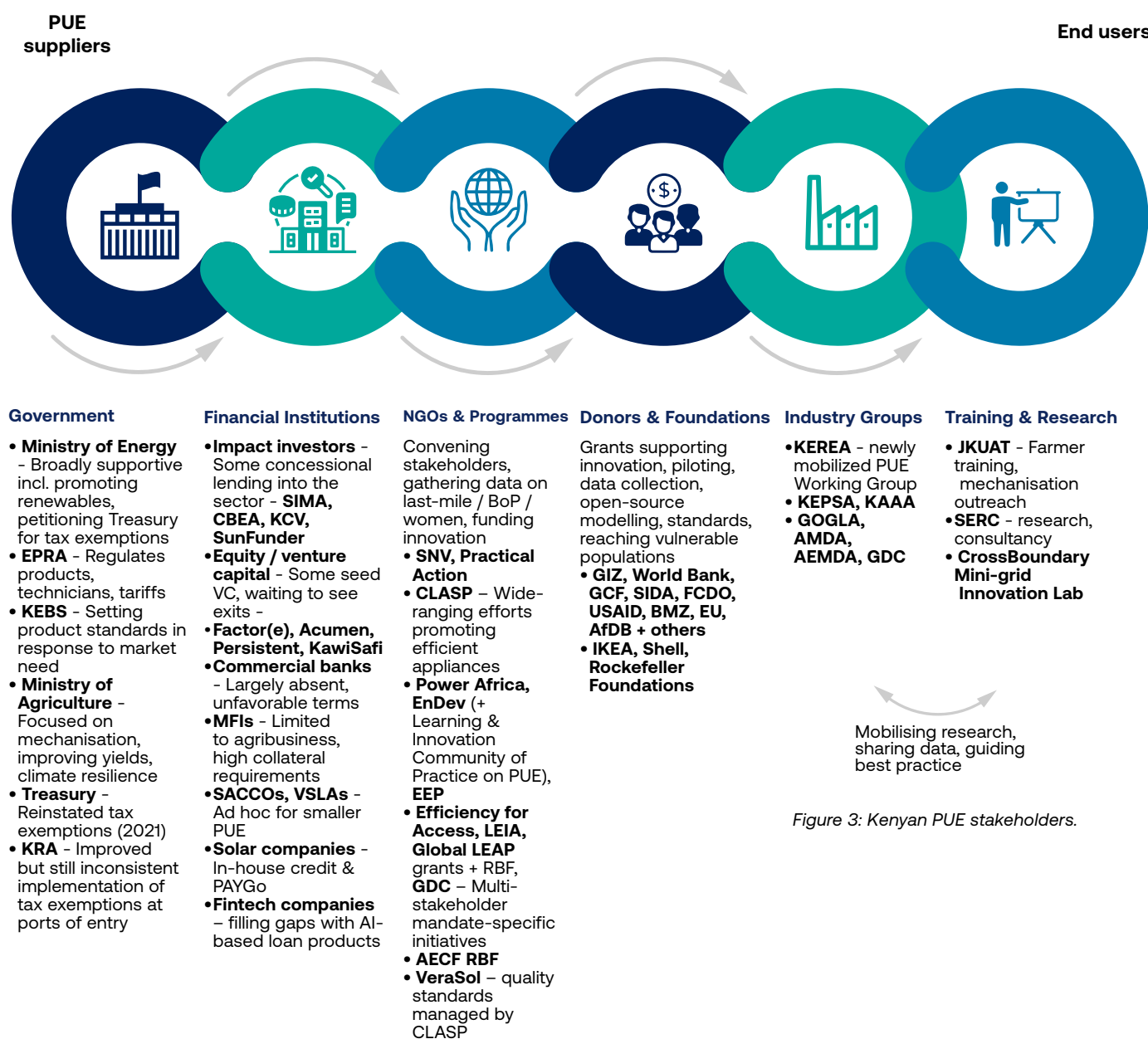


Figure 3: Kenyan PUE stakeholders.

**Kenya is heading into an election year in 2022**, and the government needs to show proactive support to a population reeling from COVID-related uncertainty, restrictions and job losses. This is a strategic moment to invest in high-potential PUE interventions.

**Senior sector leaders are calling for a convening of stakeholders** to trade knowledge and to chart a coordinated way forward.

### Recommendations

1. Capitalise on the current momentum in the PUE sector to mobilise decision-makers. **Convene stakeholders for an inter-ministerial, public-**

**private dialogue** on how to address barriers inhibiting sector growth.

2. Unlock higher-value opportunities. **Identify scalable consumer financing mechanisms for component-based solar PUE systems.**

3. Improve the enabling environment – streamline strategy, clarify regulations and build consumer awareness. **Design and fund a cross-sectoral flagship programme for PUE** on the model of Lighting Global.



# 1 Introduction

The EnDev programme is at the forefront of energy access innovation and market building in Africa. EnDev is working through SNV Kenya and other partners to implement the Accelerating Access to Energy Services project to support the market development of improved cooking and electricity solutions. Within the electricity component there is a focus on productive use applications for households and small businesses, recognising that in many countries, Kenya included, there is little in the way of consolidated market intelligence on these technologies and their value chains.

In partnership with KERECA – the industry body representing solar companies in Kenya – SNV has commissioned this analysis of the Kenyan PUE space as part of the EnDev programme. The objective is to understand “who is who” in the PUE space and what is happening within the off-grid solar PUE value chains, as well as how PUE can be supported and incentivised within the policy and regulatory context.

To date, much of the off-grid solar sector’s financing and business support has focused on smaller products that enable households and small businesses to use light bulbs, charge phones and run small appliances (‘consumptive’ use). More recently, there has been growing recognition of the economic importance and business opportunity of the productive use of energy/electricity – that which enables value addition and income generation. The enhanced ability to generate income is an important goal in terms of economic development, and it is also critically important to the solar supplier’s bottom line.

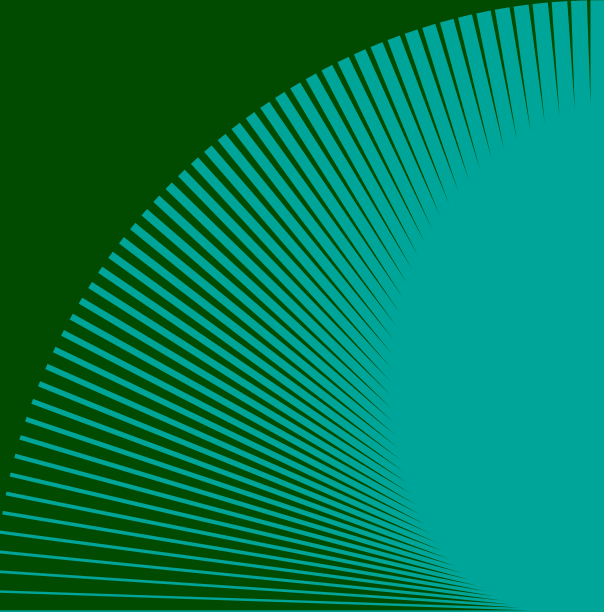
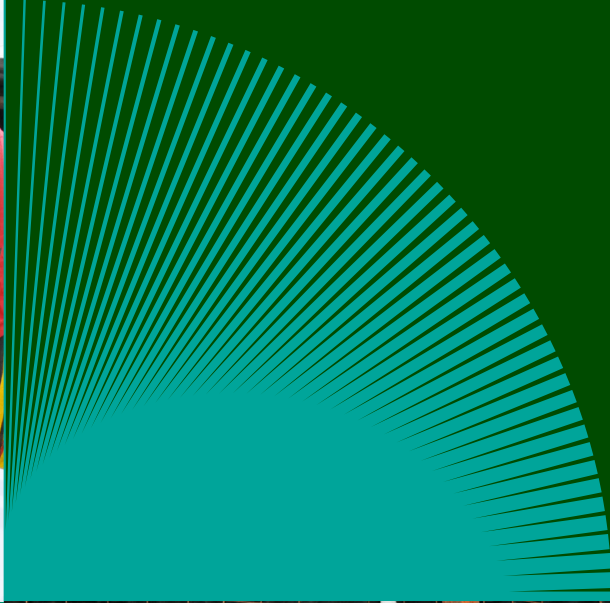
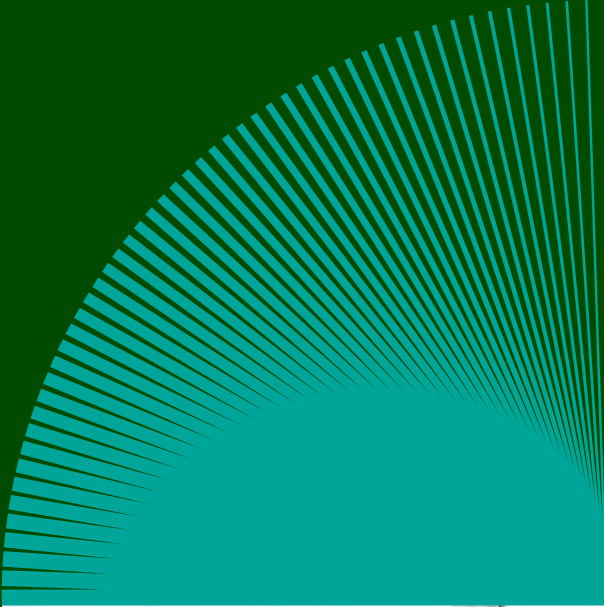
This study is meant to be of practical support to sector stakeholders. SNV has partnered with

KERECA’s PUE Working Group to channel the analysis into concrete advocacy and market-building activities.

## 1.1 Background of the Kenyan PUE market

Historically, off-grid solar in Kenya has always been used for entrepreneurial purposes, even if these experiences were not as well-documented as household uses. In particular, off-grid solar for connectivity (radio and cell phone charging) and entertainment (music and television) has long been associated with income generation in rural areas.

**1980s.** A 1982 United Nations Environment Programme conference recognised the long-term potential of PUE applications, and galvanised early support for solar water pumping and refrigeration (the latter through the WHO’s Expanded Programme of Immunization) that catalysed technology development. Singer imported some of Kenya’s first solar modules in unsuccessful attempts to electrify off-grid sewing machines. In general, though, solar photovoltaics (PV) were too expensive and poorly matched for PUE applications, and commercial use remained tentative before 1990.



**1990s.** Well-documented Kenyan early off-grid solar applications in the nineties mostly involved solar home systems (SHS) for lighting, TV and music supplied by over-the-counter suppliers in cash crop areas. The market was stimulated by the wide availability of low-cost PV modules for direct current (DC) systems. During this time, some people began expanding 12-volt (V) DC household solar to power small-scale commercial needs (lighting, TV) in kiosks, bars and hotels. DC soldering irons, high frequency radio communication and a few other DC-powered applications also began to appear. Following the pilot efforts in the 1980s, solar water pumps (SWPs) began to receive serious attention from developers like Grundfos and Lorentz and their local distributors (notably Davis and Shirliff). Most early pumps were installed as part of non-governmental organisation (NGO)-funded rural water supply projects. Some small-scale agricultural sites used water from these early solar pumping projects for horticulture and livestock needs, and these niche productive use applications emerged as commercial off-shoots of rural water supply projects.

The introduction of DC to alternating current (AC) inverters (supplied by Kenyan companies like Chloride Exide and others) enabled a much wider range of AC-power applications, notably colour TVs, larger music systems, computers, office equipment and hair clippers. These new appliances increased the portfolio of products that over-the-counter solar traders could offer, and built their standing in the market.

**Early 2000s.** Solar markets expanded greatly following the widespread introduction of cell phones, increased awareness, drops in PV prices and continuously improving equipment. The entrepreneurial creativity of over-the-counter suppliers stimulated the use of solar for income generation in a number of areas.

By 2006, thousands of rural shops were charging cell phones with locally-assembled solar kits<sup>2</sup> or car batteries. Barber shops became more common as suppliers rolled out electric clippers and as

rural vinyozi (barbers) enhanced their shops with lighting, music and phone charging. Bars, hotels and churches increasingly used solar powered TV and music systems in off-grid areas. Electric egg incubation emerged as a locally-developed niche application when solar providers realised that they could assemble solar-powered incandescent lights to warm eggs, and enable a profitable small business for their small-farm customers. And small-scale hospitality applications emerged as boutique tourism sites increasingly replaced expensive and noisy generators with small PV systems.

**Late 2010s.** Following efforts by Lighting Global to encourage investment in the sector, productive use applications began to become more sophisticated and financeable. PAYGo consumer finance enabled suppliers to offer appliances that were beyond the initial reach of base-of-the-pyramid businesses, although its use remains limited to lower-priced products. More recently, test methods have been developed to standardise and facilitate quality control, and grant programmes have facilitated the uptake of SWPs, electric pressure cookers and various products in the cold chain.

## 1.2 Methodology & scope

### 1.2.1 Methodology

This study was undertaken between April and July 2021. Information was gathered through a literature review; interviews with 45 stakeholders in government, the private sector, development partners, investors and end users (see Figure 4); an online and excel-based survey of companies active in the Kenyan market; and three focus group discussions with a total of seven members of the KERIA PUE working group.

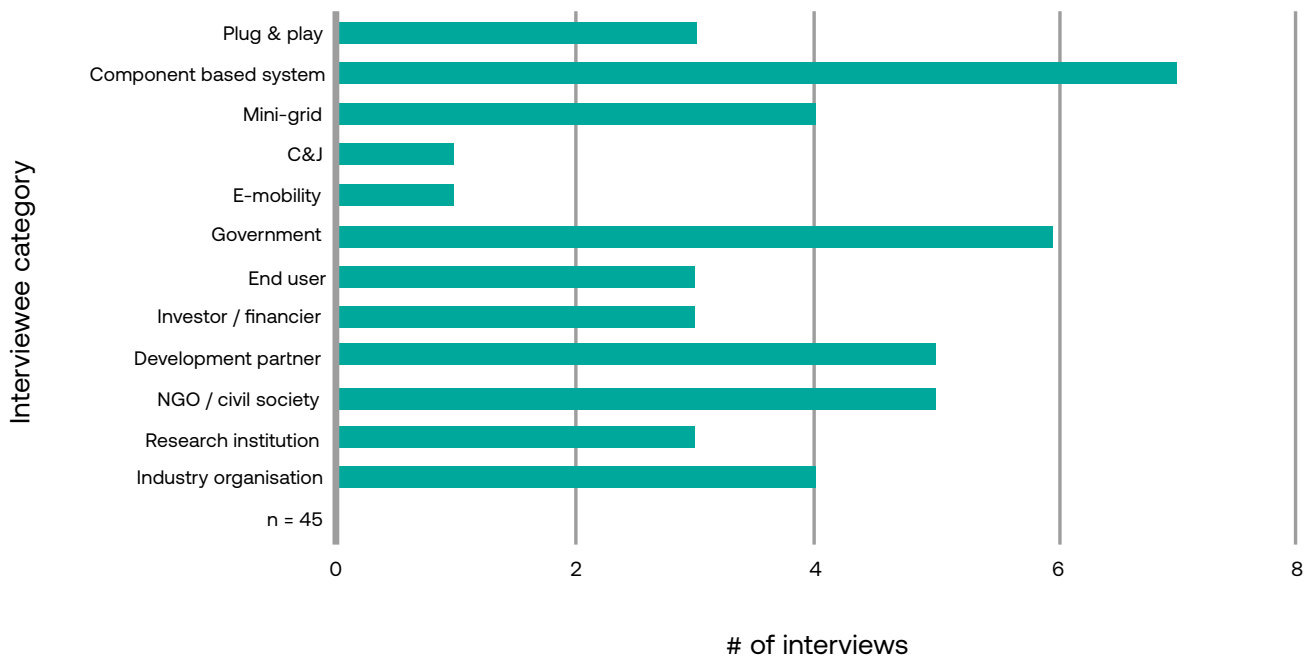


Figure 4: Interviewees by category.

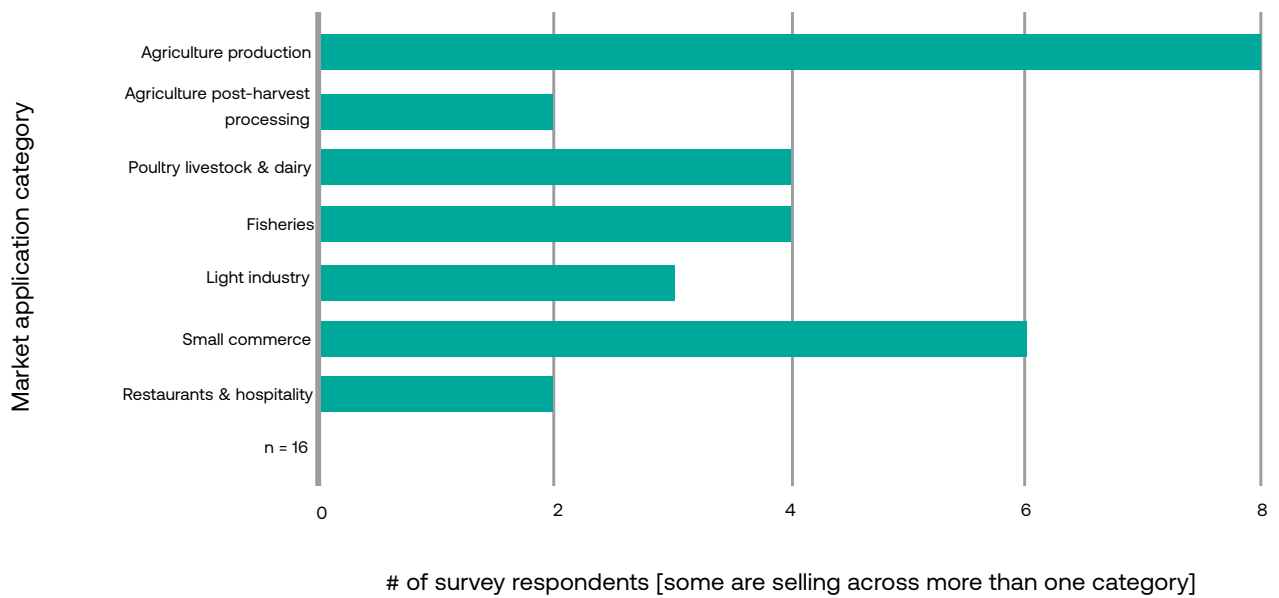


Figure 5: Survey respondents by product category.<sup>3</sup>

Sixteen companies participated in the online survey, selling PUE appliances across a range of uses (see Figure 5). Their insights have informed this report, but they are not referenced by name in order to maintain confidentiality. Though the survey response rate was not high enough to provide statistically conclusive results, the findings nevertheless offer a valuable perspective on the market.

## 1.2.2 Scope

The focus of this research is productive electric applications powered by off-grid solar,<sup>4</sup> either stand-alone or on a solar mini-grid. Though commercial and industrial (C&I) solar is vibrant in Kenya and generates cost savings for these clients, it is not included here; however, we do mention a large stand-alone cool room designed for use by commercial farms or produce aggregators, which resembles C&I but nevertheless has potential for a more explicit impact on the rural poor. On-grid demand stimulation is also not covered, though it is an important topic for Kenya Power since it copes with five million domestic connections using less than 10 kilo Watt hours (kWh) per month.<sup>5</sup> Solar thermal drying is understandably popular in theory, with mixed uptake in practice, and has been included as a case study, as its value chains

are highly localised and dissimilar to those of solar electric products. Lastly, this report does not delve into the value chains of the electric appliances and equipment sold independently of the solar equipment, for example, e-bodas (motorcycle taxis) or electric soldering irons. These are relevant, of course, but entail a broader analysis not undertaken in this work.

## 1.2.3 Analytical framework

EnDev’s ecosystem approach to PUE acknowledges the importance of multi-disciplinary and cross-sectoral coordination,<sup>6</sup> as well as an understanding of end user insights.

We have used a ‘value chain/market systems’ framework to understand the dynamics in the Kenyan PUE space. Value chain analysis emphasises a systems perspective; the role of governance and relationships; targeting leverage points to address obstacles; and empowering the private sector.<sup>7</sup> The broader market systems lens acknowledges that the (many) PUE value chains are operating within a complex context of parallel and intersecting value chains, sociocultural forces and more.

There are a number of lenses one can use to understand PUE (see Table 1).

Table 1: PUE lenses.

Power source structure/ wattage	Appliance technology	End user sub-sector/ market application	Business model	Value proposition
P&P Component-based system Mini-grid	Water pump	Agricultural production	Product sale	Mechanisation (time savings, reduced drudgery)
	Refrigerator/freezer/ cold room	Agricultural post-harvest processing	Product rental/ lease/ lease-to-own	Fuel replacement (cost savings, reduced pollution)
	E-bike/trike	Dairy, poultry and livestock	Service provision	New business (income generation, value addition)
	Mill	Fisheries	Vertically integrated	
	Etc.	Light industry	Etc.	
		Small commerce		
		Restaurants and hospitality		

<sup>2</sup> ESD Africa (2006) A Study of Productive Uses of PV Electricity in Rural Areas of Kenya.

<sup>3</sup> Some are selling PUE appliances in multiple categories.

<sup>4</sup> Lighting Global has preferred the term productive use leveraging solar energy (PULSE).

Building on the final column above (value proposition), Table 2 shows what the value added to the end user could be:

Table 2: End user PUE value propositions.

Mechanisation	Fuel replacement	New income generation/value addition activity
<p>Mechanise activity currently done by hand.</p> <p>Reduced drudgery, time savings/ increased productivity, quality improvement.</p> <p>Solar electricity is excellent for mechanising what human power (~100W) cannot do or is not best used for.</p> <p>Example: electric mill.</p>	<p>Alternatives to diesel/petrol.</p> <p>Power existing AC equipment by solar instead of genset (requires inverter and equipment must be efficient or retrofitted), or replace existing AC equipment with a solar-powered DC equipment kit or component system.<sup>8</sup></p> <p>Example: electric boda.</p>	<p>New business activity or addition of value to an existing activity.</p> <p>Consumer awareness of or financing for solar electric appliance is impetus for starting a new business or improving/ diversifying an existing one.</p> <p>Example: TV or freezer in off-grid café.</p>

Finally, building on the first column in Table 1 (power source structure/wattage), this report uses the three categories of power source – P&P kits, component-based systems and solar mini-grids – to structure the analysis (see Figure 6).

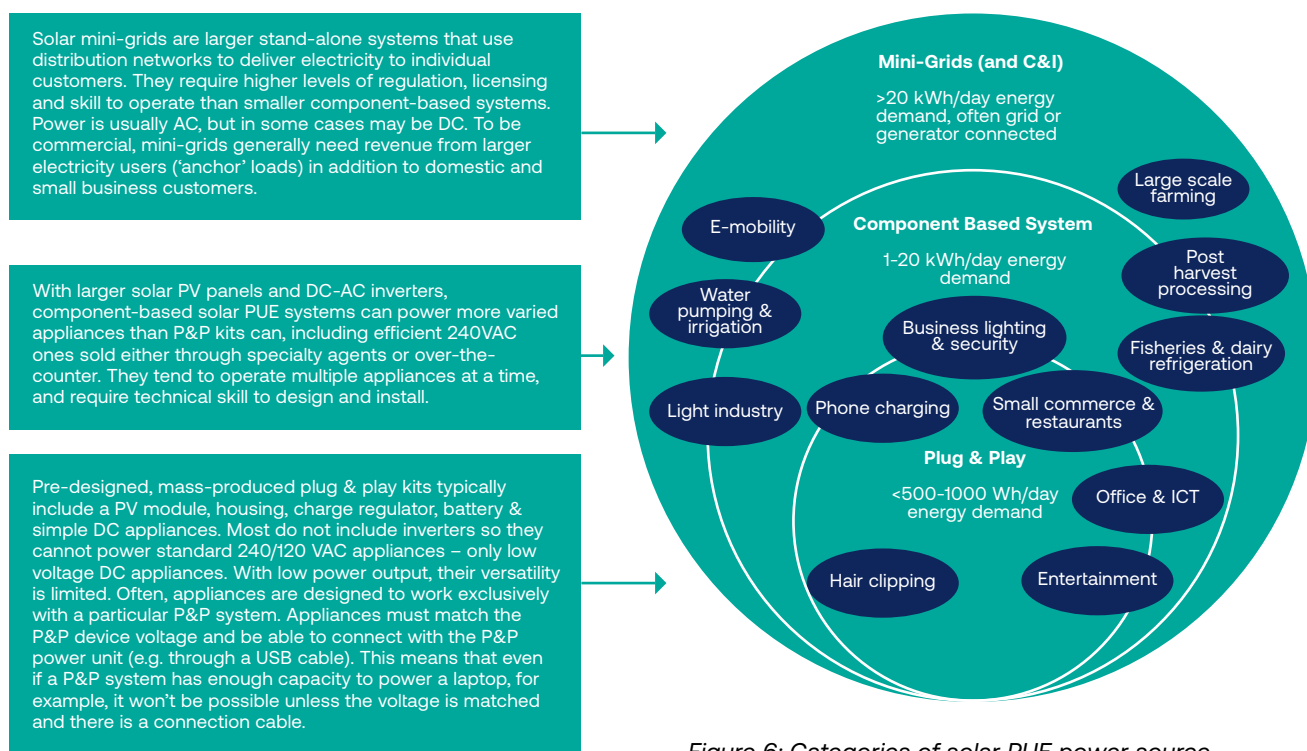


Figure 6: Categories of solar PUE power source.

<sup>5</sup> Interview with KEPSA.

<sup>6</sup> Endeavor (2021) Productive use of energy: Moving to scalable business cases.

<sup>7</sup> <https://www.marketlinks.org/good-practice-center/value-chain-wiki/overview-value-chain-approach>.







## 2 The PUE market in Kenya

**The Kenyan PUE space is a confluence of several markets** – off-grid solar, appliances, agribusiness and others – and both international and local players. This study found about 100 specialist companies selling a range of productive electric technologies (see Section 2.4.1 for more on these companies, and Annex 5.1 for a company list).<sup>9</sup>

This section looks at technologies and trends in the market, solar PUE value chains, and a range of activities in the wider PUE ecosystem, including around regulation and financing.

### 2.1 Technologies

This study found 40 types of PUE technologies available in Kenya in a range of product styles and used across seven main market applications (see Table 3). The 2020 Off-grid PUE Catalogue for Kenya <sup>10</sup> is an excellent resource on 49 specific agriculture-related PUE appliances and equipment on the market. The focus on agricultural value chains is understandable given the 40 per cent of the Kenyan population employed in the sector<sup>11</sup> and the large value to be captured by using some of these technologies, but it is important also to recognise the economic contribution of other ‘undervalued’ technologies.<sup>12</sup>

Table 3: PUE technologies in Kenya.

Market application	Technologies	Comments
Agricultural production	Water pump, irrigation system  Solar sprayer	Solar water pumps are the best known and most widely used PUE equipment in Kenya, for good reason: newly irrigated farms can see yields increase up to three times. <sup>13</sup> Small petrol pumps are widely used to irrigate tomatoes and greens in Kenya. <sup>14</sup> This is a vibrant space with new PAYGo models and new market entrants. <sup>15</sup>

<sup>8</sup> Hybridisation of fuel-powered machines is happening at the mini-grid level (e.g. solarising a diesel mini-grid), but is rare at the machine level (Interview with CLASP).

<sup>9</sup> A recent Power Africa assessment highlighted 29 companies involved in the agriculture PUE subsectors. The EPRA keeps periodically updated lists of one registered solar contractor and two registered companies selling consumer devices exclusively on its website, but does not track which of these are selling solar appliances.

Market application	Technologies	Comments
Agricultural post-harvest processing and storage	<p>Mill, huller, thresher, crusher, paste-maker, oil press</p> <p>Cold room, refrigerator</p>	<p>Agsol is piloting its posho micro-mill prototype in partnership with Mwezi and PowerGen.</p> <p>InspiraFarms is piloting a ‘first-mile’ solar or generator powered cool room; SokoFresh, which emerged from the Enviu incubator, offers both ‘cooling-as-a-service’ and market linkage for customers looking to rent shelf space for their produce.</p> <p>New models of AC and DC fridges are gaining traction. Sollatek reports strong initial sales of a 140-litre KES 85,000 DC fridge.</p>
Dairy, poultry and live-stock	<p>Cold room, refrigerator, freezer, ice-making machine, milk tank, cold transport</p> <p>Egg incubator</p> <p>Water pump</p> <p>Electric fence</p>	<p>Solar incubators are being tested. OVO Solar is a new market entrant prototyping its product [with grant support from the Energy and Environment Partnership Trust Fund (EEP Africa)] with Mwezi.</p>
Fisheries	<p>Fishing light</p> <p>Water pump</p> <p>Ice-making machine, cold transport</p> <p>Electric boat motors</p>	<p>Solar nightlights for fisher-people on Lake Victoria are gaining traction.</p> <p>Raino Tech4Impact has introduced first-mile and transport cold chain logistics for the fisheries sector.</p> <p>Start-up Asobo has launched an ‘electric propulsion as a service’ model renting electric boat engines to fisher-people on Lake Victoria.</p>
Light industry	<p>Sewing machine, loom</p> <p>Drill, hammer, soldering iron, welder, compressor, tool kit</p>	<p>Very little market information is available on this class of products.</p>

<sup>10</sup> Power Africa (2020) Off Grid Productive Use of Energy 2020 Catalog – Kenya.

<sup>11</sup> <http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/>.

<sup>12</sup> GOGLA and other stakeholders. Though phone-charging for a fee is less common now that so many households have their own solar chargers, the impact of phone and internet connectivity on the economy should not be underestimated.

<sup>13</sup> Jenny Corry Smith & Riley Macdonald (2021) Refrigerators and water pumps have reached a critical crossroads: Here’s what the off grid solar sector should do next (blog).

<sup>14</sup> Interview with KickStart.

<sup>15</sup> Interview with Energy 4 Impact.

Market application	Technologies	Comments
Small commerce	Electric boda/3-wheeler Fan, TV Refrigerator Blender, juicer, electric pressure cooker Phone charging, internet, printer Hair clipper, salon kit Public address system	Kenya is home to an estimated 20 companies in the e-mobility space <sup>16</sup> developing 2-, 3- and 4-wheel electric vehicles through either new manufacture or retrofitting fuel-based bodas and cars. Business models include on- or off-grid charged electric engines (Opibus), solar roofs on the vehicle (Solar E-Cycles), or battery swap-out (Ecobodaa).
Restaurants and hospitality		Hair clippers are being sold by a range of companies, including Engie Mobisol, Equatorial Sunpower, Solibrium, SunTransfer and Mwezi; suppliers are finding it helpful to sell them near schools, as students are required to keep their hair tidy.  Electric pressure cookers are still in early trials on mini-grids but seem to have some initial traction, though more for home convenience than for PUE.
N.B. phone and internet connectivity are cross-cutting productive applications that continue to be enormously impactful to the Kenyan economy.		

The 2021 Solar Appliance Technology Briefs series from Efficiency for Access categorises several leading technologies by their stage of global market readiness (see Table 4); as could be expected, at the national level the Kenyan market appears to differ slightly.

Table 4: Market readiness of leading appliances.

Appliance technology	Market status (E4A description)	Observed market status in Kenya
Fan	Near to market: Appliances for which the demand is strong and clear, but which are only available in low volumes and at a relatively high cost	Near to market
TV		Active market
SWP	Emerging: Early-stage technologies which have gained market traction in recent years, but remain out of reach for most consumers	Near to market
Refrigerator		Emerging
Mill	Horizon: Technologies not yet fully brought to scale, but are likely to scale up in the near future; they are early stage technologies which may be disruptive to existing dominant appliances and may create opportunities to leapfrog in terms of efficiency or cost.	Pre-horizon
Cold room		Horizon
Electric vehicle		Horizon
Electric pressure cooker		Horizon

## 2.2 Recent trends

### Sales

**There is no centralised tracking of PUE product sales in Kenya.** The Global Off-grid Lighting Association (GOGLA) reports sales of TVs, fans, refrigerators, and SWPs, along with other appliances,<sup>17</sup> but it is hard to say how much of the market these figures reflect. A large number of component-based PUE applications in Kenya are sold by over-the-counter solar and hardware traders – both brand name chains and one-off shops –

that do not report to GOGLA. As such, the GOGLA figures can be taken as the very low end of what is happening in the country.<sup>18</sup>

Nevertheless, these gaps acknowledged, by GOGLA's count (see Figure 7), solar TVs are by many multiples the most popular appliances; fridges and SWPs came in at 2,722 and 5,246 units, respectively, in 2020, with a surge in SWP sales in the second half of the year that may be due to the Global Lighting and Energy Access Partnership (Global LEAP) Results Based Financing (RBF).

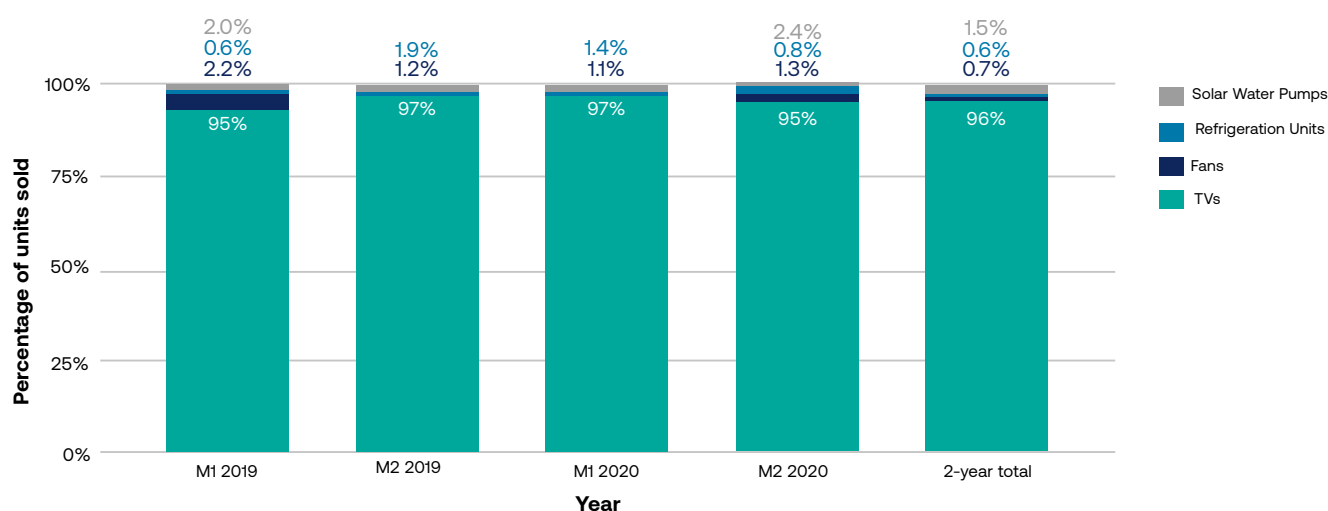


Figure 7: Solar appliance sales 2019–2020 (GOGLA).

### Survey findings

Survey respondents were selling 55 PUE appliances across the following categories:

- Agriculture production: SWP and irrigation systems
- Agriculture post-harvest processing: Mills
- Dairy, poultry and livestock: Egg incubators, refrigerators, irrigation systems
- Fisheries: Night fishing lights, ice makers
- Light industry: Compressors, sewing machines
- Small commerce: Hair clippers, mobile phone charging
- Restaurants and hospitality: TVs and PAs

In seeming contrast to the GOGLA figures above, respondents indicated that sales of SWP and irrigation systems had fallen by nearly 50 per cent

from 2019 to 2020, and light industry PUE sales dropped about 40 per cent in the same timeframe. Volumes of other products remained largely stable.

There was a preponderance of DC appliances (only 6 of 55 were AC), which reflects the greater applicability of DC for use with solar, as it does not require an inverter. Qualitative feedback from respondents follows within the text.

### Impacts of COVID

**COVID has affected the Kenyan off-grid solar market across the supply chain.**<sup>19</sup> Delays in manufacturing and import constrained inventory, and shortages in raw materials, saw prices spike for PV panels up to 10–15 per cent since early 2021.<sup>20</sup> Travel restrictions and falling household incomes placed huge strain on the ability to afford non-essential

<sup>16</sup> Association of Electric Mobility Developers of Africa (AEMDA) (2021) Electric Mobility Barriers in Kenya: Market Survey Report 2021.

<sup>17</sup> 'Other appliances' include agro-processing machines, air conditioners, irons, hair clippers, stereos, sewing machines, egg incubators and other machinery.

<sup>18</sup> The CLASP (2020) Off-grid Appliance Market Survey Report highlighted the apparent disconnect between the perceived impact of larger appliances – SWP, mills, grain processors, food dryers and milk chillers – and persistently low sales. GOGLA

products. A recent study of the impacts of COVID in Kenya found that 17-18 per cent of the survey's respondents had lost jobs during the pandemic; between 30 and 40 per cent had reduced work; and women were eight per cent more likely than men not to have had work even prior to the crisis. Also, the number of Kenyans subject to food insecurity doubled.<sup>21</sup>

**The long-term impacts of lost livelihoods are not yet clear.** PUE products are thought to have highly elastic demand,<sup>22</sup> but sales in 2020 – at least of the most popular products – appear to have increased. Kenya has a critical mass of off-grid solar and PUE technology companies, mobile money users, lending innovators and solar-savvy customers that have for years made it a particularly interesting market, and perhaps resilient as well. Moreover, the extreme challenges posed by lockdowns and other restrictions have forced companies to digitise and innovate faster and more adeptly than they might otherwise have done.<sup>23</sup> If the business case for a PUE product is persuasive, and the financing is right, it may be an attractive consumer or small business investment.

## Other trends & observations

**Other items of note regarding PUE, as told by stakeholders, include:**

- **Companies taking a systems approach to their product offering.** Companies are increasingly looking to solve for more than one constraint in the value chain, for example, cold storage solutions for a farmer's 'first-mile' and also in transport goods to market.<sup>24</sup> Others are providing market linkages for clients.
- Momentum is growing for e-mobility, as a Kenyan company featured in National Geographic's October 2021 cover story which touts, 'The Revolution is Here.'
- **Diversity in farm needs makes scaling sales challenging.** Numbers are in the low thousands for the highest-selling appliances.<sup>25</sup>
- **Emergence from under the energy access umbrella.** The value proposition of PUE is fundamentally different to that of off-grid solar, so the sales pitch must be more sophisticated. A company needs dedicated staff with

technical skills on technology and/or agricultural processes.<sup>26</sup>

- **Because the sector is still relatively nascent, there are not many demonstrably investable businesses.** Many businesses are still reliant on grants. Investors want to see scale, successful exits and strong unit economics that are yet to be proven.<sup>27</sup>
- **Off-grid solar companies shifting gears.** Once off-grid solar companies focus on appliances, they need to also focus on business training, agriculture usage training, and market linkages to generate income.<sup>28</sup>
- **Reducing agricultural losses.** Crop wastage due to lack of adequate refrigeration infrastructure is prompting growing interest in first-mile cooling.<sup>29</sup>
- **Climate financing becomes more attractive.** Sector stakeholders see increased potential to link PUE to climate benefits (through reduced CO2) and, as such, to climate financing.<sup>30</sup>
- **Significant digitisation.** Companies have invested in digitisation to mitigate risk, automate and cope with COVID.<sup>31</sup>
- **A sense that the PUE sector has been too top-down.** 'People are obsessed with the technology and forget about the user.'<sup>32</sup>

## 2.3 Off-grid solar PUE value chains

This section looks at the three supply chains introduced above: **P&P kits, component-based systems and solar mini-grids.** It is helpful to consider their distinct features, while noting the over-arching challenge of a market defined by niche appliances. The financial and logistical challenges of importing and warehousing low-volume products point to an increasingly important role for partnerships along the entire supply chain – such as for bulk procurements, import, warehousing, distribution and after-sales – as companies consolidate or specialise.

### 2.3.1 Plug and play

**P&P PUE systems are manufactured and packaged as kits** in Asia where costs are low, factories and component supply chains are in place, and from where they can be easily shipped around the world. For these reasons, local manufacture is not easy. A few suppliers (e.g. M-KOPA) have used locally-made Solinc solar PV modules.

<sup>19</sup> KawiSafi and Acumen Capital Partners (2021) Community Report 2020.

<sup>20</sup> Interview with Sollatek.

**Import is costly for smaller and last-mile distribution companies.**<sup>33</sup> Some manufacturers (e.g. Omnivoltaic, Greenlight Planet) import and keep stock in Nairobi warehouses from which they wholesale to LMDs (e.g. Solibrium, Bidhaa Sasa). Distributors can buy from the warehouse or order directly from China at a slightly lower price, but the cost savings of buying in bulk directly from China may be outweighed by the hassle of importation.

Figure 8 depicts the basic features of P&P supply chains in Kenya.

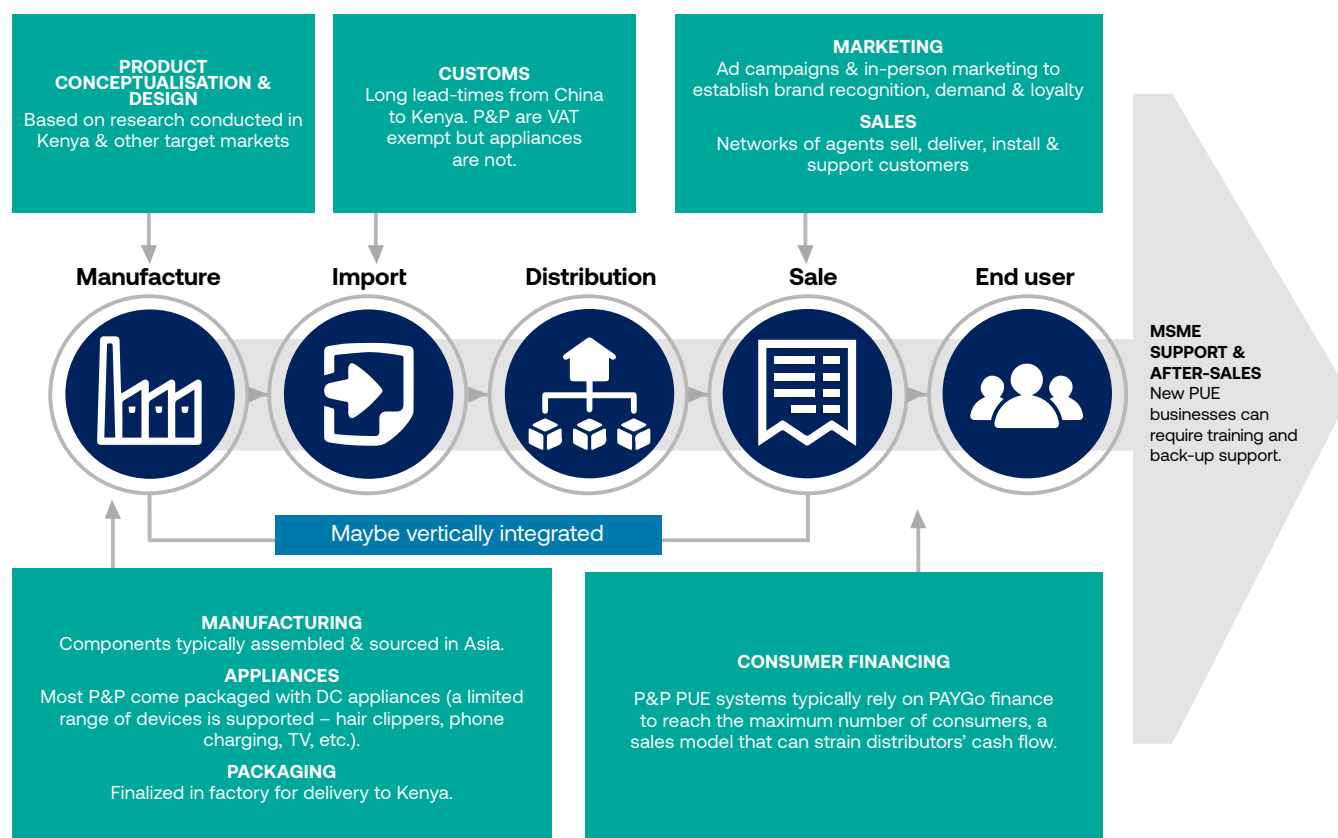


Figure 8: P&P solar PUE value chain.

**As these are 'consumer goods', manufacturers are targeting high-volume sales**, with distribution through retail outlets (hardware and electronics shops, supermarkets, petrol stations) and through networks of brand-employed or commission-based sales agents. Some distributors serve as agents for international brands (e.g. Mwezi for Rural Spark); others have arrangements for co-branding (e.g. SunTransfer and Omnivoltaic).

**PAYGo financing enables higher sales volumes and generates a valuable customer relationship** that is used to up-sell clients with more or larger appliances, either in-house or in partnership (e.g. OVO Solar selling through Mwezi – see Box 1). PAYGo has its upper limits, however, as higher-capacity, higher-value PUE appliances cost too much to be financed in-house.

*Most hatchery products are large-scale. OVO Solar has focused on developing lower-capacity incubators specifically for the off-grid market. The company hopes to leverage existing PAYGo markets, in a distribution partnership with Mwezi, with a product in the USD 250-300 range. It has produced a range of marketing and training materials, including 12 videos.*<sup>34</sup>

Box 1: OVO Solar.

**The quality-verified P&P PUE market is governed by international product standards**, as well as, to some extent, international business best practices expected or required by investors. Though field sales agents are trained, they may not be able to support customers on technicalities of appliance use. As most P&P appliances have little impact on agricultural production or processing, the value-

addition potential of P&P PUE for rural economies is fairly limited, though the solar supply chain does provide some direct and indirect employment.

### 2.3.2 Component-based solar PUE systems

**For the most part, there is little value generated for and by Kenyan PUE companies at the component manufacturing stage.** Exceptions include locally produced batteries (Chloride Exide) and PV modules (Solinc), though neither has a large market share. Small-scale agricultural inputs are designed ad hoc by the Jomo Kenyatta University of Agriculture and Technology (JKUAT).<sup>35</sup>

**Kenyan solar distribution networks are a web of partnerships** between manufacturers, importers, distributors, transporters, retailers and others. Suppliers sell directly to end users or through chains of middlemen, both solar specialist companies and over-the-counter wholesalers and traders who carry various hardware and electrical supply equipment. Where they can, companies sell in multiple ways: Sollatek, for example, distributes through Tuskys, Naivas, Chandarana and other supermarket chains; through electronics wholesalers and retailers; and direct to customers for whom they can even courier product via G4S or Wells Fargo.<sup>36</sup> But by and large, there is low visibility of non solar-specialist traders, and little information on their supply chain relationships, costs and margins, or technical capacities.<sup>37</sup>

**Component-based systems are designed to meet a client's need, and therefore assembled locally.** The quality of these thousands of individually designed systems is governed by technical certification requirements for technicians, though there are, anecdotally, deviations both positive

(highly skilled technicians that have not gotten certified) and – more commonly – negative (low-skilled technicians installing shoddy systems and/or defrauding their customers).

**Appliances may be stocked or sourced on demand** to meet clients' requests, and some suppliers are not involved in appliance sales to end users at all. The component-based PUE sector is ripe with niche opportunities, and because so much is imported, companies find it difficult to keep stock of low-volume appliances.<sup>38</sup> COVID- and Chinese New Year-related shutdowns in China have affected inventory in Kenya; the latter is easier to plan for but can still be disruptive.<sup>39</sup>

*"We employ a 'just in time' model, but it's difficult to project and we never want to miss an opportunity to provide a product to someone who wants to buy. We've had to hold off sales because of low inventory, or pay more in storage because of higher inventory."*  
- PUE company

**Taxation remains a vexing issue at customs despite various efforts to simplify procedures and lobby for tax relief.** A 2019 solar importation guide<sup>40</sup> was cited as helpful, and the July 2021 (re) exemption of some solar products (P&P kits and some components) from value added tax (VAT) has come as a welcome development to the sector. That said, a sizeable portion of the PUE market bears import duty and VAT costs. This, one stakeholder pointed out, is despite the latter requiring skilled Kenyan labour to assemble – unarguably a positive co-benefit.

<sup>21</sup> Fraym (2021) Kenya COVID-19 Pandemic Impact Response and Recovery Study.

<sup>22</sup> Interview with Shell Foundation.

<sup>23</sup> Interview with GDC.

<sup>24</sup> Interview with CLASP, EEP Africa (2020) 2020 Market Report: Productivity and Circularity in the Clean Energy Sector.

<sup>25</sup> Communication with Amiran, interview with CLASP.

<sup>26</sup> Interview with Bidhaa Sasa.

<sup>27</sup> Interview with Shell Foundation.

<sup>28</sup> Communications with Engie Mobisol, Equatorial Sunpower.

<sup>29</sup> Interviews with InspiraFarms, IFC, Astonfield.

<sup>30</sup> Interviews with CLASP, Shell Foundation.

<sup>31</sup> Communication with Solar Floppy, interview with GDC.

<sup>32</sup> Interviews with Bidhaa Sasa, Energy 4 Impact.

<sup>33</sup> The Global Distributors Collective is currently piloting a bulk procurement of solar lanterns and SHS where Sollatek will manage import and after-sales service on behalf of smaller companies that lack the capital to do so themselves. The goal is to test products in a 'sweet spot' between quality and price, as well as the relationship between the importer and LMDs. Though not specific to PUE, this could offer insights to a possible solution to challenges faced by less well-capitalised companies in meeting demand.



Figure 9 shows features of the component-based solar system value chain.

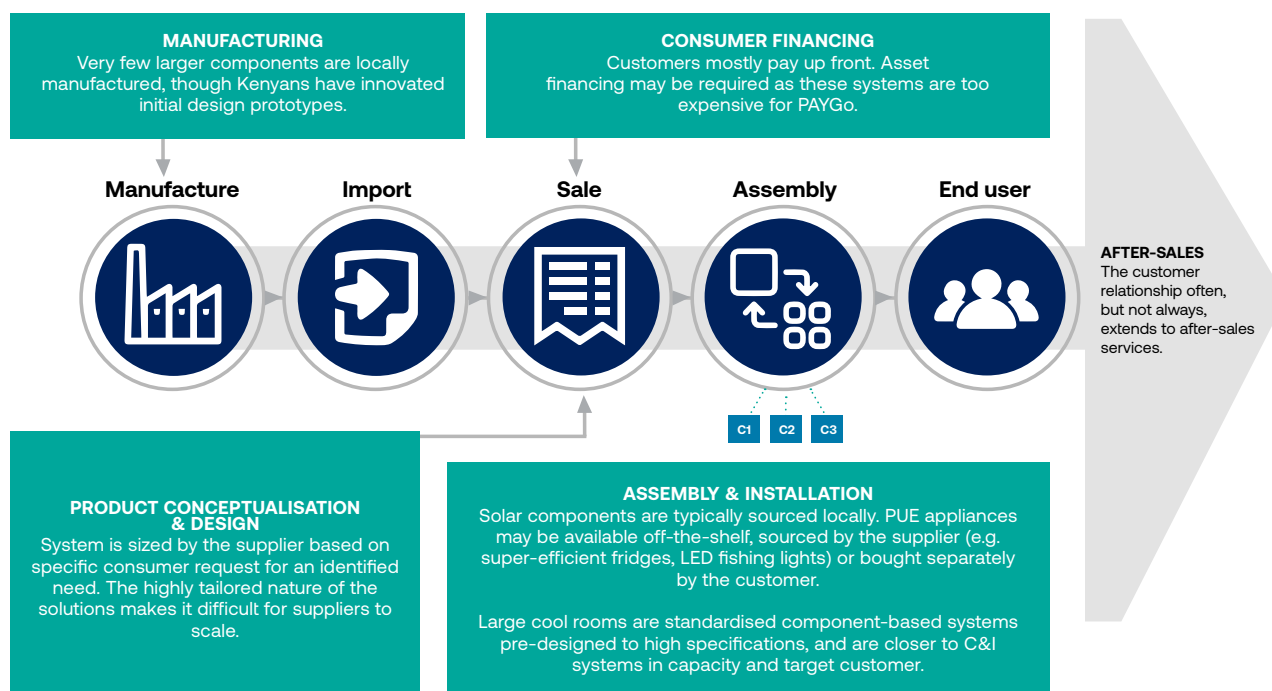


Figure 9: Component-based PUE value chain.

**SWP and irrigation systems form a large and varied sub-category unto themselves**, supplied by companies that tend to focus on pumping (e.g. FuturePump, SunCulture, Davis & Shirtliff). They are selling ‘appliance’ pumps to small-scale and individual customers and more sophisticated designed systems to businesses – with the attendant differences in supply channels. Even simpler SWP systems require a high level of technical understanding on the part of the sales agent, in assessing the site as well as communicating the difference between diesel pumping (deployed as needed) and solar (‘slow and steady’ and typically requiring water storage). The wide variability of customer situations and needs makes standardisation difficult.<sup>41</sup>

*InspiraFarms has been selling cool rooms primarily to mid- and large-scale commercial farms, powered by grid, genset or solar-hybrid electricity. With grant support from Carbon Trust and Shell Foundation, they’re currently piloting a smaller, off-grid, solar-powered ‘first-mile’ cooling room for small-scale farmers and cooperatives, typically produce outgrowers, to use in between the collection point and the centralised packshed. Their value proposition is reduced wastage and additional on-farm processing opportunities.*

Box 2: InspiraFarms.

Containerised component-based systems such as cool rooms (InspiraFarms) or centralised cooling-as-a-service facilities (SokoFresh) are pre-designed to high standards and assembled in Nairobi and onsite. These structures are naturally geared toward larger commercial or cooperative clients (who can afford them), or a service model (based on rental income). There has been a lull in the Kenyan ‘solar hub’ business model after Solar Kiosk’s bankruptcy; the only current examples are start-up Adili Solar Hubs, which is trialling a ‘cold hub’ in Turkana, and non-profit WE!Hub Victoria, which operates seven multi-function kiosks near Lake Victoria selling purified lake water and renting fishing lights and electric bikes (the latter for KES 300 per day).

**Component-based systems are more expensive, harder to finance and sell in much lower volumes than P&P systems.** Most are sold over-the-counter on a cash basis – too large for PAYGo and too small for business financing. Banks and micro-finance institutions (MFIs) lack the due diligence capacity to conduct smaller (USD 500-50,000) solar PUE system transactions, even though they can be shown to repay themselves.

**Technology and software innovations are reducing human error.** For example, soil and meteorologic sensors built into solar irrigation systems from Solar Floppy and SunCulture enable them to regulate water disbursement.<sup>42</sup> And digital credit risk-

assessment tools are being developed to help last-mile agents evaluate potential customers for product loans (not only in Kenya).<sup>43</sup>

### 2.3.3 Solar mini-grids

**Unlike P&P, which are fast-moving consumer goods, or component-based PUE, which are durable consumer goods, mini-grids are centralised infrastructure.** This report does not discuss their manufacturing, import and assembly other than to recognise the role of PUE as a consideration in site selection and financial modelling (see Figure 10). The mini-grid supply chain intersects appliance supply chains much farther downstream than smaller solar PUE do; sourcing and

financing of appliances are not core capacities of the mini-grid business but might evolve to be as the sector develops.

**Demand stimulation is crucial to mini-grid operators** as their business models rely on larger power users to assure revenue, yet micro-, small- and medium-sized enterprise (MSME) and household power usage is typically low. As owners of the customer relationship, with a view of clients' payment capacities and even standing in the community, the mini-grid operators have a valuable starting point to (up-)sell appliances to their customers.

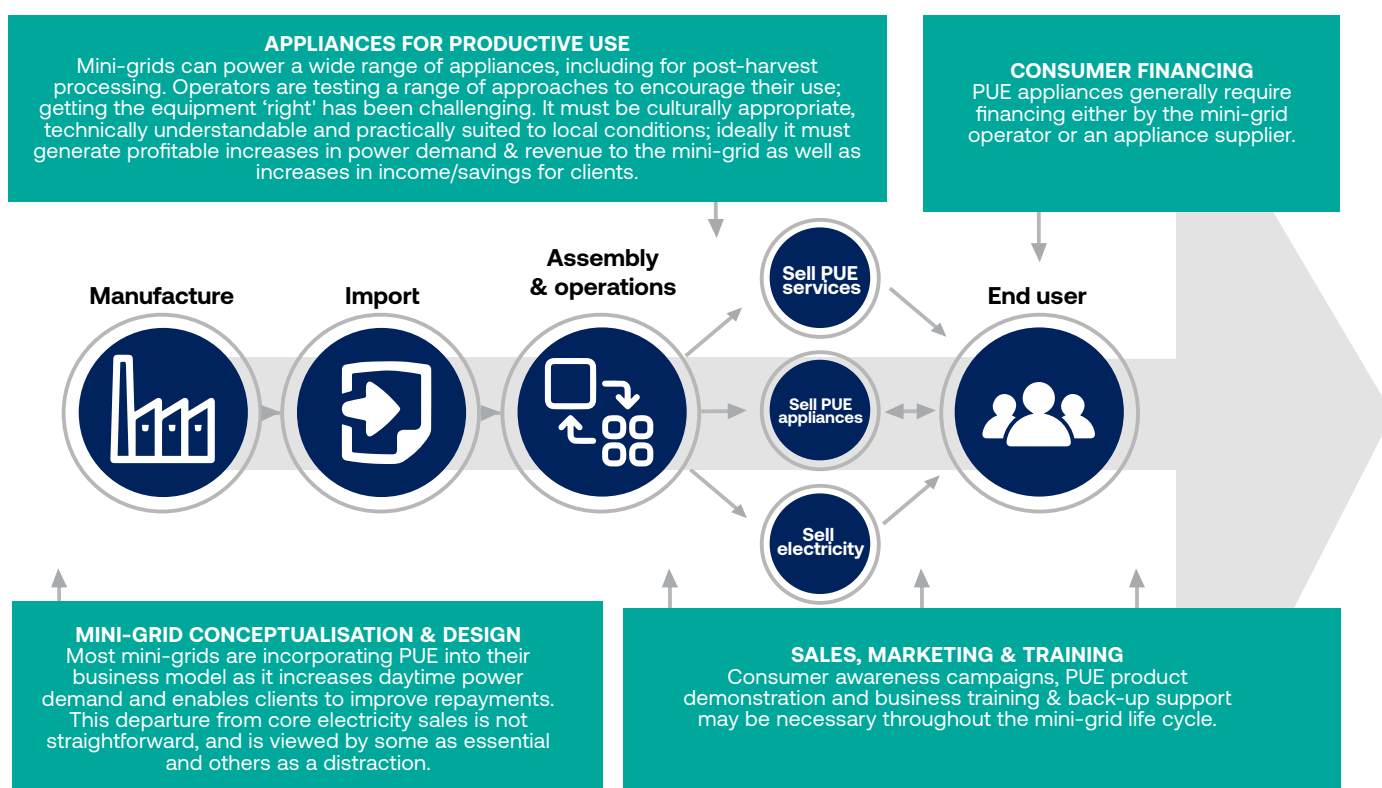


Figure 10: Mini-grid PUE value chain

Kenyan mini-grid operators are approaching PUE demand stimulation in various ways, with a range of grant-funded PUE product and business model testing currently underway (see Table 5).<sup>44</sup>

<sup>34</sup> Interview with OVO Solar.

<sup>35</sup> Interview with JKUAT.

<sup>36</sup> Interview with Sollatek.

<sup>37</sup> Several years ago, Lighting Global did a 'deep dive' of the Kenyan retail solar market. An effort along these lines, with expanded focus to include larger and PUE systems, would generate a valuable view of the market's size and depth.

<sup>38</sup> Interview with Mwezi.

<sup>39</sup> Interview with SunCulture.

<sup>40</sup> ACE TAF (2019) Importation Guidelines for Solar PV Products and Systems in Kenya.

<sup>41</sup> Communication with Equatorial Sunpower.

<sup>42</sup> Communication with Solar Floppy, SunCulture website.

<sup>43</sup> The second Global Distributors Collective Innovation Challenge is supporting winning companies in Zambia and Uganda, with their technology partners, to develop, respectively, a 'data-driven underwriting service' and digital tool to 'assess customer credit worthiness via savings groups'.

<sup>44</sup> The State of the Global Mini-grid Market Report 2020 also has a helpful discussion of business models, p. 116.

Table 5: Mini-grid PUE business models.

More involvement		←—————→			Less involvement	
Mini-grid facilitates market linkages or off-take of produced goods	Appliance owned and operated by mini-grid	Appliance procured and sold by mini-grid to its clients	Partnership between mini-grid and appliance supplier who sells to its clients	Power sales with little/no focus on PUE		
<p>Facilitating PUE is central to Powerhive’s model. It co-owns a poultry business, rents out hatcheries, is trialling a lease-to-own model for electric bodas and 3-wheelers (with grant funding), and is testing 10 electric Agsol posho mills (with support from the CrossBoundary Mini-grid Innovation Lab). For the poultry business, it has negotiated a chicken off-take arrangement with a large meat producer, and just commissioned a slaughterhouse.</p> <p>Is the future of mini-grids in whole supply chain stimulation? Not necessarily. Powerhive aims to spin these businesses off and retain them as energy clients.</p> <p>Powerhive also ran a pilot – incentivised by the Collaborative Labelling and Appliance Standards Program (CLASP) RBF – to sell electric pressure cookers to households that has been a modest success, both in customer interest and in creating a 20–30 per cent increase in household energy use. It found that 70 per cent of buyers used the cookers for home consumption and 30 per cent for micro-enterprises.</p>					<p>In Kenya, PowerGen sells grid electricity to end users for a customer management fee paid by Kenya Power. As it is not making money on kWh sales, there is no intention to develop PUE on these mini-grids.<sup>45</sup></p>	
<p>Of Kudura’s 11 sites in Busia county, Sidonge is a pilot site for PUE. The Sidonge mini-grid powers a business centre owned by Kudura. Shop owners pay rent to Kudura and are offered financed appliances for their business, such as a TV for the video hall, deep freezers for retail shops, equipment for a salon/kinyozi, and juicers and deep friers for making chips. The incremental increase in kWh usage is minimal.</p> <p>Another pilot for solar incubators ran into difficulties with the customers – who were not experienced chicken breeders – lacking the ability to identify fertilised eggs.</p>		<p>Renewvia remains focused on power sales. PUE facilitation ideas are still in an exploratory phase. They are speaking to companies offering electric boats, water purification, ice making and cassava milling products.</p> <p>With the exception of water purification, all PUE under consideration is based on a cost savings value proposition. For example, fishing communities are either not able to cool the fish or rely on highly costly and inefficient transport of ice from elsewhere.</p>				

Though it is too early to draw conclusions, stakeholders have offered the following observations:

- **The impact of PUE demand stimulation on electricity consumption and revenue is unclear.**

Typical household consumption is extremely low per connection. Initial data from the Green Mini-grids (GMG) Kenya Facility indicates that a grain mill can consume 50 times more daytime power than a typical customer, and an incubator or electric pressure cooker about 20 per cent more.<sup>46</sup> It appears that even with PUE activity, though, consumption is not increasing enough to make up for lower commercial tariffs offered to MSME clients.<sup>47</sup>

- **Appliance financing has been an awkward fit for mini-grid operators.** Currently, financing happens on the books, which is complicated administratively since repayments are billed separately to kWh payments. Options may be to

gather enough repayment data to entice MFIs to take up these loans in the future, or to develop software to enable mini-grids to manage asset financing in addition to power sales.<sup>48</sup>

- **To focus on power without close consideration of a farmer's (off-grid) water supply** may be 'putting the cart before the horse' in some cases,<sup>49</sup> as the business case for investing in post-harvest processing equipment relies upon optimised yields. This may call for mini-grids to pipe water themselves, or sell financed SWPs.

## 2.4 The PUE market (eco)system

### 2.4.1 PUE stakeholders

Alongside, and in support of, the main value chain actors, a host of other parties are at work in the PUE ecosystem.<sup>50</sup> Figure 11 shows key stakeholders, with further analysis following below.

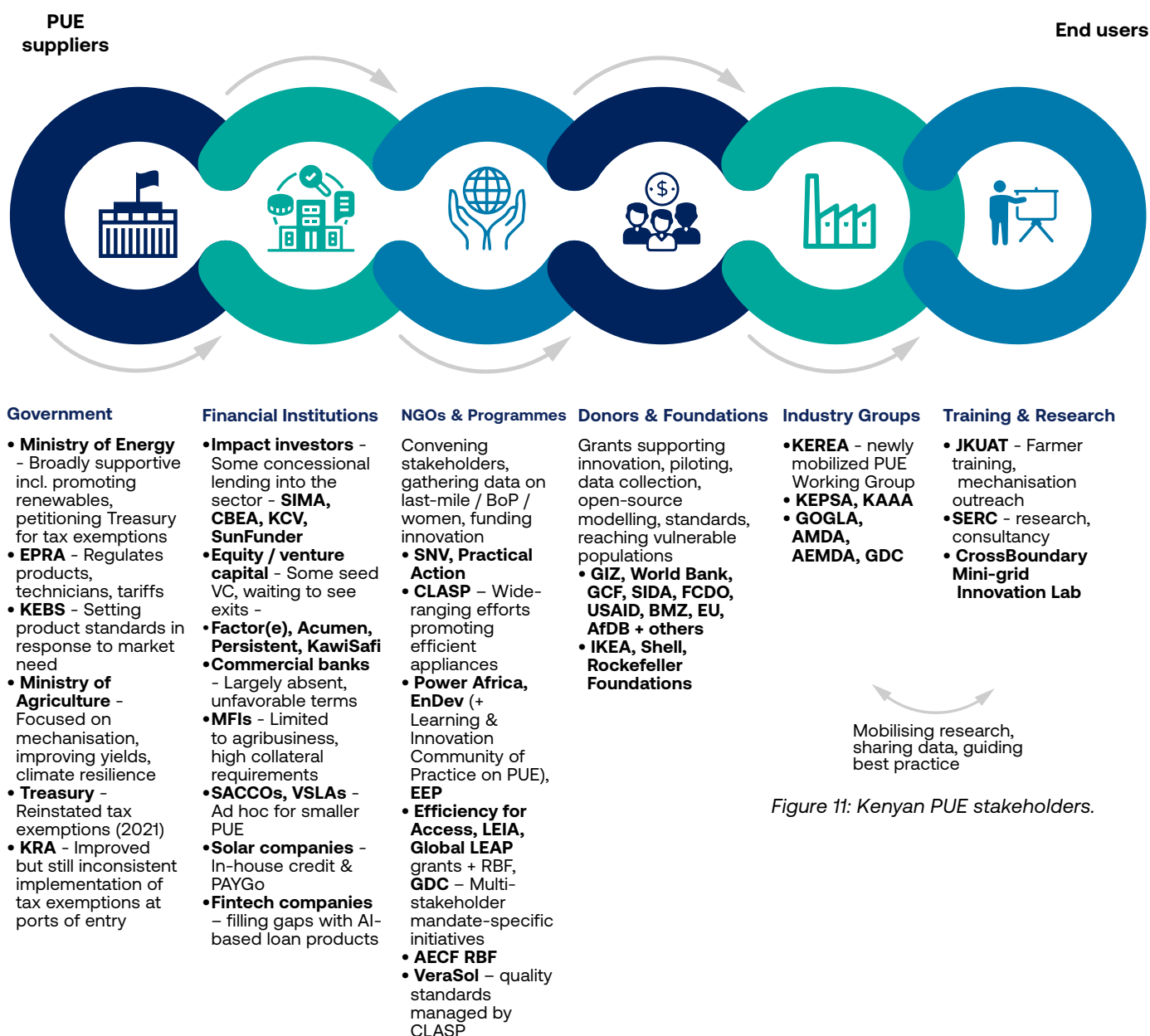


Figure 11: Kenyan PUE stakeholders.

## 2.4.2 PUE suppliers

There are about 100 companies that are active in the PUE space in Kenya (see Figure 12, and Annex 5.1 for a list. To note on Figures 8, 9 and 10: companies working with multiple types of systems are included in more than one count; the totals therefore exceed 100). They include manufacturers with product(s) in the market,<sup>51</sup> locally-based distributors selling to end users, and various actors in between. Seventeen per cent of component-based system suppliers and one-third of P&P suppliers are vertically integrated – that is, manufacturers who have direct engagement with end users (see Figure 13).

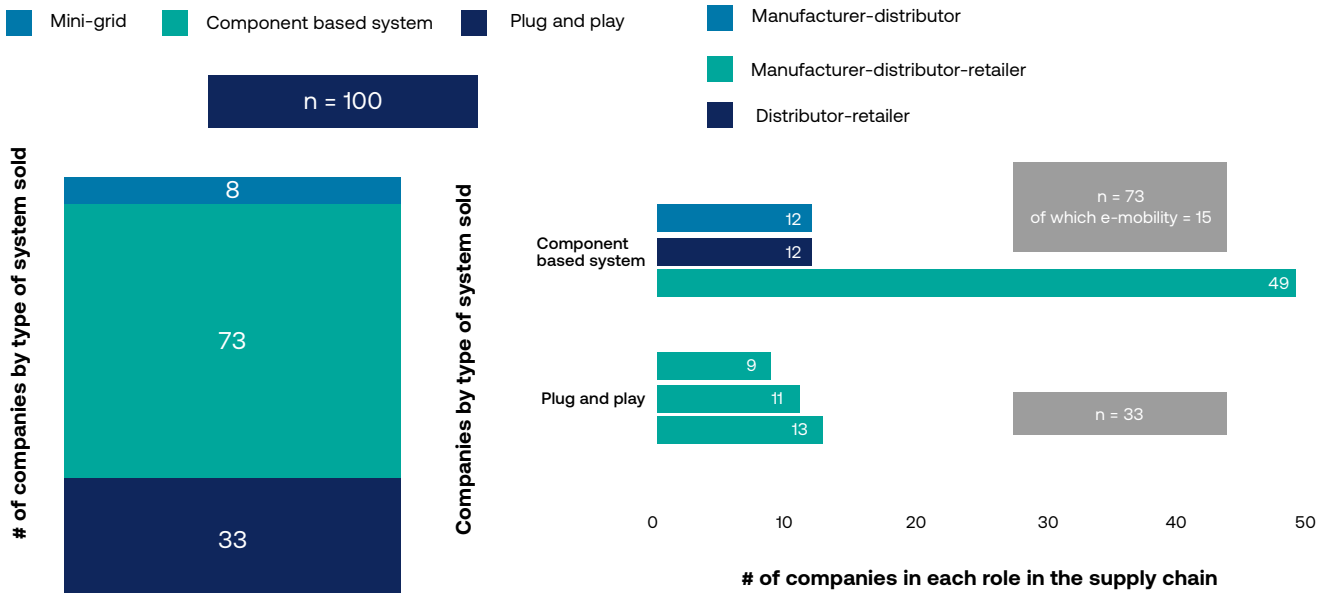


Figure 12: Companies by solar power system type.

Figure 13: Roles of companies in the PUE sector.

Eighty-two per cent of these companies are in some way involved in the SWP and irrigation, cooling (including refrigeration, ice-making and other cold chain) and e-mobility sectors (see Figure 14).

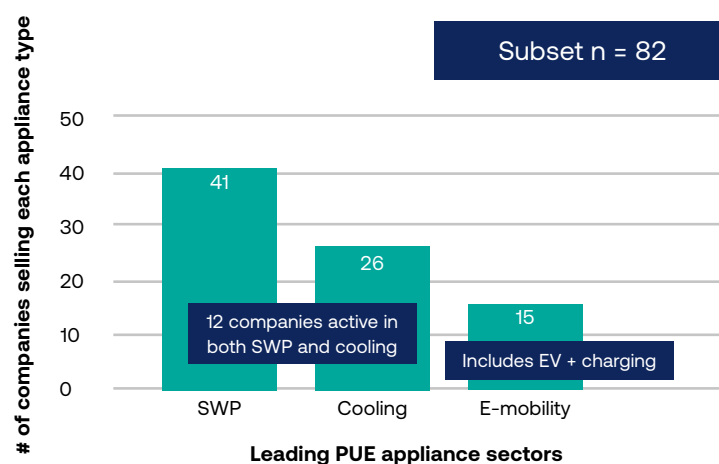


Figure 14: Subset of companies supplying major appliances.

<sup>45</sup> In other countries, PowerGen is sourcing and financing PUE equipment for its customers, typically a replacement of fuel-based appliances with electric, but with no intention of getting more deeply involved in the customers' businesses. These customers tend to numerate and can easily be persuaded of the cost savings of converting to electricity. PowerGen is less interested in household-based PUE, as it needs to deploy more units to see any real boost in revenue, which means more products that could need after-sales support.

<sup>46</sup> Green Mini Grid Facility (2021) Concept 1-Accelerating the Productive Use Ecosystem.

<sup>47</sup> Interview with CrossBoundary Mini-grid Innovation Lab.

KEREA member companies have recently formed a PUE Working Group that will look to engage the government, investors and development partners on issues of concern and interest to advancing the market.

### 2.4.3 End users

**Kenyan PUE customers have intersecting identities**, as appliance users at the end of the PUE value chain, as well as sellers and producers within other value chains, including those within agriculture, dairy/livestock/poultry, fisheries, small commerce, light industry and hospitality sub-sectors. As has been documented elsewhere,<sup>52</sup> the cost-benefit of PUE is highly context-dependent, not least because of the place- and gender-specificity of some value-add activities.

**As with SHSs, the PUE market is, to some extent, driven** by higher-income rural and peri-urban populations who have the ability to afford, and the appetite to take risks on, new technologies. These include grid-connected and grid-proximate customers using solar as a backup or replacement for Kenya Power. One dairy farmer in grid-connected, peri-urban Machakos estimates that more than half of the homes and businesses near him have solar of all sizes, including large systems.<sup>53</sup>

**Not all PUE appliances are used for income-generating use**, even the SWP. While a 2021 60 Decibels survey found that 93 per cent of SWP customers are using the product for irrigation or agriculture,<sup>54</sup> Davis & Shirtliff have noted that their SWP customers are predominantly government (50 per cent) and NGOs (20 per cent) whose water supply projects, though value adding, would not necessarily directly increase incomes. Of the remaining 30 per cent going to individuals or small businesses, about one-third are likely to be using the pump for non-agricultural purposes.<sup>55</sup> This may point to additional nuance in sales figures (that, though an

appliance may be 'productive', it is not always used as such), or, perhaps, in marketing strategy.

**Customers are earning money renting their PUE equipment to others.** This supplements existing income and boosts repayment capacity, particularly with larger and less-common appliances such as mobile water pumps or public address systems. The latter are currently in demand in the leadup to an election year, and can earn the owner many times the PAYGo repayment. It is unclear whether warranties cover a product used commercially and by others in this way.

### 2.4.4 Policy & regulatory environment

**PUE easily aligns to the goals laid out in Vision 2030 and the 2010 Constitution**, and a thriving sector would boost Kenya's progress toward the sustainable development goals.<sup>56</sup> Several ministries have overlapping interests in the sector's development, including energy, agriculture, economic development and environment. The latter oversees Kenya's climate change mitigation and adaptation plans, to which PUE can contribute through the replacement of diesel with solar, improved farming practices associated with solar irrigation, and diversification of income across various sub-sectors.

**The enabling environment is broadly conducive for PUE.** In practice, however, PUE policy is siloed within the energy and agriculture sectors, with little mention of it in major documents (with one important exception) and no cross-sector coordination. Non-agriculture PUE falls ostensibly under the Ministry of Industry, Trade and Economic Development (MoITED), which oversees MSMEs, but the topic of PUE generally goes unnoticed. Table 6 summarises the main stakeholders and strategic documents in the PUE space.

<sup>48</sup> Interview with CrossBoundary Mini-grid Innovation Lab, Factor(e) blog: Looking beyond appliances: Systemic barriers to mini-grid demand stimulation (September 2020).

<sup>49</sup> Communication with Yaron Cohen.

<sup>50</sup> Though not addressed in this report, we acknowledge intersecting value chains such as the transport sector or end-markets for fisheries, processed crops, dairy products, etc.

<sup>51</sup> The list of manufacturers was collected from KEREA, survey respondents and recent market assessments by AEMDA (e-mobility), and Power Africa (PUE). It focuses on agriculture and e-mobility, and therefore almost certainly omits some (possibly many) electric appliance manufacturers. It also includes four P&P companies selling small SHS but not a TV or larger appliance; they remain in the list in acknowledgment of the small-scale income generation possible through phone charging or value addition through solar-lit market kiosks.

<sup>52</sup> For example, in Lighting Global (2019), the market opportunity for productive use leveraging solar energy (PULSE) in Sub-Saharan Africa or NREL and Energy 4 Impact (2018) Productive use of energy in African mini-grids: Technical and business considerations.

## Institutional environment

Table 6: Government entities in the PUE space.

Government institution	Document	Comments
Ministry of Energy (MoE)	<p>National Energy Policy 2019</p> <p>Kenya National Electrification Strategy 2018 (KNES)</p> <p>National Energy Efficiency and Conservation Strategy 2020 (NEECS)</p>	<p>Existing relevant policy documents are mainly roadmaps and strategies to reaching universal energy access, among other objectives. The <b>Energy Policy</b> mentions stand-alone solar, as well as challenges facing energy efficient appliances such as lack of tax rebates, insufficient standards and low uptake, and a need to promote local manufacture. <b>KNES</b> recognises a role for stand-alone solar to electrify 1.9 million households by 2022. Neither document specifically mentions PUE.</p> <p>The <b>NEECS</b> is the main government document to address PUE. It promotes energy efficiency across five pillars which include agriculture and electric transport, offering a range of specific recommendations which include for the use of solar electricity. An Implementation Plan is awaiting signature by the Cabinet Secretary.</p>
Energy and Petroleum Regulatory Authority (EPRA)	Draft Energy (Solar PV Systems) Regulations 2020	EPRA regulates the off-grid solar and mini-grid sectors, including electric appliances and equipment. They enforce quality and minimum energy performance standards for P&P and designed solar PV systems;
Authority (EPRA)	<p>Energy (Appliances Energy Performance and Labelling) Regulations 2016</p> <p>Draft Energy (Mini-grid) Regulations 2021</p>	EPRA regulates the off-grid solar and mini-grid sectors, including electric appliances and equipment. They enforce quality and minimum energy performance standards for P&P and designed solar PV systems; certification of solar PV technicians. See Table 7 for more information.
Ministry of Agriculture (MoA)	<p>National Agricultural Mechanisation Policy 2021</p> <p>Draft National Mechanisation Bill 2021 and Draft National Mechanisation General Regulations 2021</p>	<p>The new policy, bill and draft regulations promote mechanisation of the sector. The policy has been approved and bill/regulations are in draft form pending approval.</p> <p>The policy promotes the use of equipment to intensify production, enhance value addition, reduce costs and reduce drudgery. It does not explicitly mention how the equipment should be powered, through there is acknowledgement that the government has the responsibility of promoting the use of renewable energy sources.</p> <p>The bill provides for the establishment of an Agricultural Mechanisation Board.</p>

Government institution	Document	Comments
	Irrigation Act No. 14 of 2019	The National Irrigation Authority was established as a successor to the National Irrigation Board. This act touches on community-based smallholder irrigation and drainage schemes, but not on the energy source to be used.
MoITED	<p>Micro and Small Enterprises Act 2012</p> <p>Micro and Small Enterprises Strategic Plan 2020–2024 – 3rd Draft</p>	<p>Both documents promote small industry, including manufacturing, agribusiness, trade and service sectors. The act mandates collaboration with relevant actors in Information and Communications Technology, Mining and Energy.</p> <p>The draft plan does not explicitly mention solar, but acknowledges renewable energy broadly with regards to sensitising MSMEs on its benefits.</p>
Kenya Bureau of Standards (KEBS)	Various standards (see Table 7)	<p>KEBS sits under MoITED. Its electrotechnical unit develops standards in cooperation with regulators from relevant line ministries. The KEBS mandate is to improve the quality of what is available in the market, protect consumer safety (&gt;35V on electric equipment), address market spoilage, and ensure that businesses are playing by the same rules. Its goal is to keep up with innovation but avoid stifling the market.</p> <p>In the energy sector, KEBS typically borrows from International Organisation for Standardisation (ISO) and International Electrotechnical Commission (IEC) standards. Some are formally adopted; others are adapted for Kenyan use. Developing and enforcing standards is resource intensive; for one to be developed, there needs to be a decent volume of product in the market and a determination of whether self-regulation by local companies could work in lieu of formal regulation.</p>

<sup>53</sup> Interview with Daniel Pakili.

<sup>54</sup> Efficiency for Access Coalition and 60 Decibels (2021) Uses & impacts of solar water pumps: Insights from Kenya, Rwanda, Senegal, Tanzania, Uganda, Zambia.

<sup>55</sup> Interview with Davis & Shirtliff.

<sup>56</sup> In particular, seven (affordable and clean energy) and eight (decent work and economic growth).



Government institution	Document	Comments
National Treasury	Finance Act 2021	<p>In 2020, the Treasury re-introduced 14 per cent VAT on solar equipment, including batteries. This increased to 16 per cent in January 2021, as the temporary COVID-related 2 per cent VAT relief expired. The most recent budget has reinstated VAT exemption, effective 1 July 2021, on ‘specialised equipment for the development and generation of solar... energy, including PV modules, DC charge controllers, DC inverters and deep cycle batteries that use or store solar power.’ This mirrors the language of import duty exemption in the East African Community Customs Management Act.</p>
Ministry of Environment and Forestry (MoEF)	<p>Updated Kenya Nationally Determined Contribution (NDC) 2020</p> <p>National Climate Change Action Plan (NCCAP) 2 (2018–2022)</p> <p>Draft Extended Producer Responsibility (EPR) Regulations 2021</p> <p>National E-Waste Management Strategy 2020</p>	<p>In 2020, Kenya submitted an updated <b>NDC</b> to the United Nations Framework Convention on Climate Change. The document outlines Kenya’s greenhouse gas mitigation plans and priorities, including renewables and energy efficiency, with no specific mention of PUE except ‘low carbon and efficient transport systems.’ Though it does not include specific transport-related mitigation targets, the NDC refers to the <b>NCCAP 2</b>, which mentions piloting electric vehicles as part of national greenhouse gas emissions reductions.<sup>57</sup></p> <p>The <b>Draft EPR</b> Regulations place responsibility on ‘producers’ – any entities introducing a product into the Kenyan market whether by manufacture or import – for the full life cycle of their products, including end of life disposal or recycling. Products regulated include batteries, electrical and electronic equipment, and vehicles. In June 2021, the MoEF launched the Kenya Extended Producer Responsibility Organization to accelerate the growth of Kenya’s recycling ecosystem.<sup>58</sup></p> <p>The <b>National E-Waste Management Strategy</b> is a five-year plan (2019/20 to 2023/24) that acknowledges both formal and informal e-waste; suggests incentives for waste electrical and electronic equipment refurbishment or takeback; and proposes data collection on waste flows.</p>

## Regulatory framework

The PUE space in Kenya is affected primarily by the following regulations in the energy sector (see Table 7):

- Quality or minimum performance standards for solar PV and appliances
- Certification requirements for solar technicians
- Tariff-setting rules for mini-grids
- Taxation of imported equipment

**There are no national standards for designed productive use applications, nor for DC appliances.** It is not a priority right now. Efficiency (minimum energy performance) standards exist for several appliances (see below). KEBS has received requests to develop standards for solar fridges (which, because the component parts are not new, will remain self-regulated) and solar thermal dryers. There are 21 standards in place for the electric mobility sector.<sup>59</sup>

VeraSol, an evolution of the Lighting Global Quality Assurance programme, plays a major role globally

in quality certification for the off-grid solar sector.<sup>60</sup> Both VeraSol and KEBS use the IEC TS 62257-9-8 standard for solar systems under 350W, so EPRA accepts VeraSol quality assurance certification in lieu of doing its own permitting for these products. VeraSol has also developed quality test methods for SWP and electric pressure cookers.<sup>61</sup>

Minimum energy performance standards enforcement is through:

- Approval and permitting of every product model, a requirement for import to Kenya
- Pre-Export Verification of Conformity managed by KEBS, which has agents in countries of origin who check compliance and EPRA permit prior to export
- Border checks to ensure goods meet standards, done online through approved importation permits
- Spot checks in the market, to check conformity to how standards compliance is displayed to customers – correct label, on correct appliance, displayed in the correct place
- Ad hoc lab testing in response to complaints of poor standard equipment (has not yet been necessary)

Table 7: PUE energy regulations.

Regulatory document	Technology/topic	Description/comments
Energy (Appliances Energy Performance and Labelling) Regulations 2016	Minimum energy performance standards (MEPS) for refrigerators, air conditioning, lighting, motors, (magnetic) ballasts	The regulations include six MEPS that are technology-specific. For lighting, for example, they are specific to fluorescent bulbs and LED bulbs. KEBS has more recently developed one MEPS for all lighting technologies (technology agnostic).  This revised lighting MEPS is one of three new standards approved but not yet enforced (the others are for LED TVs and computer monitors). To do so requires a regulatory impact assessment, consisting of a baseline study of existing appliance performance in the country, then simulation of the economic, social and environmental impacts of adopting the standards.
Draft Energy (Solar PV Systems) Regulations 2020: builds on the Energy-Solar PV Systems Regulations 2012)	Stand-alone solar	This is based on IEC TS IEC 62257-9-8 for <350Wp P&P systems and was gazetted in January 2021. It replaces the old KS 2542 standard. If a product is registered with VeraSol, no re-approval in Kenya is required.
	Solar technicians	This requires solar technicians to be certified. The 2020 draft proposes transitioning from the old certifications of Classes Technician (T) 1-3 to new categories Solar PV Worker 1-4. One feature of the shift is to amend the maximum permitted system size for T1 and T2 upwards, to reflect market changes.

Regulatory document	Technology/topic	Description/comments
		This also creates new classes for manufacturers, importers, vendors and contractors (from Classes Vendor (V) 1 and 2 and Contractor (C) 1 to Solar PV Contractor 1-4 and Solar PV Manufacturer) – with the idea of clarifying overlaps and confusion in the 2012 Regulations.
Draft Energy (Mini-grid) Regulations 2021	Mini-grids	The 2019 Energy Policy stipulated provisions for mini-grid regulations (Section 169), which are in advanced draft form. A final participatory public consultation was held in July 2021, and the provisions are expected to be gazetted. In the interim, the Energy Policy provides principles sufficient as guidelines for EPRA to act on.

**Of particular relevance for mini-grid PUE is end user tariff-setting.** EPRA reviews developers' tariff proposals alongside project financials, and approves cost-reflective tariffs on a case-by-case basis. Developers use different tariffs for their commercial and household customers (and may further tier each of these categories); approved tariffs are in the range of KES 50-100/kWh, which is high compared to grid rates but not necessarily enough to run a profitable business on.<sup>62</sup> EPRA is currently considering whether and how to account for PUE costs and revenues that accrue to the developer in the tariff calculation.

**Another discussion is around what happens when Kenya Power arrives with the grid.** Off-grid systems are seen by some stakeholders not as an end in themselves but, where possible, a means to generate a pocket of economic activity worth extending the grid to.<sup>63</sup> Though this would be far on the horizon, if at all, in this light the stimulation of PUE and income generation by the mini-grid could be seen as a long-term priority for the utility as well.

Table 8: Tax status of PUE components.

Product	Import duty	VAT
Solar home system	Exempt	Exempt
Solar home system appliance (TV, clippers)	Non-exempt	Non-exempt
Solar panel	Exempt	Exempt
Balance of system components (inverter, battery, charge controller)	Exempt	Exempt
Solar water pump	Non-exempt	Non-exempt
Electric mill	Exempt	Non-exempt
DC appliance	Non-exempt	Non-exempt
Refrigerator (efficient)	Non-exempt	Non-exempt

**PUE stakeholders appreciate the recent re-institution of VAT exemptions on solar panels and system components.** Earlier exemptions had been rescinded, then the government temporarily reduced VAT from 16 per cent to 14 per cent in reaction to COVID, and returned it to 16 per cent in early 2021. But as one stakeholder noted, it's one thing written down, another thing in practice.

**More specific to the productive use sector, the debate continues** over taxation of 'off-grid' (highly efficient) AC appliances that are meant for use with solar power but could also be used on the grid. For that matter, DC appliances still attract duty and tax. One interviewed company has been charged anywhere between 0 per cent (exempted) and 25 per cent on different consignments of a DC fridge. The private sector has long maintained that the additional costs, passed on to low-income customers whose demand for PUE products is highly elastic,<sup>64</sup> are a central obstacle to market growth. Undoubtedly, the unpredictability is destabilising as well. Table 8 summarises the current tax status of PUE products.

## 2.4.5 Financing

### Supply chain financing – commercial and non-commercial

**Kenyan solar PUE companies are financed by their own profits, grants, venture capital and impact debt.** The local banking sector is by and large absent from the scene (only 2 of 14 survey respondents had sourced a loan this way; see Figure 15). International investment goes to internationally-owned P&P manufacturers and mini-grids, while local retail suppliers of component-based systems typically operate without international visibility, with occasional access to grants (AECF, EEP) and, infrequently, supplier credit. They are squeezed between manufacturers who do not (or cannot) offer supplier credit and customers who struggle to afford the equipment.

**Investors are interested in the PUE sector but are still learning.**<sup>65</sup> A lack of scaling potential for expensive and/or niche products is a major constraint, and financiers may need to adapt their approaches, cluster opportunities or finance business models that effectively address these issues.

**Impact debt has been available** from SIMA Funds (senior debt to a range of Kenyan-headquartered

off-grid solar companies,<sup>66</sup> including LMD Deevabits<sup>67</sup>); the CrossBoundary Energy Access (CBEA) fund (blended finance to PowerGen<sup>68</sup>); Kenya Climate Ventures (debt, convertible debt and equity to early stage companies, including Sunken); and SunFunder (syndicated USD 11 million debt for SunCulture in 2020,<sup>69</sup> which structures the loan repayment over 30 months to mirror end users' repayment to the company). The newly launched USD 84 million Energy Access Relief Fund (managed by SIMA) will offer small (USD 50,000-2.5 million) loans on favourable terms to 90-100 companies facing COVID-related liquidity challenges.<sup>70</sup>

**The greater technical complexity, higher cost and limited market size for niche PUE applications, including those with most potential to add real value, are of little interest to equity investors.**<sup>71</sup> Some equity has been invested by Factor(e) (seed stage, including in InspiraFarms); Acumen (seed and early stage into various Kenyan companies<sup>72</sup>); Persistent (venture investments in Asobo and Ecobodaa); and KawiSafi (growth, including for the InspiraFarms 'Mobile First Mile Precooler'). The new Ascent Rift Valley Fund 2 will invest USD 100 million in East African small- and medium-sized enterprises (SMEs) across various sectors, including agro-processing, though its accessibility to smaller companies is unclear.

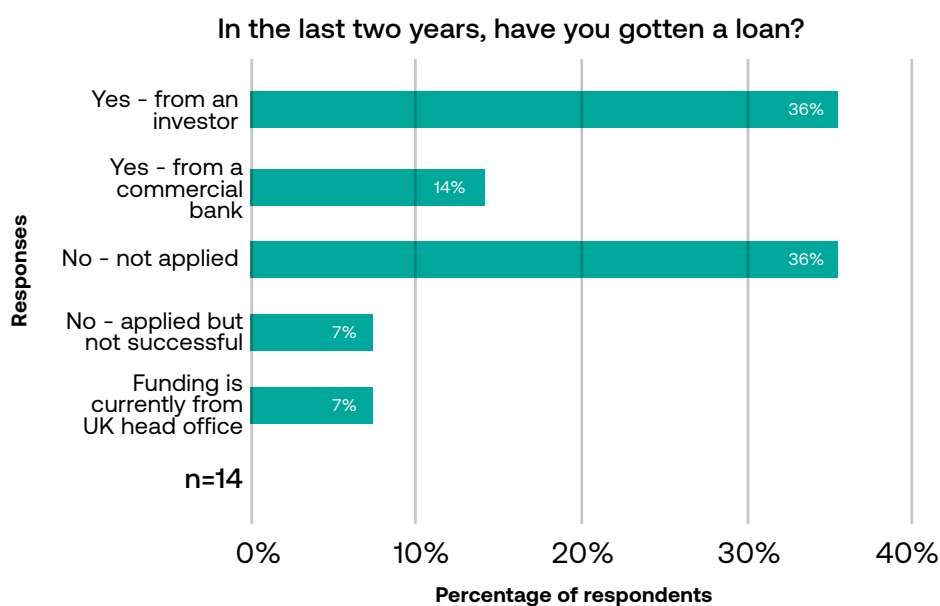


Figure 15: Survey responses re: access to finance.

<sup>67</sup> See <https://changing-transport.org/ndc-update-kenya/> for more details.

<sup>68</sup> <http://www.environment.go.ke/?p=8362>.

<sup>69</sup> <https://renewableenergy.go.ke/electric-mobility/>.

<sup>60</sup> In collaboration with VeraSol, Efficiency for Access has piloted a quality assurance framework for off-grid TVs and fans. While not specifically 'productive', these are relevant as part of a growing effort to protect off-grid consumers and quality product manufacturers.

<sup>61</sup> Test methods available for SWP here and electric pressure cookers here.

<sup>62</sup> GMG Facility Kenya.

**The investment context is evolving**, including through crowdfunding such as the Energise Africa platform,<sup>73</sup> and more flexible instruments such as from the new Energy Entrepreneurs Growth Fund, which is providing USD 1-10 million equity, mezzanine and/or debt finance to off-grid companies alongside targeted technical assistance (TA).<sup>74</sup> Still, many smaller entrepreneurs, LMDs and component suppliers are struggling to secure equity sufficient to finance a track record and to attract working capital loans.<sup>75 76</sup>

**In light of these challenges, many companies do not have the bandwidth or risk appetite to take big chances** without support. Much of the research and development in the PUE sector is currently grant-funded; organisations providing financial support to Kenyan PUE companies are noted in Table 9<sup>77</sup>:

*‘Compared to PAYGo solar volume, potential appliance demand is too small to justify commercial investment in new technology. We received a grant to develop our product.’ – PUE company*

Table 9: Grant funding to PUE companies.

Type of grant support	Organisations
Product/business model research and development  Proof of concept	<ul style="list-style-type: none"> <li>- CrossBoundary Mini-grid Innovation Lab – grants for mini-grid PUE product and business model testing</li> <li>- DOEN Foundation – grants (+debt/equity) for renewable energy and sustainable food, among other areas</li> <li>- Efficiency for Access design challenge [low energy inclusive appliances (LEIA)]</li> <li>- Global Distributors Collective (GDC) – GBP 50,000 innovation grants + TA</li> <li>- Kenya Climate Innovation Centre Greenbiz – competition funding innovative climate-smart businesses, including in renewable energy and agribusiness</li> <li>- Powering Renewable Energy Opportunities (PREO) – up to EUR 250,000 + TA for building PUE partnership models<sup>78</sup></li> <li>- Shell Foundation – support to various companies</li> </ul>
Scaling up/reaching new markets	<ul style="list-style-type: none"> <li>- Africa Enterprise Challenge Fund (AECF) RBF – 2021 awardees will likely include PUE companies</li> <li>- EEP Africa – innovation and catalyst windows offer grant and follow-on debt financing to awardees. Most recent call was in 2020.</li> <li>- EnDev with co-financing from IKEA Foundation – RBF, catalytic grants, innovation fund + TA to support innovative PUE business cases for irrigation, cooling and drying</li> <li>- Global LEAP RBF – incentives for SWP and fridge sales</li> <li>- Water for Energy and Food – innovation challenge (East Africa)</li> </ul>

**RBF has been welcomed but is not a panacea.** The Global LEAP RBF has driven SWP and refrigerator sales in Kenya in the last couple of years. That said, RBF is a tool to drive scale and may therefore not be the right approach for products not yet ready-for-market, for niche products selling low volumes, for companies targeting middle-class customers<sup>79</sup> and for companies lacking working capital. Companies have failed to meet their RBF sales goals, and some are not convinced it is worth the effort associated with reporting and verification.<sup>80</sup>

**Grants are not being used for direct end user subsidies.** SunCulture is working with BBOXX and the Government of Togo on a pilot to subsidise end user costs by 50 per cent; there is nothing of the kind in Kenya. End user subsidies should be treated with caution; in other countries, they have had mixed success, and can be highly disruptive if poorly designed. Furthermore, in Kenya, taxes can add 40 per cent to importers’ costs, which is reflected in consumer prices,<sup>81</sup> rendering subsidy an inefficient use of public funds. Though not Kenya-specific, an

upcoming handbook on smart PUE subsidy design from the International Finance Corporation (IFC) and the recent launch of the End User Subsidies Lab for off-grid solar products reflect recognition that well-designed subsidy may be a tool for bridging the affordability gap.<sup>82</sup>

## Consumer financing

*'The potential is enormous. We have USD 20 million in our sales pipeline, but our farmer clients lack finance.'* – Solar water pump supplier

**The Kenyan PUE market is driven by in-house consumer financing – and hindered by the lack thereof.** All but one survey respondent is offering some form of credit in-house, either on instalment terms or through PAYGo.<sup>83</sup> Several mini-grid developers are financing appliances. However, in-house credit is difficult to implement. In addition to affecting the company's cash flow, PAYGo for PUE is further complicated by the fact that locking the customer out of the appliance for non-payment shuts off their primary path to repayment.<sup>84</sup>

Additionally, there is a major financing gap for component-based systems, which to date have been too high-cost and low-volume to be suited to PAYGo, and too bespoke and risky for external financing. Large PAYGo companies are set up to finance thousands of USD 50-100 products but not hundreds of USD 1,000 products, the latter of which require extensive consumer interaction. The wide range of PUE equipment costs – from USD 500-50,000 – would seem to preclude generalising about financing, but consumer credit is consistently a challenge.

**There is little to no appetite from third-party lenders to finance PUE products on terms appropriate for the market.** From P&P to larger component-based systems, companies are offering lease-to-own and other credit options out of necessity.<sup>85</sup> This may be viable for larger-ticket items, the sale of which can justify a high transaction cost of vetting and managing a long-term loan relationship.<sup>86</sup> SunCulture offers Pay as You Grow financing over 15-30 months; InspiraFarms will sell its new off-grid cool rooms on an 'operating expenses' basis. Some are hoping that the consumer repayment data they have been collecting in these early years can help entice external funders into the sector.

**The IFC provided a USD 100 million subordinated loan to Equity Bank Kenya for on-lending** to SMEs in various sectors, and encouraged Equity to look at renewable energy and climate-smart agriculture as part of a 'building back greener' focus.<sup>87</sup> Several Kenyan PUE companies have talked to Equity about offering credit to their customers, but none has been successful.<sup>88</sup> This echoes slow disbursement rates from other on-lending facilities,<sup>89</sup> even with earmarked funds and TA, it is difficult to change or circumvent banks' deeply rooted risk aversity and lending criteria.

**Historically, attempts in Kenya to finance solar through MFIs have fallen flat,** despite their being theoretically well-positioned to finance PUE purchases in the USD 500-50,000 range. Multiple MFIs have failed in their solar offerings,<sup>90</sup> hindered both by terms that are broadly untenable<sup>91</sup> and by complicated logistics of coordinating with the solar company on pricing, distribution and after-sales support. Savings and Credit Cooperative Societies (SACCOs) are another possible avenue, close to their customers and with years of asset financing experience; their diversity and number, however, make scalable financing support a challenge. SACCOs are also more likely to be risk-averse in the current climate.

**Survey respondents say that end user finance is where support is needed most.**<sup>92</sup> There is a need to bridge the gap between in-house consumer lending that strains companies' working capital and the prohibitive terms available from financial institutions.

**Some solutions may emerge from the Kenyan digital finance space,**<sup>93</sup> which has more than 120 digital lending platforms<sup>94</sup> issuing loans valued at approximately KES 2 billion (USD 18 million) per month.<sup>95</sup> The sector has come under criticism for 'predatory' practices, including extremely high interest rates;<sup>96</sup> the 2020 amendment to the Central Bank of Kenya Act covering digital lending has been strengthened as recently as July 2021 to require additional disclosure by digital lenders.<sup>97</sup> But there is scope for optimism. Nairobi start-up Kwara, for example, hosts more than 20 SACCOs on its secure banking platform, digitising its operations and streamlining credit referencing, among other tasks. Another newcomer, Apollo Agriculture, is providing working capital loans to farmers for small-scale productive equipment, among other inputs. By the time of its USD 6 million Series A round in 2020, Apollo had 40,000 farmers on its books.<sup>98</sup>

**Others are hoping to generate learnings on PUE credit options.** CrossBoundary Mini-grid Innovation Labs are supporting research on asset financing, and Amiran partnered with Shell Foundation in 2019 to test in-house credit approaches for equipment in the USD 2,000-5,000 range, which generated insights including the need for sound economic modelling for credit structuring and risk mitigation through insurance.<sup>99</sup> For larger-ticket PUE investments, there may be a case for a specialist financier to emerge to serve the sector.<sup>100</sup>

In the meantime, Kenyan companies and development partners are finding ways to de-risk consumer financing, including:

- Automation that mitigates user error or increases productivity (e.g. water, soil and leaf movement sensors)<sup>101</sup>

- Digitised credit risk assessment that mitigates sales agent error<sup>102</sup>
- Micro-insurance (e.g. internet of things connected crop insurance)<sup>103</sup>
- Collection of user repayment data over time (e.g. Pawame is piloting proprietary software to monitor PAYGo repayments that tracks creditworthiness and provides mobile agricultural data services)<sup>104</sup>
- Companies (e.g. Amiran, Equatorial Sunpower) are offering their customers training on the business use of PUE products, with a view to boosting customer revenues and thereby repayment rates

## 2.4.6 Training and research

Within the country, there are several institutions building the solar PUE knowledge base (see Table 10).

Table 10: PUE training and research activities.

Institution	Comments
JKUAT	JKUAT is the premier engineering college in Kenya. It can modify agricultural equipment to suit local conditions or needs, particularly to mechanise what is currently done manually. This is done ad hoc, on request from a group of farmers, and typically donor-funded. To date, there has not been much work on the solarisation of agricultural technologies.
Strathmore Energy Research Centre (SERC)	<p>SERC does PUE product testing, standards development, research and consultancy. Its solar testing lab, though not accredited with Lighting Global, is fully operational, and lab staff are involved in international and national standards discussions, including with ISO, IEC, AFSEC, E4A, LEAP and CLASP. SERC is fielding requests from companies looking to pilot solar mills, driers, water purification systems and electric pressure cookers – currently, it is working with a German university and manufacturer, Phaesun, to pilot the SureChill solar cooling equipment, and is hosting the e-mobility company Solar E-cycles, which is piloting solar-powered tricycles.</p> <p>A study on PUE projects in Kenya, in collaboration with Strathclyde University (UK) and a Malawi university, will be published in late 2021. The SERC team is also developing a solar refrigeration and cooling course, as part of its ongoing capacity-building mandate.</p>

<p>CrossBoundary Mini-grid Innovation Lab</p>	<p>Funded by the Rockefeller Foundation, Carbon Foundation, Shell Foundation and Partnership for Growth, the Lab is working with developers to design and test prototype business model improvements, including appliance financing. These are grants to purchase and offer appliances to customers on financing terms calculated with TA from the Lab. In return, they share data on repayment/default rate, consumption and revenue per user.</p> <p>The Lab is currently preparing a report on whether increases in power consumption from PUE are profitable for the consumer and for the operator.</p>
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<sup>63</sup> Interview with KEPSA.

<sup>64</sup> Interview with Shell Foundation.

<sup>65</sup> The Efficiency for Access Investor Network may well generate some ideas, as a forum for more than 30 impact investors interested in learning more about the PUE space.

<sup>66</sup> SIMA has invested in Greenlight Planet, SolarNow, BBOX, d.light, MKopa, Azuri, Solargen and Pawame.

<sup>67</sup> <https://www.angaza.com/2020/10/13/sima-angaza-distributor-finance-fund-announces-first-three-investments/>.

<sup>68</sup> CBEA have open-sourced their mini-grid financing approach.

<sup>69</sup> SunFunder (2020) Annual Review 2020.

<sup>70</sup> <https://simafunds.com/fund-management/earf/>.

<sup>71</sup> Communication with Yaron Cohen.

<sup>72</sup> Acumen's portfolio includes Juhudi Kilimo, Solaris Off-grid, RVE.Sol, SolarNow and PowerGen.

<sup>73</sup> Azuri, BBOX, SolarNow, Sollatek, SunTransfer as of January 2020, as noted in the Energise Africa Investment & Impact Report (May 2020).

<sup>74</sup> <https://triplejump.eu/fund/eegf/>.

<sup>75</sup> GDC (2021) The growth and fundraising journeys of LMDs. Analysis includes four Kenyan companies selling smaller PUE: Bidhaa Sasa, Mwezi, Pawame and Solibrium.

<sup>76</sup> GMG Facility (2021) Concept 1: Accelerating the Productive Use Ecosystem. The GMG Kenya Facility has noted that while impact investors are offering increasingly helpful capital + TA packages, their investment criteria still leave many PUE companies behind.

<sup>77</sup> See Annex 2 for more information on donor programmes, including those focused on TA or other non-financial support.

<sup>78</sup> GMG (2021) Concept 1-Accelerating the Productive Use Ecosystem.

<sup>79</sup> For example, companies in the Global LEAP SWP RBF are serving a relatively wealthier customer base than the Kenya national average, per Efficiency for Access Coalition & 60 Decibels (2021).

<sup>80</sup> Draws on comments from several stakeholders.

<sup>81</sup> One Kenyan PUE supplier regularly reprices their products to reflect specific shipment costs. On pre-orders or PAYGo sales, companies may absorb both upward and downward cost fluctuations; how this factors into product pricing over time is difficult to tell.

<sup>82</sup> IFC anticipates the release of its study, undertaken by Dalberg, in late 2021. The End User Subsidies Lab is a collaboration between GOGLA, ESMAP/ Lighting Global and the ACE TAF.

<sup>83</sup> Sollatek does not offer credit but occasionally allows individual clients to pay by layby, whereby they make instalment payments and take the product home once fully paid.

<sup>84</sup> Interview with Shell Foundation.

<sup>85</sup> Interview with SunCulture.

<sup>86</sup> Amiran (2020) Piloting a new approach to agricultural credit for productive use assets – learnings from Amiran Kenya – Project Madaraka.

<sup>87</sup> IFC Supports Equity Bank's Plans to Grow SME and Climate Finance Lending in Kenya (4 April 2019).

<sup>88</sup> Interview with IFC, communication with Solar Floppy.

<sup>89</sup> For example, AFD's SUNREF credit line.

<sup>90</sup> Communication with Eliza Hogan.

<sup>91</sup> 100 per cent + collateral requirements, tenors under 12 months, and interest rates up to 30 per cent annually.

<sup>92</sup> Feedback from this research, as well as from the recently published SWP consumer report from the Energy for Access Coalition and 60 Decibels (2021).

<sup>93</sup> <https://www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market#>.

<sup>94</sup> Geopoll (2019) Case study: Digital lending grows in popularity in Kenya.

<sup>95</sup> Business Daily (9 March 2021) Digital lending space ripe for firm regulation.

<sup>96</sup> Quartz Africa (2021) Kenya is preparing to crack down on flood of high-interest loan apps.

<sup>97</sup> Bloomberg (13 July 2021) Kenya Central Bank seeks 'teeth' to regulate digital lenders.

<sup>98</sup> <https://techpoint.africa/2020/07/27/apollo-agriculture-feature/>.

<sup>99</sup> Shell Foundation (2020) Piloting a new approach to agricultural credit for productive use assets.

<sup>100</sup> Communication with Yaron Cohen.

<sup>101</sup> Communication with Solar Floppy, SunCulture website.

<sup>102</sup> The second Global Distributors Collective Innovation Challenge is supporting winning companies in Zambia and Uganda, with their technology partners, to develop, respectively, a 'data-driven underwriting service' and digital tool to 'assess customer credit worthiness via savings groups'.

<sup>103</sup> Communication with Solar Floppy.

<sup>104</sup> EEP Africa (2020).







### 3 Discussion: opportunities and barriers in the Kenyan PUE space

Policy makers will need to show proactive support to a population reeling from COVID-related uncertainty, restrictions and job losses. The unemployment rate, at 9%, remains five percentage points above pre-pandemic (late 2019) levels.<sup>106</sup> These issues notwithstanding, by early 2021 the economy was showing signs of recovery, bolstered by good harvests, rising export demand and remittances. And over the next several years one million youth are set to join the Kenyan labour force annually, posing a historic opportunity to reap a ‘demographic dividend’ – if the jobs market can keep up.<sup>107</sup>

**This is a strategic moment to invest in high-potential PUE interventions.** The section below offers a brief analysis of opportunities and challenges in the sector, with recommendations following in Section 4.

Figure 17 shows survey respondents’ challenges and priorities in their own words.

*What challenges are you facing? “Low awareness.” “Uncertainty around long-term impacts of COVID on economic standing of our customers on PAYG.” “Finance.” “Working capital.” “Reduced payback rate by farmers due to COVID economic impact.” “Change in government regulation.” “Duties and VAT add considerable cost to the end user price.”*

*What factors are helping the PUE market grow in Kenya? “Finance, finance, finance.” “Awareness is high and demand is high.” “Growing awareness.”*

What support would most help the PUE market grow in Kenya?

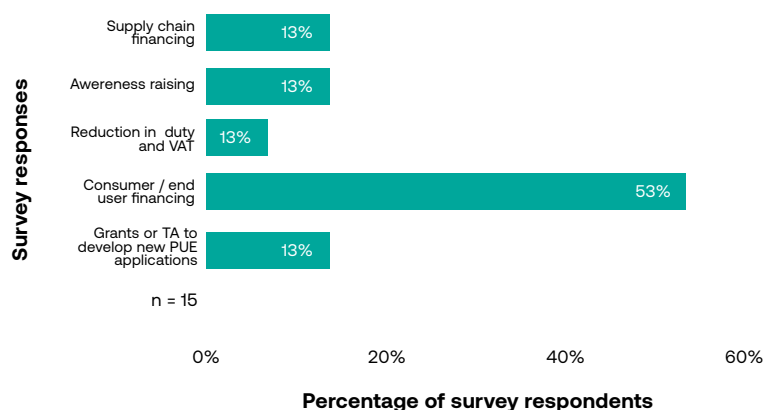


Figure 16: Responses from survey participants re. support needs

### 3.1 Emerging opportunities

This section highlights opportunities for PUE companies to reach more customers sustainably and profitably, and for government, investors and development partners to help.

**Electric appliances are improving and making their way to market.**

**SWPs and irrigation systems have considerable potential in Kenya**, as farmers look to replace diesel pumps or invest for the first time as a means of reducing dependence on increasingly less predictable rains. The current addressable market could be greater than 400,000, with potential to triple by 2030. SWPs are the focus of support efforts by Efficiency for Access and LEIA (among others), the latter of which convenes a technical working group that has updated the minimum performance testing method alongside a raft of other product development support. The market is not without its challenges, of course; the lack of homogeneity among SWP end users precludes standardisation, adds costs for suppliers and renders financing difficult. Over-abstraction of groundwater resources is also a real concern. However, the sector is growing.

**With more than 100,000 motorcycle taxis in Nairobi alone, an estimated 60 per cent cost savings over petrol through switching to electric, and a surge in new companies entering the mix, e-mobility is gaining early traction** with local mini-grid operators financing 2-wheelers to their clients and the government of Kenya including electric transport in its NDCs. EEP Africa saw a 'significant increase' in funding applications related to e-mobility in 2020. Opibus is featured in National Geographic's October 2021 cover study titled 'The Revolution is Here'; it is among 14 electric vehicle companies that participated in a recent Kenyan market survey commissioned by the Association of Electric Mobility Developers of Africa (AEMDA). At the moment, there is no standardisation of batteries or charging apparatus, each of which is vendor-specific, though for e-bodas this is surmountable with adapters. Other obstacles include a lack of trained technicians and asset financing. However, as a 'horizon' technology, these challenges are to be expected. Anticipating a proliferation of batteries, companies should take EPR guidelines seriously from the start.

**The off-grid cold chain is productive across sub-sectors.** Off-grid refrigerator brands – both AC and DC – have changed and grown in number considerably in the last five years, from primarily being used in vaccine storage to designs suitable for household and MSME customers. Their potential in the small-scale dairy value chain, where 25 per cent of milk is wasted, could be significant. More broadly, a recent unpublished study of customers in the Global LEAP RBF programme indicated a 2.5 times increase in income from using a fridge. Uses in the restaurant and small commerce sectors are also attractive, and larger cool rooms are targeting reductions in agricultural losses.

**Business models are evolving rapidly, spurred by grant funding, data and COVID realities.**

**Improved business practices as a consequence of the COVID pandemic** are moving companies toward levels of sophistication and evidence-based decision-making that will enhance their attractiveness to investors. COVID has generated a flurry of innovations in business efficiency (to cope with working capital constraints), digitalisation (to cope with travel restrictions), partnerships (to reach new customers more efficiently), and credit (to cope with reduced consumer ability to pay). Some of these COVID-related measures may become standard practice as life returns to normal (e.g. remote customer engagement in support of in-person).

**Before and beyond the impacts of COVID, technology and software innovations are reducing friction in market operations.** This includes automation and digitisation to reduce human error, mitigate lending risk, ease the conversion from fuel power to electric, facilitate field staff management and standardise credit risk assessments, among other things.

**Kenyan PUE companies are testing 'systems' approaches** to either their business model (vertically integrated in-house manufacturing, consumer financing, distribution, marketing, etc.) or their market value proposition ('horizontally' solving for more than one part of the target market value chain).

Vertical integration comes with a range of benefits, including ownership of the customer relationship and valuable data collection, but also drawbacks, including substantial strain on a company's cash

flow, particularly as high-priced products (such as PUE appliances) require a multi-year loan to customers.

By horizontally solving for multiple needs of their customers at once, a number of Kenyan companies amplify benefits throughout the customer's business. Examples include Powerhive directly supporting a poultry business for its clients and also facilitating end markets for the birds, and Raino Tech4Impact offering cold storage plus cold transport. It is not yet clear where the trend is heading; some companies may diversify their offering while others may specialise (and partner) as the market grows.

**There is unrealised potential for cross-marketing and distribution through existing hardware, fast moving consumer good, electronics and agribusiness supply chains.** For example, out of 32 Kenyan LMDs who are members of the GDC, 11 sell solar PUE and 11 sell agricultural equipment, but the overlap is only five that sell both. These six agricultural equipment LMDs may be just the tip of the iceberg when it comes to alternative avenues for solar PUE companies.

**Service and rental models are becoming interesting (again)** in light of high equipment costs, indeed following global trends on sharing and rental economies. Portable battery-charged products may be rented out, or a semi-permanent and centrally located system can offer energy-based services such as cooling or water purification. SokoFresh is selling cooling-as-a-service, Asobo is selling propulsion as a service, and mini-grids are experimenting with lease-to-own equipment sales and power-based service models (such as e-bodas). Looking beyond Kenya, Ugandan PUE company Bodawerk is developing an AgrE-Hub that will rent out e-tractors, batteries and farm implements charged on a solar DC mini-grid.

**As customers take up new PUE activities, companies are providing additional training.** With P&P appliances available on PAYGo, some end users are making opportunistic decisions to start new income generating activities – without knowing how to earn money, per se. The onus is on the company, at their cost, to provide business or technical skills training to optimise value addition of their customer's

investment.

**Momentum on financing is slow but growing.**

**Support in bridging the supply chain financing gap is underway** and should continue. A number of investors (e.g. SunFunder), consulting firms (Open Capital, I-DEV) and donor programmes (PFAN, GET. Invest, Power Africa) have provided direct support to PUE companies to improve their investment readiness. The Efficiency for Access Investor Network is convening investors interested in learning more, and GDC recently published an analysis on LMD financing challenges that identifies specific leverage points.

**The PUE sector is increasingly well-positioned to access climate and/or carbon finance,**<sup>129</sup> for example, for displacement of polluting fuel-based power sources and transitioning from diesel-powered 'flood' irrigation to solar-powered drip irrigation practices.<sup>130</sup> As climate change mitigation gains urgency, the environmental benefits of solar PUE may be monetisable. In order for carbon finance to be used in the sector, there would need to be mechanisms for aggregating sufficient volumes of carbon savings to justify transaction costs.

**PUE design slowly taking into account role of women.**

The 2020 Off-grid Appliance Market Survey<sup>131</sup> found that refrigerators and SWPs are perceived to be 'most impactful' for women, alongside electric sewing machines – rankings that reflect assumptions that women's commercial activity follows similar patterns to their domestic roles.<sup>132</sup>

However, some PUE designs remain focused on men. Existing fuel-powered mills in Kenya, for example, tend to be stand-alone and male-operated. But the micro-mills now being trialled on some mini-grids are physically and socially operable by women. 5 Changes in the aesthetics of machinery (from 'noisy fuel' to 'silent electric'), their venue (in the home or in a central meeting place), the availability of financed products, or even 'female-centred design'<sup>6</sup> that takes into accounts women's smaller hands or different daily usage patterns, are worth a deeper dive.

<sup>105</sup> World Bank (June 2021) Kenya Economic Update: Rising above the waves.

<sup>106</sup> Ibid.

<sup>107</sup> These figures estimated based on the 2019 Efficiency for Access SWP Outlook, which estimated a 2019 addressable market across sub-Saharan Africa (SSA) of 700,000 with potential to grow to 2.8 million by 2030; and data from GOGLA indicating that between 2018 and 2020 sales of SWPs in Kenya represented 60 per cent of all reported sales in SSA.

<sup>108</sup> Interview with LEIA. The SWP Working Group is also collecting field data on pumps in Kenya, Tanzania and Senegal; interviewing smallholder farmers in Kenya and five other countries; and much more.

### **The sector is ready for a champion.**

**Senior sector leaders<sup>136</sup> are calling for a convening of stakeholders** and an identification of a solar PUE ‘champion’ to move the market forward. The Ministry of Agriculture is eager to engage energy stakeholders, and the Ministry of Energy would be a natural actor to coordinate a cross-sector forum in which this champion could be identified. These ideas are echoed by members of the KEREPA PUE working group and the Kenya Private Sector Alliance KEPSA leadership. Development partners should offer strategic support.

## **3.2 Barriers**

### **Affordability will remain a crucial challenge, and consumer finance options are currently limited.**

**The impacts of COVID have been devastating on end users’ incomes and employment.** The ability of low- or irregular-income families and microenterprises to absorb up-front costs in exchange for longer-term savings or potentially uncertain revenue is likely to be severely curtailed. Even in normal times, ‘small-scale farmers tend to be risk-averse, even to the extent of not adopting the technological advances that could significantly improve incomes.’<sup>137</sup>

**Consumer financing options are available, but limited in reach or by terms that are difficult for potential customers to afford.** Appliance financing is being offered by mini-grid operators, though whether this will remain part of a successful business model remains to be seen. Micro-finance or shop credit is available to buyers of component-based systems on an ad hoc basis. PAYGo has many benefits, but whereas M-KOPA began as a micro-lender, this is not a role other solar companies necessarily want or can manage – particularly sellers of expensive component-based systems. Modifications to the PAYGo model that might benefit the customer – for example, extending a repayment grace period so that new customers have time to develop a cash flow<sup>138</sup> – would require suppliers to have financial support to manage in the interim.

**With MFIs largely out of the picture, there is a major gap to be filled.** New ideas are needed. Kenyan fintech companies are targeting smallholders with micro-loans that look promising. However, for larger-ticket, bespoke systems, ‘nobody has cracked

asset financing for the sector<sup>139</sup> – yet. To catalyse the market, a dedicated asset financing vehicle is needed.<sup>140</sup> NGOs and development partners could support with vetted local technical teams to assure system quality. The often-cited example of cooperative-based rural electrification and appliance financing in the United States, started in the 1930s and continuing today, is a valuable starting point.<sup>141</sup>

### **The diversified and niche nature of PUE products makes it difficult to scale a business – and difficult to access financing.**

**Investors are focused on new electricity-based businesses and enabling technologies, less so on** converting the fuel-powered status quo to electric<sup>142</sup> or niche appliances. An exception may be the e-vehicle market, where 60 per cent savings compared to fuel costs, scale opportunities and reduced carbon emissions could make investments commercially attractive.<sup>143</sup> However, for a sector dealing predominantly in low volumes of specialised goods, this points to the particular importance of partnerships and to an opening for investors willing to take a portfolio approach to help drive the market into consolidation and/or specialisation.<sup>144</sup>

### **Awareness is low. Consumers know about solar but not what it can do.**

*‘Marketing teams that go to rural areas do not necessarily understand potential applications or how to make field assessments. Customers don’t have the answer because they aren’t aware of potential appliances, so sales decisions are based on incomplete information.’ – PUE company*

**The various technical solar options are rarely known by consumers,** neither are their potential productive use applications. For ‘consumptive’ solar, customers tend to either know what they want (e.g. an electric light or a phone charger), or are persuaded that these products will improve their well-being. For PUE, the value proposition is not always obvious; calculations must be made, and the sales agent must be equipped accordingly. For some technologies such as solar irrigation, customers must be walked through a behaviour change from old practice to new. Brand-agnostic consumer marketing support would be a boon to the sector, in addition to empowering consumers to choose quality.

**Government is supportive, but concrete action has been limited, inter-ministerial coordination is lacking and incentives continue to be confusing.**

**With some exceptions, the four key ministries of energy, agriculture and industry, trade and development and environment are not, to date, communicating on PUE.** The MoE views PUE through its energy lens, with a focus on energy access and demand stimulation. The MoA does not specifically recommend any off-grid solar-powered solutions, even in the new Mechanisation

Policy, although their contributions to the NEECS are evidence of cross-sectoral potential. The MoITED oversees MSMEs but lacks tangible ideas on the opportunities of off-grid solar for small traders, restaurants and cottage industries. Finally, the MoEF holds both climate change and electronic waste mitigation in its purview and should be involved in any future discussion around the replacement of fuel with PV and/or battery systems.

**Fiscal policy affecting the PUE sector is too complex and unpredictable to provide investor**

<sup>109</sup> Ecobodaa website, interview with Opiibus, Efficiency for Access (2021) E-Mobility solar appliance technology brief, GIZ (2019) Electric mobility in Kenya: The facts.

<sup>110</sup> EEP Africa (2020).

<sup>111</sup> AEMDA (2021) Electric mobility barriers in Kenya: Market survey report 2021. Twelve of 14 participating companies had been established in the past three years.

<sup>112</sup> Efficiency for Access (2021).

<sup>113</sup> Jenny Corry Smith & Riley Macdonald (2021).

<sup>114</sup> Interview with IFC. The impact of refrigeration on small-scale dairy value chains is tempered by other market and regulatory dynamics, for example, the lack of premium pricing for chilled milk.

<sup>115</sup> Jenny Corry Smith & Riley Macdonald (2021).

<sup>116</sup> GDC and CDC (2021) How is the last mile distribution sector adapting and innovating following COVID-19?

<sup>117</sup> Energy Catalyst (2021) Digital transformation to support last mile distribution: overcoming barriers together.

<sup>118</sup> Vertical integration has been discussed widely in other publications, for example: Dalberg Advisors, Lighting Global et al (2018) Off Grid Solar Market Trends Report; GOGLA (2019) Investing in the off-grid solar sector: What you need to know; USAID (2019) Off-Grid Solar Market Assessment.

<sup>119</sup> CLASP, World Bank. The WB has noted, for example, that irrigation and enhanced processing opportunities are often linked, as the former may stimulate yields sufficient to warrant value addition. [World Bank (2017) Double Dividend: Power and Agriculture Nexus in Sub-Saharan Africa].

<sup>120</sup> As the Factor(e) guests on this podcast put it: "to bundle or to unbundle?" Investing at the nexus of food and energy – Power for all podcast (April 2021).

<sup>121</sup> Interview with GDC.

<sup>122</sup> Solar Kiosk went out of business, and the 'rental' model has been quiet, though with some indications in other countries – such as Bodawerk in Uganda, mentioned above – of new efforts in this regard.

<sup>123</sup> Interview with CLASP.

<sup>124</sup> Freedomlab (2020) The sharing economy is dead, long live the rental economy.

<sup>125</sup> PREO.

<sup>126</sup> Contejean A & Verin L (2017) Making mini-grids work: Productive uses of electricity in Tanzania.

**certainty.** Much has been said and done about the reversals, confusing coding and unpredictable on-the-ground implementation of tax exemptions. Experts have weighed in on considerations around 'responsible taxation'<sup>145</sup> and efforts by the Kenya Revenue Authority (KRA) KEPSA, KERIA and development partners to clarify processes have resulted in genuine improvements. But, the industry still suffers from the government's lack of predictability both in the annual budget list of exemptions and in the application of exemptions at customs.

**The environmental impact of a surge in appliance sales must be pre-emptively and proactively mitigated,** including through Extended Producer Responsibility Regulations. Cold rooms and refrigerators use insulation and refrigerants; a proliferation of water pumps risks over-abstraction of under and overground water resources,<sup>146</sup> and the safe disposal and treatment of end-of-life batteries is a major concern for e-waste management.<sup>147</sup>

<sup>127</sup> GMG (2021).

<sup>128</sup> GDC (2021) The growth and fundraising journeys of LMDs.

<sup>129</sup> Interviews with CLASP, Shell Foundation.

<sup>130</sup> <https://www.sustainability-times.com/environmental-protection/drip-irrigation-can-reduce-the-vast-footprint-of-rice-cultivation/>.

<sup>131</sup> Jenny Corry Smith & Riley Macdonald (2021).

<sup>132</sup> CLASP (2020) Off-grid Appliance Market Survey.

<sup>133</sup> Interview with GMG Facility Kenya.

<sup>134</sup> Interview with Opibus.

<sup>135</sup> Human-centred design puts people – rather than technology – at the centre of a product design process.

<sup>136</sup> Interviews with MoE, MoA, AECF, IFC, KEPSA, GOGLA.

<sup>137</sup> Gassner, A., D. Harris, K. Mausch, A. Terheggen, C. Lopes, RF Finlayson, P. Dobie. (2019) Poverty eradication and food security through agriculture in Africa: Rethinking objectives and entry points.

<sup>139</sup> EEP Africa (2020).

<sup>139</sup> Interview with Shell Foundation.

<sup>140</sup> Communication with Yaron Cohen.

<sup>141</sup> In the early days of rural electrification, the U.S. government worked with rural electricity cooperatives to offer low-interest electrification financing, appliance financing and technical support. Factor(e) presents a helpful summary of its relevance to the Kenyan off-grid sector here. More information on current-day small farm financing in the US is here.

<sup>142</sup> Interviews with Factor(e), IFC.

<sup>143</sup> Interview with Opibus.

<sup>144</sup> Communication with Yaron Cohen.

<sup>145</sup> ACE TAF (2021) Impact of VAT and Import Duty on the Solar Sector in Kenya: A policy position paper presented by KERIA and GOGLA.

<sup>146</sup> GOGLA (2019) Productive use of off-grid solar: Appliances and solar water pumps as drivers of growth.

<sup>147</sup> Interview with SERC.







## 4 Recommendations

This report maps the vibrant network of 100 companies and broader PUE ecosystem actors in Kenya. These companies are supplying 40+ types of solar appliances to customers across the socioeconomic spectrum – and could do so even more effectively and sustainably with strategic support from government, investors and the development community. The following three recommendations<sup>148</sup> are presented to mobilise stakeholders:

### 1. Convene stakeholders for an inter-ministerial, public-private dialogue.

There is momentum, as explicitly stated by stakeholders interviewed during this study, for a gathering of interested parties to trade information, identify roles and articulate priorities. A meeting in Nairobi would set the stage for cooperation going forward.

The objective of such a dialogue would be to generate exchanges among decision-makers on how to address key barriers inhibiting the PUE sector. This would ideally lead to increased sharing of information, creating a working Inter-ministerial Committee, identifying a champion for PUE within the Kenyan institutional landscape and agreeing on initial recommendations for priority action as well as identifying supporting organisations.

The second and third recommendations would ideally build upon the outcomes of this meeting.

### 2. Address the consumer financing gap for component-based solar PUE systems.

Though in-house financing mechanisms for P&P and mini-grid PUE are not perfect, they are nonetheless successfully enabling customers to access more expensive items. But the component-based segment of the Kenyan PUE market – comprising 75 per cent of the companies active in the country – is largely self-financed at the moment, severely restricting uptake.

The key objective would be to develop scalable consumer financing mechanisms for PUE, by engaging interested financiers to design and de-risk a dedicated PUE asset financing vehicle. A programme needs to be designed to support existing fintech lenders to improve or expand their loan product for PUE, de-risk consumer lending for component-based solar PUE systems through an independent quality verification mechanism (e.g. freelance engineers funded by an NGO) and clear reference points for technical best practice. Furthermore, such a financing programme would

<sup>148</sup> A separate Policy Action Plan provides more detailed analysis of opportunities to improve the regulatory environment.

fund business model testing for companies innovatively addressing challenges of niche product sale and investigate the opportunities for diesel replacement or improved irrigation PUE to qualify for climate financing, and how this might work in practice.

### **3. Design and fund a cross-sectoral flagship programme for PUE on the model of Lighting Global.**

Some of the successes of the Lighting Global programme have carried over into the solar PUE sector, for example around quality standards. But PUE is a confluence of stand-alone solar, agribusiness and appliance sectors (among others) with its unique consumer awareness, technical capacity and data needs.

A flagship programme on the model of the Lighting Global programme would improve the enabling environment for PUE companies. Based on detailed

product and value-chain specific market mapping, such a programme can support the inter-ministerial committee in implementing priority activities and engaging and assisting ministries and county officials to ensure PUE applications are included in County Energy Plans. Quality of appliances would improve by supporting KEBS and EPRA to review and implement standards in the sector, accompanied by brand-agnostic consumer awareness campaign. Such a programme can also generate a knowledge base on gender and youth in the PUE sector, and ultimately drive the design of an outcomes-based mechanism such as an impact bond to incentivise companies to reach target populations with high impact PUE applications.



## 5 Annexes

### 5.1 Companies active in the Kenyan PUE sector

Table 11 shows companies which are active in the sector. As noted in the main text, several companies are active in more than one product category, so are counted/listed here in each row that is relevant.

Table 11: Companies active in the Kenyan PUE sector.

Category	Active companies
P&P	Agsol, Amado Solar, Azuri Technologies, Barefoot Power, BBOX, Beier, Bidhaa Sasa, BioLite, d.light, Deevabits, Ecozen, Engie Mobisol, Equatorial Sunpower, Fosera, Givewatts, Global Ice TEC AG, Greenlight Planet, M-KOPA, Mwezi, OvoSolar, Pawame, Phocos, Powerpoint Systems, Raino Tech4impact, Rural Spark, SolarNow, Solibrium Solar, Spark Possibilities, Steca, SUNami, Sunken, Suntech Power Ltd., Surechill
Component-based systems	<p>Adili Solar Hubs, African Energy, African Solar Power Systems Ltd., Amado Solar, Amiran, Centre for Alternative Technologies (CAT), Chloride Exide, Creative Innovation, Davis &amp; Shirliff, E.A. Drillcon, Ltd., Eco Desh Power Solutions Ltd., Ecozen, Engoho Kuku Farmer, Ennos, Epicenter Africa Ltd., Equatorial Sunpower, Fountain Vent, Fresh Box, FuturePump, Go Solar, Greenserve Agrisolutions Ltd, Grekkon Ltd, Grundfos, Harmonic Systems, InspiraFarms, Irrico International, Kenital, Lorentz, Mulika Africa, Mwangaza Lights, Oasis Green Africa, Omnivoltaic Energy, Phocos, Powerpoint Systems, Savanna Circuit Tech, Schneider Electric, Shakti Pumps, Shurflo, SokoFresh, Solar Floppy, Solar Works, SolarGen, SolarNow, Solibrium Solar, Solinc, Sollatek, Steca, Sun Pump, SUNami, SunCulture, SunDanzer, Sunken, Sunny Irrigation, Suntech Power Ltd., SunTransfer, TransAfrica Water, Village Industrial Power (VIP), Wilo East Africa</p> <p>E-mobility: Asobo, Basi-Go, Auto Track EA LTD, Chaji Energy, Drivelectric/ Knights Energy, E-Safiri, Ecobodaa Bikes, EVChaja, Fika Mobility, Kiri EV, Mazi Mobility, Meta Electric, Opibus, Solar E-Cycles, Stima Mobility</p>
Mini-grids <sup>149</sup>	PowerGen, Powerhive, Renewvia, Kudura (RVE.Sol), Schneider Electric, SolarGen, Virunga Power

## 5.2 Development partners supporting the Kenyan PUE sector

The list in Table 12 includes initiatives not specific to Kenya but nevertheless available to Kenyan companies.

Table 12: Development partners supporting the Kenyan PUE sector.

Programme	Donors	Comments
Mini-grids	IKEA Foundation, DOEN Foundation, Good Energies Foundation, FMO	Published an open-source modelling methodology to construct and evaluate solar PUE business models. <sup>150</sup>
AECF	Swedish International Development Cooperation Agency (SIDA)	COVID relief fund has supported SunTransfer's sale of fishing lights around Lake Victoria.  RBF (in Kenya only) is being awarded shortly (August 2021), anticipating PUE companies in the list.
Catalysing Agriculture by Scaling Energy Ecosystems	Shell Foundation and UK Research and Evidence Division	GBP 30 million, five-year funding partnership. Ecosystem approach includes access to energy-enabled assets, access to finance/insurance, access to markets, and access to knowledge. Aim is to de-risk early-stage companies.
Climate Resilient Agriculture for Tomorrow	Netherlands Ministry of Foreign Affairs  Implemented by SNV	Stimulating the application of renewable energy and energy efficiency solutions in prioritised agricultural value chains (oil seeds, pulses, potatoes and cereals) in Uganda, Tanzania and Kenya since 2018 as part of the overall resilience building and mitigation strategies in climate smart agriculture.
EEP Africa	Austria, Finland, Nordic Development Fund (NDF) Managed by NDF	The most recent call for proposals in 2019 saw nearly half of applicants incorporate productive use in the core project design.
Efficiency for Access Coalition	Acumen, Clinton Health Access Initiative Foundation, DOEN Foundation, EnDev, World Bank/ESMAP, Good Energies Foundation, IFC, IKEA Foundation, Power Africa, Rockefeller Foundation, Shell Foundation, SIDA, UKAID, USAID  Implemented by CLASP + Energy Savings Trust	Promoting energy efficiency as a catalyst for clean energy access. Programmes aim to scale up markets and reduce prices for superefficient, off- and weak-grid appropriate products, support technological innovation, and improve sector coordination.  Global LEAP offers efficient off-grid appliance support through competitions and results-based financing. 2019–20 RBF in Kenya (among other countries) for off-grid refrigerators and SWP.

<sup>149</sup> The State of the Global Mini-grids Market Report 2020 notes a range of companies' manufacturing control systems, hardware, energy storage and generation equipment for mini-grids. With the exceptions of Engie and Schneider Electric, they are not included in this report.

<sup>150</sup> A2EI (2020) Productive Use Report Agricultural Technologies.

Programme	Donors	Comments
Empowering Women Engendering Energy	SIDA, AfDB Implemented by Hivos/ ENERGIA	ENERGIA is the International Network on Gender and Sustainable Energy, hosted by Hivos. Its Empowering Women Engendering Energy programme, which supports women's entrepreneurship in PUE, is being implemented in Senegal, Nepal, Kenya, Nigeria and Tanzania.
EnDev	Netherlands, Germany, Norway, the United Kingdom, Switzerland and Sweden  Implemented by SNV Kenya	The EnDev Programme is an energy access partnership currently financed by six donor countries; the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH acts as lead agency, cooperating closely with the Netherlands Enterprise Agency at the global level.  The SNV EnDev III project Accelerating Access to Energy Services is a market development initiative to support Kenya's SE4All goal to achieve 100 per cent universal access to modern energy services by 2030 for both cooking and electricity. Its 'electricity component' focuses on PUE targeting small-scale business and social institutions, and also promotes solar for household lighting on a limited scale targeting the poor and vulnerable communities in Kakuma Refugee Camp.
GDC	FCDO	Started in 2019, it now has 204 member companies, all of which are selling to last-mile customers. About two-thirds are energy companies. It ran an Innovation Challenge in which Mwezi trialled a solar drip irrigation digital sales tool to help guide sales agents to identify the right product for each customer. Pilot learnings will be open source, and a report will be published later in 2021.
Green Mini-Grid Facility Kenya	FCDO, EU	Grants and TA to promote GMGs. Phase 1 (2017): FCDO funding – Funded three companies: Kudura, Powergen, Powerhive = around 10,000 connections total (Powergen sites soon to be operational). Phase 2: EU funding – Expanding the Kudura Busia site; added support to Renewvia – a few counties – Kajiado, Turkana – 11 sites. Different sizes between 50 connections to a few hundred. Stakeholder in drafting of new mini-grid regulations.  Produced a number of studies on PUE.
Green Mini-Grid Help Desk	AfDB  Implemented by E4I	Covers PUE/Kenya within SSA – TA for developers + policymakers.

Programme	Donors	Comments
Green People's Energy for Africa	BMZ  Implemented by SNV Kenya	Promote access to SWP for smallholder farmers in Laikipia County.
Kenya Off-Grid Solar Access Project	World Bank  Implemented by Government of Kenya, with SunFunder and SNV as facility managers	Concessional loans and RBF. Mini-grids to sell power at national tariff. Stand-alone solar RBF. Only PUE facet is solar water pumping.  Recently issued an RfP for a study of off-grid demand stimulation.
LEIA	FCDO, IKEA Foundation  Implemented by Energy Savings Trust and CLASP	LEIA acts as the secretariat for the Efficiency for Access coalition. Focus on market research, technology research, product testing, market scoping. It also runs the Global LEAP awards and the Efficiency for Access design challenge, the latter of which includes participants from Kenyan universities. Grants to companies to pilot innovative ideas and explore new markets.  Developing a tech brief overview of e-mobility space. Providing 10-12 briefs – last few months and coming few months.  Kenya-specific support has included:  <ul style="list-style-type: none"> <li>- Solar milling testing (Agsol)</li> <li>- Water and cold chain for Lake Turkana fisher people (Adili Solar Hubs)</li> <li>- Walk-in cold rooms market assessment</li> <li>- Global LEAP off-grid cold chain challenge – which did not really help the companies get off the ground; R&amp;D fund has therefore come in to support</li> <li>- E mobility (newly established AEMDA, Powerhive)</li> <li>- Egg incubators (OVO Solar)</li> <li>- Milk chilling – local assembly approach (SureChill + Phaesun)</li> </ul>
PRODUSE	ESMAP, AEI, GIZ	Toolkit and manual providing guidance for energy practitioners on integrating and implementing PUE to electrification activities.
EnDev Learning and Innovation Community of Practice on PUE		SNV has been coordinating the EnDev PUE L&I CoP which brings several organisations to share knowledge and lessons. Activities have included publication of an overview of successful and innovative PUE approaches from EnDev implementers, and knowledge dissemination through webinars/workshops.

Programme	Donors	Comments
PREO	FCDO, IKEA Foundation  Implemented by Carbon Trust + Energy 4 Impact	Energy demand stimulation through grants, TA, market intelligence, partnership building, knowledge hub. Under the Transforming Energy Access programme.  PREO will fund Action Learning Projects up to EUR 300,000 in value. July 2020 challenge fund most recent; more to come in 2021 and 2022, accepting applications for SSA PUE up to EUR 300,000 in value.  Kenyan companies supported: Bodawerk, InspiraFarms, SokoFresh.
Various programmes	Practical Action	A range of support to the Kenyan PUE market, including irrigation promotion for youth growing groundnuts, poultry and tomatoes in Western Kenya; PUE technology catalogue for irrigation, milling and cold chain technologies in five countries including Kenya; support to Agsol to test their micro-milling business model; commissioned a study on the viability of solar irrigation in Kenya (webinar coming soon); institutional support to the MoE under an EU programme.
Water and Energy for Food Initiative	GIZ, USAID, SIDA, EU, FAO  Implemented by GIZ in Kenya	Follow-on to Powering Agriculture. Convening, TA, grants. Developed digital tools such as a SWP irrigation toolbox, both online and by android app.  East African programme hub put out an 'innovation' call for proposals targeting private sector players working at this nexus, closed 15 June 2021. TA will include baseline studies, capacity building, awareness creation. Target 15 entities that already have traction, validated solutions looking to scale. EUR 50,000-500,000.



## 5.3 Case studies

### 5.3.1 Manufacturer: Opibus

Swedish-Kenyan electric mobility start-up Opibus is bullish on the Kenyan market. It is rolling out three products: (1) electric vehicle drive trains (battery, motor and control system) that can be fitted into existing buses, taxis and cars to replace their internal combustion engines (ICE); (2) electric (e-) bodas; and (3) electric vehicle charging infrastructure.

The company's entry into the Kenyan market has been with 12 converted electric safari vehicles, which offer both cost savings over fuel and a silent ride, which is optimal for getting up close to animals; the tourist operators also have relatively higher purchasing power, allowing Opibus to get some early traction. Beyond e-safari, its first focus will be B2B or business-to-government fleet electrification of delivery and public transportation vehicles, as this will enable the development of a network of charging stations over pre-defined routes.

E-bodas are an exciting opportunity as well. Opibus has converted 140 so far and target 5,000 next year, at a projected retail price of USD 1,300 per bike. A pilot with Powerhive, whereby Powerhive purchased the bikes and financed them to their customers, is moving into a commercial phase. Funding has been from angel investors and grants.

In order to scale profitably, instead of replacing ICEs on existing bodas, they will assemble locally-made frames with a mix of local and imported parts. Over time they hope to source or produce as much in Kenya as possible to save on costs and lead time. End-of-life batteries will be repurposed or disposed of according to industry best practice.

Opibus's e-bodas have swappable batteries charged with low-amp AC (there is no option to do this with DC, which would be much more expensive). As such, they are best charged on the main grid or on a mini-grid. Stand-alone solar with an inverter would be possible, but it would take a while; the company estimates that a 200Wp SHS would charge the bike in about 12 hours.

Opibus says e-bodas offer up to 60 per cent savings on operational costs between fuel and maintenance, the latter of which is minimal-to-none on an electric bike. Some behaviour change will be needed; for example, regular motorbike drivers are accustomed

to holding the brake while revving the engine – not a feature of an e-bike. There is some government interest, but not much else. The private sector – as with other early-stage technologies – will lead the way.

### 5.3.2 Distributor: Solibrium

Solibrium is a Kenyan solar distributor of Omnivoltaic products, sourced either directly from China or from the Omnivoltaic warehouse in Nairobi. Prices are higher for locally sourced products, but this helps for short-term stock replacement. For imports, the company pays partially up front, partially prior to the product being exported from China, and the balance before the shipment is cleared from customs. Everything is taxable, with the exception of some solar components.

Most of Solibrium's customers are rural and low-income. Demand is high, but affordability is a major constraint. Nearly all of its customers choose PAYGo plans over cash up front. Customer engagement makes up a substantial portion of the company's operating costs, in both after service and accounts follow-up. The company uses a mix of employed sales coordinators and commission-based 'freelancer' sales agents recruited from the local community.

One of the company's successful products is the hair clipper, for which it charges a deposit, plus monthly repayments. Another is a solar public address system, which is picking up sales as Kenya heads into a elections year. This is a good money-maker for the customer, who can rent it to a politician for more than USD 50 per day, many times his daily repayment amount to Solibrium. Repayment delays are fairly common, and Solibrium works proactively with its customers on a way forward.

The biggest challenge for Solibrium is working capital to purchase inventory. The company has looked at potential debt options, but with COVID and a PAYGo consumer financing model, banks are uninterested. It recently participated in the EnDev programme, which subsidised 80 per cent of the costs of agent recruitment, training and marketing in Nandi, Baringo, Kitui, Uasin Gishu, Laikipia and Turkana West counties, where consumer awareness is low.

### 5.3.3 Customer: Great Lake Feeds and Fish Farm

Fred Obudho is the founder of Great Lake Feeds and Fish Farm. He provides feed and fingerlings to fish farms. He employs 18 staff, of which 12 are women and 90 per cent are youth (finished secondary school or in university). Fred is a trained solar engineer, and as a secondary business sells and installs solar pumps to local farmers in his area.

Fingerling production requires fresh water, so he uses solar pumps to bring water from the lake to 30 ponds. To meet high demand, he sometimes ends up selling fingerlings that are too young, and earns less for these than mature ones. A mature fingerling (two months old) is sold for KES 10, but if it is a few weeks old it is sold for KES 3. Feed production is done with machines powered by the grid. He processes and packages the feed on site and sells to fish farms located nearby using vehicles and motorbikes all owned by him. He would like to have 100 ponds, as there is an enormous market in the area.

The solar pump cost him more up front than a diesel pump, but its running costs are lower. That said, for proper aeration he needs the pumps to run 24 hours a day, but without backup power they currently do not operate at night. This results in losses; he can find dead fish in the morning. For the feed production, his biggest challenge is Kenya Power and Lighting Company blackouts; he can go up to three weeks with no power.

Fred would love to go completely off-grid with solar, which he estimates could save him KES 70,000–80,000 monthly on his power bills, but the quote he got from a major Kenyan supplier was KES 18 million, which he does not have. He has not applied for a loan from a bank or SACCO, but he is considering it.

### 5.3.4 Product: Solar drying

In Kenya, farmers lose up to a third of their produce post-harvest before it can be sold.<sup>151</sup> Apart from income losses, poor drying has contributed to aflatoxin contamination, which is a major food safety and public health concern. Appropriate drying technologies could potentially enable small-scale farmers to significantly reduce post-harvest losses and improve food quality, while generating income and employment opportunities.<sup>152</sup>

Solar dryers use sun to heat air to a constant temperature in an enclosed chamber, which helps

facilitate the extraction of humidity from produce. Ventilation is enabled and kept constant through fans (which can be solar electric), air inlets and outlets.

Advantages of solar dryers to open air drying are:

- The rate of drying increases with higher temperature and movement of air in the chamber.
- Food is enclosed in the dryer and therefore protected from dust, insects, birds, animals and rain.
- A higher temperature prevents insect infestation, and the faster drying rate reduces the risk of spoilage by microorganisms.
- A dryer can be constructed from locally available materials at a relatively low cost and will need minimum maintenance – low capital and running costs.
- A dryer requires a small area of land to dry a similar amount of crop.

The Kenya Agri-business and Agro Industry Alliance is the leading agro-processing industry group. Grekkon, a Kenyan agribusiness company offering greenhouses, irrigation systems and solar dryers, offers a commercial metallic solar dryer made of galvanised steel with a cover of clear UV treated greenhouse polythene sheet. It has shelves for drying fruits, meat, fish and vegetables.<sup>153</sup> The price ranges from USD 600–1,100 depending on drying capacity (40–130kg).

Despite numerous NGO and commercial attempts, solar drying has failed to take off at volume in Kenya as a marketable product or service. There are several reasons for this:

- Because of its dependence on solar irradiation, the technology is limited in usefulness during cloudy periods unless there is a backup (electric) heating system.<sup>154</sup>
- The market for dried products such as fruits or grains is extremely quality constrained. Products need to be dried evenly and consistently. Commercial fuel- or electric-powered driers do this better than solar thermal driers.
- Small amounts of solar drying do not have financial value beyond the household or local level, as larger-scale or export-level demand is not typically possible through individuals.
- Traditional uses of solar drying (fish drying, open-air grain drying) are still widely used but do not require investment and are not easily improved upon.

<sup>151</sup> KNBS via Standard Media, Business Daily.

<sup>152</sup> <https://www.sciencedirect.com/science/article/pii/S0301479720306629>.

<sup>153</sup> <https://grekkon-eldoret.co.ke/natural-solar-dryers/>.

<sup>154</sup> <https://www.cag.org.in/blogs/solar-dryer-and-its-types>.





## 6 References

- Access To Energy Institute, A2EI (2020) Productive Use Report Agricultural Technologies.
- AEMDA (2021) Electric mobility barriers in Kenya: Market survey report 2021.
- Africa Clean Energy (ACE) Technical Assistance Facility (TAF) (2019) Importation Guidelines for Solar PV Products and Systems in Kenya.
- Amiran (2020) Piloting a new approach to agricultural credit for productive use assets – learnings from Amiran Kenya – Project Madaraka.
- Best, S. (2016) Energising local economies: Experiences of solar start-ups in Kenya’s small-scale fishing and agriculture sectors.
- Blodgett, C, Leaf, H, Kickham, L & Moder, E. Powering Productivity: Early Insights into Mini Grid Operations in Rural Kenya.
- CLASP (2020) Off-grid Appliance Market Survey.
- CLASP (2019). The State of the Off-grid Appliance Market.
- Contejean A & Verin L, (2017) Making mini-grids work: Productive uses of electricity in Tanzania.
- Dalberg Advisors, Lighting Global et al (2018). Off Grid Solar Market Trends Report.
- Dzanku, FM, Jirström, M, Marstorp, H (2015) Yield gap-based poverty gaps in rural Sub-Saharan Africa. World Development.
- ECA & ASD (2020). Market assessment study: Productive Use Leveraging Solar Energy (PULSE) in Uganda.
- EEP Africa (2019) Powering Productivity: Lessons in Green Growth.
- EEP Africa (2020) 2020 Market Report: Productivity and Circularity in the Clean Energy Sector.
- Efficiency for Access (2021) 2021 Solar Appliance Technology Briefs.
- Endev (2020) Productive use of energy: Moving to scalable business cases.
- ENERGIA (2019) A gender approach to the promotion of productive uses of energy (policy brief).
- ERC (2018). Solar PV Industry Baseline Study- Draft.
- ESD Africa (2006) A Study of Productive Uses of PV Electricity in Rural Areas of Kenya.
- Factor(e) (2019) Laboratory characterization of income generating appliances: A study to further mini-grid development.
- Fraym (2021) Kenya COVID-19 Pandemic Impact Response and Recovery Study.
- Gassner, A., D. Harris, K. Mausch, A. Terheggen, C. Lopes, RF Finlayson, P. Dobie. (2019) Poverty eradication and food security through agriculture in Africa: Rethinking objectives and entry points.
- GDC & Energy Catalyst (2021) Digital transformation to support last mile distribution: overcoming barriers together.
- GDC (2021). The growth and fundraising journeys of LMDs.
- GDC, CDC (2021). How is the last mile distribution sector adapting and innovating following COVID-19?

- GIZ (2019) Electric mobility in Kenya: The facts.
- GIZ (2016) PVs for Productive Use Applications: A Catalogue of DC-Appliances.
- GIZ, ESMAP, BMZ (2013) Productive Use of Energy (PRODUSE) – Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa.
- GMG (2020) Agribusiness & Rural Enterprise Development to Strengthen Mini Grid Models.
- GMG (2020) Barriers & Opportunities With Appliances, PUE & A2F.
- GMG (2021) Concept 1: Accelerating the Productive Use Ecosystem.
- GMG (2021) Concept 2-Productive Use of Energy Leadership Initiative.
- GMG (2020) Consumer Financing.
- GOGLA (2019) Investing in the off-grid solar sector: What you need to know.
- GOGLA (2019) Productive use of off-grid solar: Appliances and solar water pumps as drivers of growth.
- GOGLA (2020) 2020 Off-Grid Solar Market Trends Report.
- GOGLA (2019) Global Off-Grid Solar Market Report H1 2019.
- GOGLA (2019) Global Off-Grid Solar Market Report H2 2019.
- GOGLA (2020) Global Off-Grid Solar Market Report H1 2020.
- GOGLA (2020) Global Off-Grid Solar Market Report H2 2020.
- IFC (2019) Assessment Study: Stand-alone Solar for Productive Uses in Uganda.
- KawiSafi, Acumen Capital Partners (2021) Community Report 2020.
- KIRDI (2017) Accelerating Pico-Solar PV Market in Kenya KIRDI (2017) Accelerating Pico-Solar PV Market in Kenya.
- KNBS (2020) Economic Survey Popular Version Lighting Africa (2018) Off-Grid Solar Market Trends Report 2018.
- Lighting Global (2019). The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa.
- NREL & E4I (2018) Productive Use of Energy in African Micro-grids.
- OVO Solar (2020). Mwezi Kenya Egg Incubators - Impact and product pipeline.
- Power Africa (2020) Off Grid Productive Use of Energy 2020 Catalog – Kenya.
- RMI (2018) Closing the circuit.
- SE4ALL (2020) State of the Global Mini-grids Market Report 2020.
- Shell Foundation (2017). Promoting Productive Uses of Energy in Uganda.
- Smith & Macdonald (2021) Refrigerators and water pumps have reached a critical crossroads: Here's what the off grid solar sector should do next (blog).
- Thornton PK, Jones PG, Owiyo T, Kruska RL, Herrero M, Kristjanson P, Notenbaert A, Bekele N and Omolo A. (2006). Mapping climate vulnerability and poverty in Africa).
- USAID (2019) Off-Grid Solar Market Assessment Kenya.





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