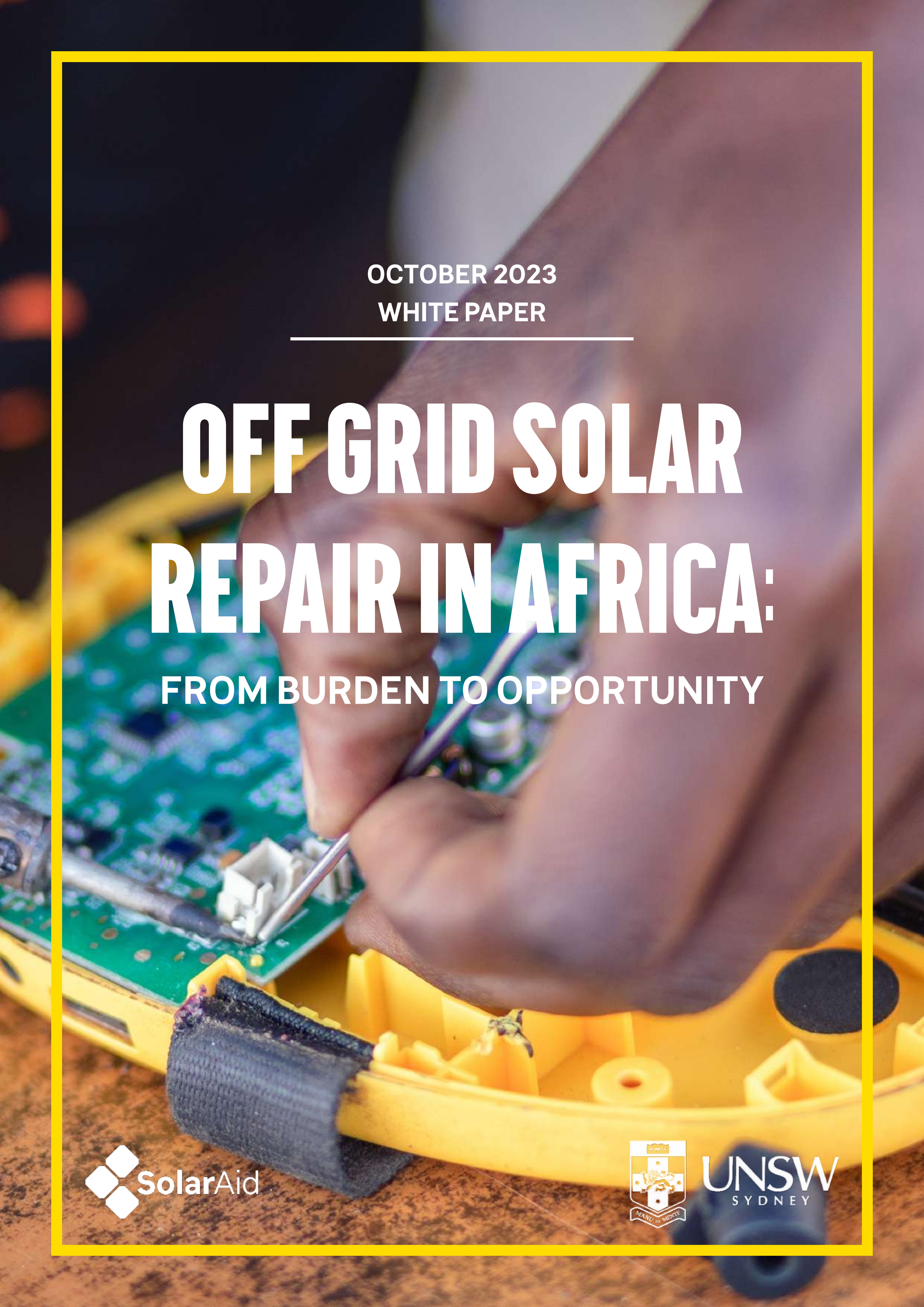

OCTOBER 2023

WHITE PAPER

OFF GRID SOLAR REPAIR IN AFRICA:

FROM BURDEN TO OPPORTUNITY

SolarAid

UNSW SYDNEY

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GLOSSARY OF TERMS

Global Off-grid Lighting Association (GOGLA) – GOGLA is the global association for the off-grid solar energy industry. It has around 200 members who focus on providing low-income households and small businesses with affordable, high-quality off-grid solar products and services. GOGLA aims to enable sustainable businesses and accelerate energy access, through market insights, standards and best practice, and advocates for catalytic policies, programmes and investment.

Solar Energy Kits (SEKs) – These include solar lanterns, multi-light kits and solar home systems (SHS). Solar lanterns are typically simple, one-light lanterns with one LED light with a 0.5–3.0 Watt-peak (Wp) solar panel, and a rechargeable battery. Multi-light systems include up to four LED lights with a standalone solar panel rated up to 10 Wp and a rechargeable battery, and often a USB for mobile phone charging. SHSs have a solar panel rated from 11 Wp to usually up to 350 Wp and provide multiple electricity functions, such as lighting and powering a wide range of appliances such as TVs and fans. SHSs are offered in plug-and-play setups or based on open-market components. These definitions are derived from the *Off-Grid Solar: Market Trends Report 2022: State of the Sector.*[1]

Branded SEKs – Branded SEKs are SEKs that are sold by specialised off-grid solar companies that are usually members of GOGLA. In general, 'branded' products have been certified by international agencies (e.g., VeraSol) and operate with websites promoting their product's brand (i.e., branding). They are sometimes described as 'affiliated products' (as in, companies affiliated with GOGLA) or as 'quality-verified products'. These products usually come with warranties and aftersales support.

Unbranded SEKs – These are SEK products that have not been 'quality verified' and for the most part, their trade networks are opaque. The World Bank describes them as products offered by manufacturers who are not seeking to build brand value.[2] These products are sold across Africa through hardware stores, street vendors and informal purveyors. These products rarely come with warranties or aftersales support, and their quality is highly variable.

Solar E-Waste – Solar e-waste refers to the electronic waste generated by discarded SEKs at the end of their useful life – including photovoltaic (PV) panels, battery storage, lights and any associated appliances that are bundled with SEKs or sold separately by the distributor.

Repair Agents – Repair Agents are off-grid solar sales Agents who have been trained to conduct repairs of off-grid solar products. The repair of SEKs is an added commercial service that they can offer their customers.

Repair Technicians – Repair Technicians are independent repairers who conduct electronic repair, including the repair of SEKs.

CONTENTS

EXECUTIVE SUMMARY

Since 2010, an estimated 150 million solar energy kits (SEKs) have been distributed throughout Africa,[1] revolutionising electricity access for millions of off-grid and rural households. However, the promise of this solar boom is hampered by estimates that nearly 75% of these SEKs have likely ceased functioning.[i] This presents a significant challenge for the sustainability of the continent's off-grid solar sector.

While SEK recycling initiatives have an important role to play, there are notable limitations. High logistical costs and a lack of relevant local infrastructure, means that recycling is only able to offer a limited role in addressing the potential waste flows from these non-functioning solar products. Therefore, a more salient approach to addressing the rise of non-functioning SEKs is to focus on repairing them and extending their life spans. This approach is also the most environmentally sustainable while extending customer value for money and allowing for the development of a local repair and reuse economy.

There are opportunities for companies working in Africa's off-grid solar sector to embrace (or further embrace) repair and refurbishment operations, as they offer opportunities for enhancing customer value, strengthening brands, delivering on environmental promises and creating jobs. Potential change to national regulations and shifting investor supporter portfolio requirements also means that companies could face future risks if greater repair practices are not incorporated.

This report explores the potential for SEK repair in Africa by drawing on valuable lessons learned and insights from SolarAid's *Solar Saver: second-generation lights* project in Zambia. The pilot programme tested two decentralised repair models by (a) training in-house product distributors in repair and (b) leveraging third-party Repair Technicians in the informal economy.

It concludes that there is a high potential for the repair of SEKs because:

1. A dynamic electronics repair economy already exists across Zambia and other parts of Africa.
2. Around 90% of customers do not tend to throw out non-functioning solar products, opting instead to store or 'hibernate' them in the hope of being able to use them again in the future.
3. More than 90% of SEKs were successfully repaired at a relatively low cost, illustrating the size of the potential repair market.

Nevertheless, significant barriers prevent the full realisation of a vibrant repair economy for SEKs. This includes:

1. Some leading manufacturers, due to an understandable focus on durability and protecting internal fintech components (i.e. tamper proofing), have adopted SEK designs that have low levels of repairability.
2. Technicians lacking access to repair manuals, spare parts and tools.
3. Limited customer access to trusted and trained Repair Technicians.

SolarAid's *Solar Saver: The second-generation lights* project successfully overcame the last two barriers, resulting in high-quality, safe repairs by product distributors and third-party Repair Technicians, building customer trust and building loyalty towards the SunnyMoney brand. This approach demonstrates a potential, low-cost solution to addressing the challenge of repairing non-functional SEKs across Africa.

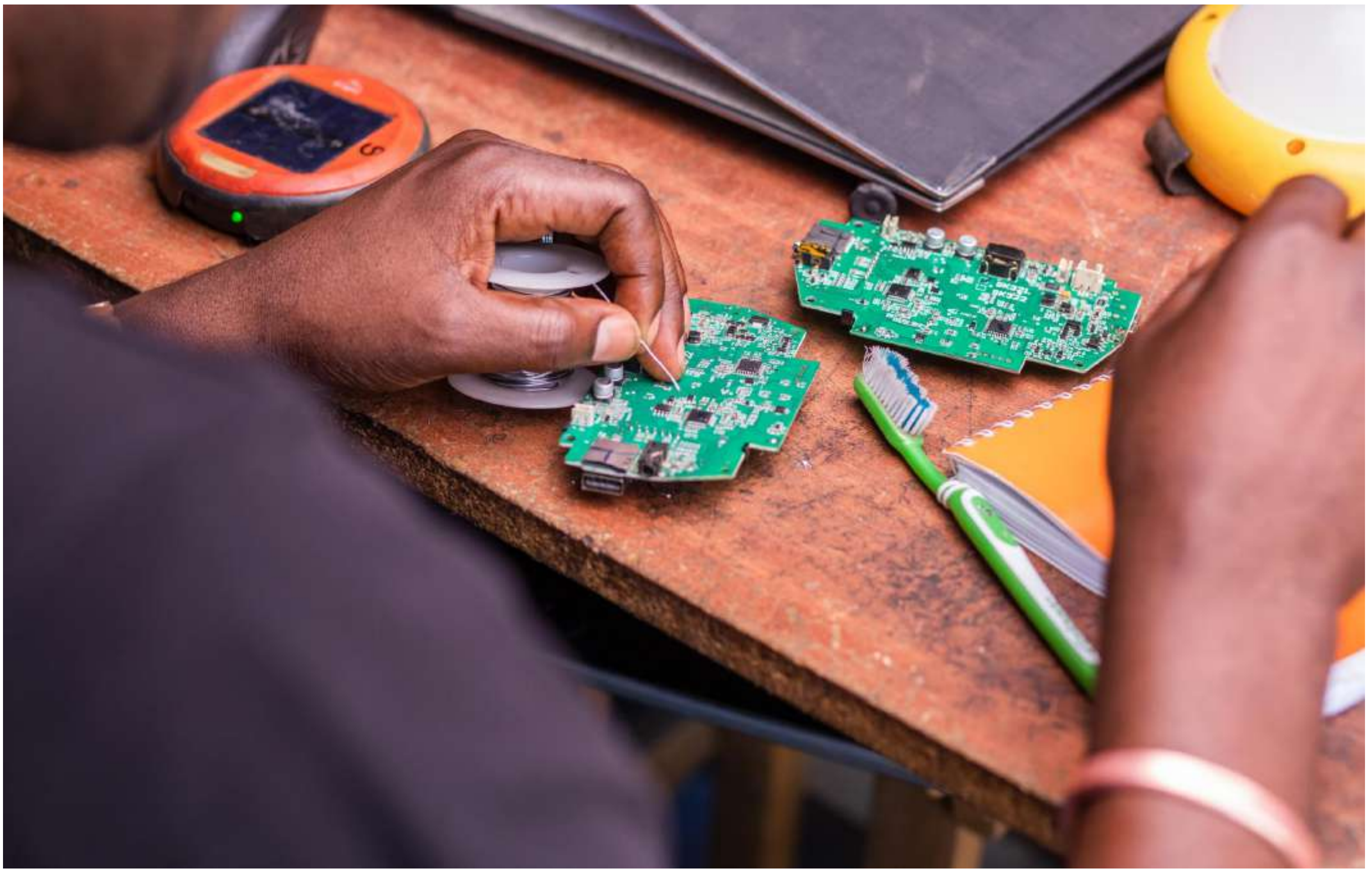
This white paper puts forward six recommendations which will help develop an effective and sustainable SEK repair economy in Africa. These recommendations relate to different phases of the SEK value chain (from design through to post-warranty) and cut across different stakeholders within the sector including investors, SEK manufacturers, SEK distributors, aid donors and governments.

[i] More than 110 million (or these 150 million) SEKs were sold three or more years ago in Africa. The average life-span of SEKs (as reported in a number of studies cited below in this report) is three years old.

1. **Prioritise repair as a core principle in the off-grid solar sector -** including in-house repair and refurbishment operations and supporting the broader development of repair skills and access to spare parts in targeted markets.
2. **Test the economic viability of a range of business models for localised SEK repair –** these approaches could offer pathways to de-risk the off-grid solar sector's engagement with repair activities.
3. **Improve off-grid solar product quality standards to include repair** considerations to ensure that SEKs feature designs that can be easily repaired by local Repair Technicians.
4. **Create enabling environments for local repair**, including a sector-wide focus (including governments, as well as SEKs manufacturers and distributors) on ensuring that spare parts for SEKs are affordable and widely available. This includes considerations of a 'right to repair' for customers.
5. **Collaborate to expand work on the development of open access repair guidance and safety information for a wide range of SEKs.** The 'SunnyMoney Repair Guide' mobile phone app offers a compelling foundation to build on.
6. **More research is needed** to understand how applications of repair might vary across different markets and national contexts. Donor support for this research is critical to help de-risk interventions into SEK repair.

SolarAid is currently in the design stage for the next phase of their repair project. This will test the economic viability of the two decentralised repair models they are testing while building their mobile repair app further – exploring its expansion geographically and into other product types. The results will be open source and designed to provide guidance and use cases for sector wide adoption.

SolarAid will be seeking consultation, technical assistance and funding with leading off-grid sector stakeholders to ensure this final stage of the pilot achieves its aim of providing utility and real adoption pathways for the whole sector.



Repair Technician Brian Nongo, Zambia. Photo: SolarAid/Jamil Banda

INTRODUCTION

The sale of solar energy kits (SEKs), in the form of solar lanterns and small packaged solar home systems (SHSs) (powering lights and small electrical devices), has experienced an unprecedented boom in Africa over the past decade: an estimated 21 million SEKs were sold in 2022,[ii] a rapid rise from the 200,000 SEKs sold in 2010.[2–4] In part, this boom has been underpinned by the rapid establishment of an off-grid solar private sector industry in Africa that has attracted more than US$3 billion in investment since 2010.[1] The sector comprises a range of start-up and established energy companies using various financial and technology innovations to facilitate the distribution of solar products across the Africa. Overall, this private sector driven off-grid solar boom has made considerable gains in terms of addressing energy poverty and contributing to the United Nation's Sustainable Development Goal 7: "affordable, reliable, sustainable and modern energy access for all" by 2030.

Nevertheless, in the wake of this successful boom, there is an emerging question - what happens to these small-scale off-grid solar technologies when they break down?[5] Compounding this issue is the fact that the off-grid solar industry in many African countries has only limited regulation, meaning the quality of SEKs can vary greatly, with some products only having lifespans measured in terms of months. Even branded, quality-assured, SEKs usually have limited 1–2-year warranties and expected product-life spans of a few years.[iii]

As such, in the shadow of millions of SEKs and associated appliances sold since 2010, there is a wave of waste that most Africa countries are poorly equipped to deal with.[6] This is a concern as off-grid solar products contain various hazardous materials; for example, products can include lead, cadmium, mercury and sulphuric acid, which may cause serious adverse effects to humans and the environment if disposed of incorrectly.[7]

The off-grid solar industry, and its supporters, have become increasingly aware of this issue, and a range of different strategies and pilot initiatives have been launched that are directly focused on addressing waste issues, including refurbishment, repair and recycling schemes. This is a positive sign, and unsurprising, as the ethos of "social good" and "sustainability" are a central part of the broader industry's identity and approach,[8] and represent core values for many working within the sector.[9] Nevertheless, despite some laudable work by different companies in the sector, meaningfully addressing the issue of off-grid solar e-waste is still largely an aspirational objective, particularly outside major markets, and settings where SEKs without quality certification tend to proliferate. In this white paper, we consider how a repair approach is a vital aspect of a more sustainable off-grid solar sector by drawing on SolarAid's recent experience with repairing their off-grid solar products in Zambia.

The specific objectives that we are seeking to address in this paper are:

- An understanding of the current status of solar e-waste issues and repair in Zambia.
- Insight into the forms of solar repair that are currently occurring on the ground and the challenges that impede them.
- An appreciation of the forms of off-grid solar repair knowledge that exist and how they might be strengthened.
- Explore the viability and replicability of different models of repair that could be adopted in the off-grid solar sector.

This white paper explores pathways for how repair practices can be championed by last-mile solar distributors, and the off-grid solar sector more broadly. These findings have been derived from an analysis of SolarAid's *Solar Saver: second-generation lights* project in Zambia.

In its conclusion, this white paper maps out a series of recommendations for the off-grid solar sector – including off-grid solar distributors, off-grid solar manufacturers, governments, investors, and donors – in terms of what steps forward are needed to facilitate repair, and thereby provide customers with greater value for money, and greatly improve sustainable practices in Africa's off-grid solar sector.

[ii] This 2022 figure is a conservative number, as both industry sales numbers are incomplete and informal market size are likely to be underestimated.
[iii] The performance and durability of SEKs can vary considerably based on factors such as quality certification, maintenance and product type (e.g., SHSs typically last longer than solar lanterns). There is a pressing need for open access information on the durability of quality certified SEKs in order to better understand how they might vary compared to uncertified SEKs.

SOLAR E-WASTE: CURRENT INDUSTRY INITIATIVES AND KNOWLEDGE

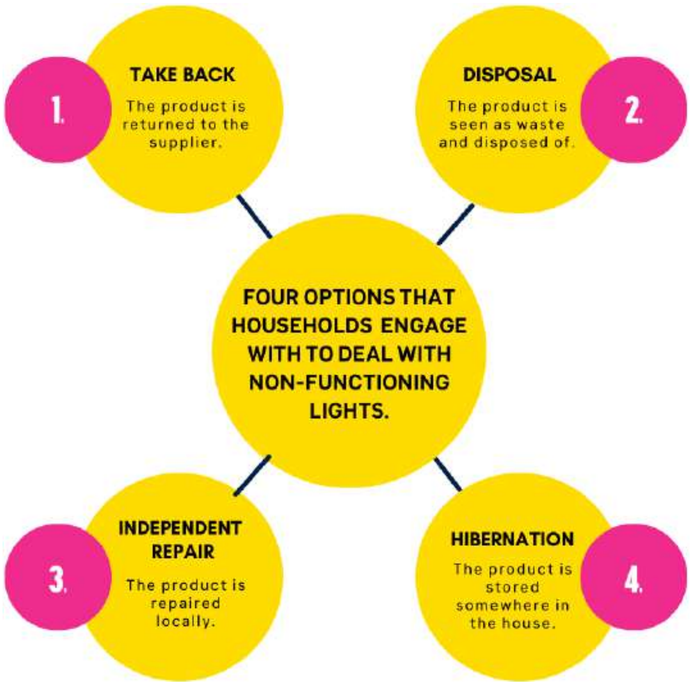
Solar e-waste in Africa has become an increasingly prominent issue since the late 2010s, with numerous reports and articles – industry and academic authored – focused on the subject, exploring different possibilities and challenges to addressing the issue.[10] Efficiency for Access – a global coalition to accelerate clean energy access through affordable, high performing and inclusive appliances an international not-for-profit organisation that advocates on appliances and equipment performance in the energy sector – and GOGLA – the industry association for the off-grid energy sector – have taken leading roles in fostering debates and addressing the growing solar e-waste problem.

GOGLA, for example, hosts a circularity working group to promote reductions in resource usage and minimising e-waste through a closed-loop system approach to the off-grid solar industry. As a part of this work, they have launched training modules on how to reduce solar e-waste in the sector.[11,12]

An early prominent initiative to tackle solar e-waste in the sector was the Efficiency for Access Global LEAP Solar E-Waste Challenge, which was a grant facility that was financed by USAID and the FCDO's Transformation Energy Access (TEA) Programme and administered by CLASP – an international not-for-profit organisation that advocates on appliances and equipment performance in the energy sector. Run across 2019 and 2020, this funding facility was focused on identifying innovations in e-waste management for the off-grid solar sector and awarding up to US$200,000 in grant funding for pilot projects. In the first round, four off-grid solar distribution companies and four recycling companies received funding to conduct pilot projects mainly focused on establishing systems of solar e-waste collection, recycling and refurbishment.[13] In the second round, four companies received funding for projects focused on improving battery performance in off-grid solar applications.[14]

Findings related to the Global LEAP Solar E-waste Challenge,[9,15] the Efficiency for Access Pathways to Repair in the Global Off-grid Solar Sector authored by Energy Saving Trust and Edinburgh University, as well as a series of other studies funded by USAID,[16] FCDO[17] GIZ,[18] NEFCO,[19] NORAD,[12] CDC Group (now British International Investment),[20] and various universities,[5–7,21–26] have provided important insights into guiding SolarAid's current work with solar e-waste in Zambia.

When SEKs cease to function, while some households may attempt DIY repairs with varying degrees of success, there usually four options that most engage with to deal with the product: 1) *Take-back* - The product is returned to the supplier (in particular, if under warranty), where the product will usually end up being repaired, replaced, refurbished, recycled or disposed of; 2) *Disposal* - The product is seen as waste and disposed of (usually informally); 3) *Independent Repair* - The household organises for the product to be repaired by a local repairer; and 4) *Hibernation* - The product is stored somewhere in the house, as the SEK is still seen as carrying (potential) value, despite its state of disrepair.[9]



One conclusion, across much of this existing research, is that the *recycling* of off-grid solar products is likely to only play a very minor role in addressing solar e-waste flows. This is for several reasons, including: 1) A lack of recycling infrastructure 2) It is expensive and logistically complex; 3) There is low resource value in the afterlives of many SEKs; and 4) There is limited capacity (and incentives) within the private sector to facilitate recycling practices. In most national settings there is a lack of relevant recycling infrastructure (and policy legislation) to be able to effectively recycle off-grid solar products,[17] meaning many materials need to be sent abroad for recycling that meets international standards.[19] This is logistically complicated and costly and carries its own environmental burdens (e.g., carbon emissions associated with transporting the materials). Also, considering the waste hierarchy, recycling is generally not the most sustainable approach as, compared to reuse and repair, more resources are wasted in the process. The necessary targeting of *rural* energy poverty accentuates this issue – SEKs tend to be highly distributed (i.e., last-mile distribution), making their collection both costly and complicated.[9,16,22,25–27] Their small size also means that their recyclable components often have relatively low resource value.[5,25,28] Overall, this has meant that many off-grid solar companies – particularly smaller operations – do not have the resources or capacity to implement collection programs.[15,19] Some bigger and more established companies have operations and procedures in place to deal with end-of-life products, including partnerships with recycling centres, yet even these are only able to collect a fraction of products.[7,9] As such only a very small percentage of off-grid solar e-waste reaches a formal recycler.[12] Regardless of these limitations, recycling undoubtedly has a role to play in addressing waste; however, in order to slow the flow of materials that need to be recycled, more work is needed in the areas of "prevention" and "extension" when it comes to solar e-waste (e.g., recyclable and repairable design of products, robust quality certification, and localised repair).[12,16] This is particularly pertinent for companies, as producer responsibility for waste flows is being an increasingly important policy area, as exemplified by the work of the Producer Responsibility Organisation (PRO) that was recently established in Kenya.

Repair approaches – which are used to extend the life of SEKs – are thus widely lauded in recent reports as being critical for achieving a more sustainable off-grid solar sector by reducing solar e-waste.[21,22,29] One phenomenon supporting the promise of greater repair, is that many of the existing studies have noted that many households chose to "hibernate" rather than discard (or even give up for recycling) their afterlife SEKs. Households still have an attachment to non-functioning off-grid solar products, or might believe that the products might have future value and use to them.[28] Thus, many afterlife SEKs are kept in storage, waiting for a future potential use.[5,21,23,28,30] While these stored products can present potential household hazards,[16,20] it does suggest that there is a ready, willing and materially available market for an off-grid solar repair sector. The challenge is to convert these hibernated products from"dead storage" into products that are either repaired, or at the very least harvested for parts, and thus ultimately incentives (e.g., affordable and accessible repair, payment for non-functioning products) are needed to encourage households to end the hibernation of their products. Time is a factor to consider here, the longer products are hibernated, the more likely they are to be dated (i.e., old design) and have less appeal in terms of being repaired.

There are two relatively distinct categories of Agents engaged in off-grid solar repair: 1) In-House: repairers employed or contracted by off-grid solar companies to enact repairs; 2) Third-Party: localised informal electronic repairs who have added SEKs to the repertoire of devices that they repair.[31,32] While there are overlaps between these two groups, there are also tensions.[31] The latter – the informal repairers – have the greater reach: geographically in terms of areas covered (including more remote locations), but also in terms of the range of solar products repaired, as they are brand agnostic. However, this raises also challenges as customers with branded SEKs risk invalidating their warranties by engaging the services of informal repairers. Thus, most off-grid solar companies do not actively support third party repair. This is further complicated by the fact that these operations can suffer from a lack of necessary tools, lack of access to spare parts and, paradoxically, access to electricity (e.g., to use soldering irons).[24] A lack of formal training also means they are potentially exposed (unnecessarily) to hazards during their work.[15]

The former – in-house operations with repairers employed by off-grid solar companies – tend to be more restricted as they only focus on their own range of products and their repair facilities are situated in urban centres. They are effective for dealing with products covered within warranty periods, they are less salient for products out of warranty. Off-grid solar companies also tend to initially replace products – and then repair, refurbish and resell – rather than repair products in situ – due to cost efficiencies and to reduce service interruptions to customers. They tend to control their products throughout their life cycle and are reluctant to use local informal repairers. This potentially relates to be concerns about the skills of informal repairers and thus the quality of their repair work.

PROBLEM	IN-HOUSE	THIRD PARTY
LACK OF TOOLS	Minor	Significant
TRUST	Significant	Significant
SKILLS GAP	Minor	Significant
DESIGN ISSUES	Significant	Significant
LACK OF DATA	Significant	Significant
LACK OF SPARE PARTS	Minor	Significant

Branded SEKs can also sometimes be designed in a manner that restricts informal repair, with propriety screws, locked systems and poor appliance interoperability with other solar products outside of their brand. On the one hand, these approaches can be justified in terms of ensuring product durability, maintaining integrity for warranties, and protecting internal fintech components. On the other hand, there have been some critiques that they can facilitate an unsustainable "repeat sales" business model of dealing with non-functioning products post-warranty.[29] There are thus both technical and economic issues that hinder the design and implementation of more repairable SEKs.

These structural barriers notwithstanding, there ultimately exists "a vibrant repair economy in sub-Saharan Africa that predominantly serves rural areas."[9,30] These informal repairers "are often closer to end users, especially if located in rural areas." And ultimately, largely due to the prohibitive cost of travel, people with "defective solar lamps are likely to try to have them repaired at one of these repair shops rather than at distributors that are located in urban or peri-urban centres".[16,27] The challenge is to augment the work of these existing repair enterprises in order to scale repair services in a manner that balances the need for off-grid solar companies to maintain control (e.g. over PAYG functions) and the community need for decentralised third-party repair services. This would provide greater value to customers and enhancing the sustainable impact in the off-grid solar sector. Existing research has noted key areas that need to be addressed for this to be realised, this includes: more repairable product designs (including certification and recognition for repairable design in the sector).[16] There are also broader international trends with the 'right to repair' movement, whereby repairable design is increasingly becoming a requirement in the European Union and other nations. More skills training for informal repairs (for material product repair, and for safe repair practices),[27] establishing greater trust between informal repairers and off-grid solar distibutors,[9,15,16] as well as trust between households and repairers, and finally more data on the geography and nature of off-grid solar disrepair in terms of where broken products are, what kinds of issues are driving products to break down, what kinds of local repair are occurring, and how this differs between formal and informal SEKs.[7,9,16,21]

This white paper now turns to insights from SolarAid's hybrid approach to repairing pico-solar products in rural regions of Zambia, incorporating both in-house and third-party repair. In line with broader trends across Africa, 1 these products reflect the vast majority of the over 2 million SEKs sold in Zambia since 2008,[24] and as such represent a large source of demand for repair services in rural and remote geographies.

SOLARAID

Organisational Overview

SolarAid is an international charity, established in 2006, with a vision to create a world where everyone has access to clean, renewable energy. Together its social enterprise, SunnyMoney, set up in 2008, it is committed to helping the world achieve universal access to solar powered light and electricity in underserved rural communities across Africa by 2030.

SolarAid has played a leading role in the development of the solar market in Africa. It was one of the first organisations to specialise in the sale and dissemination of small-scale solar products, supporting initiatives across Kenya, Tanzania, Uganda, Senegal, Madagascar, Malawi, and Zambia.

Establishing its operations in Zambia in 2008, SolarAid has played a critical 'market building' role, building trust awareness and demand for pico-solar lights and solar home systems across rural areas across the country. In partnership with rural schools, communities and through the development of a network of solar Agents, SunnyMoney has distributed over 400,000 off-grid solar products, directly impacting more than 2.2 million people in Zambia. This makes it one of the largest disseminators of solar products in Zambia to date, roughly accounting for 21% of all solar products sold.[24]

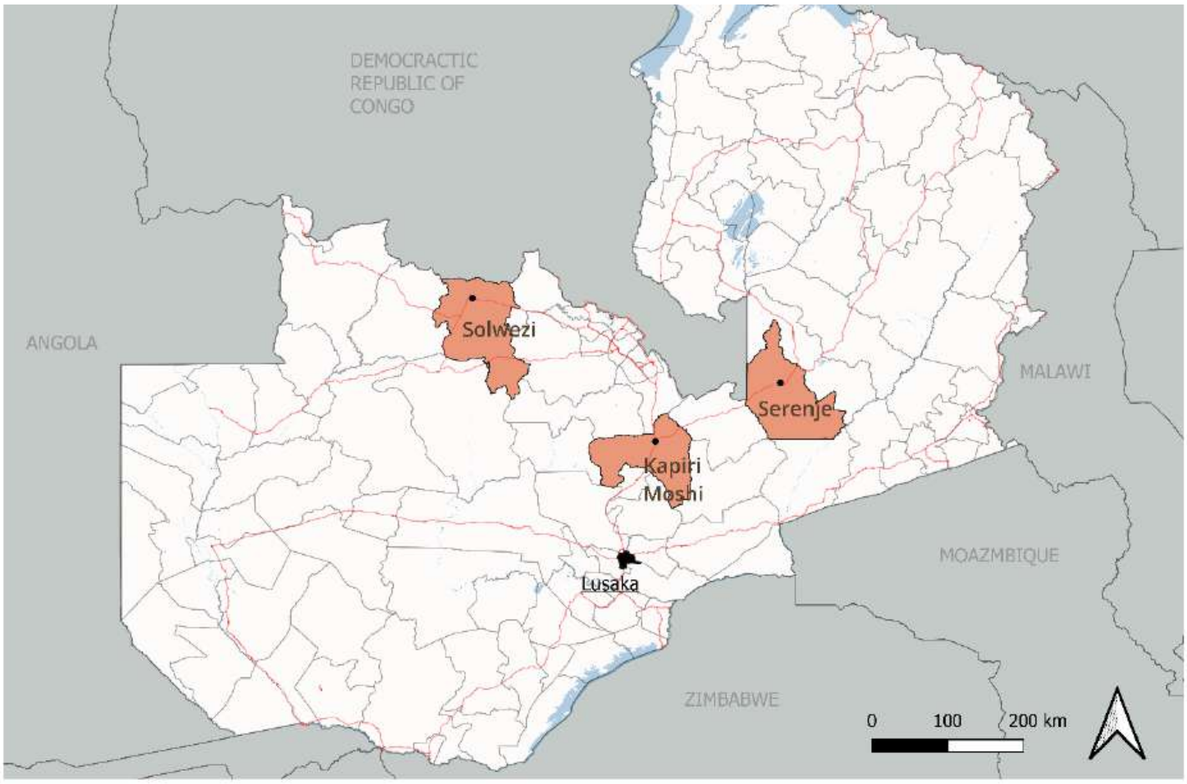
As a charity, focused on the development of sustainable, business-based solutions, SolarAid has been able to focus its efforts on low-income population segments based in remote, hard to reach, communities which purely commercial actors struggle to reach. Their work is designed to de-risk future investment by the private sector.

SolarAid has played a central role in testing with different strategies designed to extend the lifespan of small solar products, building repair capacity to benefit customers and reduce e-waste. SolarAid open sources its work so that learnings, knowledge and models can benefit and be adopted by the wider off-grid solar sector.

A key part of this work has been SolarAid's work trialling different approaches to address the issue of solar e-waste. This has included a partnership with the University of Edinburgh in 2018/2019 to pilot the distribution of *SolarWhat?!:* "a small portable solar lamp that is "easily repairable and powered by a mobile phone battery that is widely available across Africa".[22] SolarAid was a winner Solar E-Waste Challenge Winners of the 2019 Global LEAP Awards which provided pilot funding to conduct solar repair experiments across Zambia, including work with local Repair Technicians and building capacity to repair solar lights, as well as developing a repair mobile app to facilitate diagnosis and repair of solar lights by Technicians in rural areas.[33] In 2020 and 2021, SolarAid collaborated with the University of New South Wales to explore how notions of "right to repair" are applicable to Zambia and the broader off-grid solar sector. [24] John Keane – SolarAid's CEO – also conducted a peer-review for the influential *Pathways to Repair in the Global Off-Grid Solar Sector* report.

Most recently, with funding from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), on behalf of the Federal Ministry for Economic Cooperation and Development, SolarAid implemented the *Solar Saver: second-generation lights* project in 2022 and 2023. The project had the objective of extending the life of small solar lights through better maintenance and repair for low-income Zambians. This was realised via experimenting with interventions that address many of the issues of solar repair and waste reflected in the aforementioned literature. The project's work was focused within the districts of Serenje, Kapiri Mposhi and Solwezi in Zambia. This white paper examines the outcome of this project.

Case Study Sites



Location	Province	Population	Land Area (km2)	Pop Density (per km2)
Serenje District	Central	158,192	11,455	13.8
Kapiri Mposhi District	Central	371,068	9,688.20	38.3
Solwezi District	North Western	332,623	3,335.80	10.1
Zambia	**-**	**19,610,769**	**752,612**	**26.1**

Serenje District is located along the road connecting Lusaka (Zambia's capital) to southern Tanzania. The district is sparsely populated, with the majority of households being engaged in subsistence farming.

Kapiri Mposhi District is located relatively close to the capital city of Lusaka. A densely populated district, its district capital – Kapiri Mposhi Town – serves as a trade area that supports tobacco, wheat, maize and livestock enterprises.

Solwezi District is sparsely populated district in north-west Zambia, bordering the Democratic Republic of Congo. Solwezi is a mining region, copper is the main mineral extracted although cobalt, gold and uranium are also mined near its district capital, Solwezi Town.

Project Methodology

The *Solar Saver: second-generation lights* project covered repairs in smaller SEKs – that align with SolarAid's portfolio – including solar lamps, and smaller plug-n-play solar home systems (up to 12Wp). The project was brand agnostic, and repaired non-SolarAid products, including informal SEKs.

The project had two key facets. The first was focused on training locally based repairers. This included training sales Agents who were already selling SolarAid off-grid solar products ("Repair Agents"), meaning that they can add "product repair" as an additional service they can offer their customer base. Fifteen (15) Agents were trained in total. The project also trained five "Repair Technicians" and worked with them to add solar repairs to their existing services. This included establishing a repair centre at the Solwezi Trades Technical School. These Technicians, who were already involved in electronic (and solar) repair in their communities, were targeted with the aim of enhancing their existing skills and promoting safe repair practices. The project also involved sourcing and importing replacement parts for solar lights (e.g., batteries and printed circuit boards (PCBs)), with the objective of kickstarting a supply chain for affordable, high-quality spare parts for the Repair Technicians. Repair Agents and Repair Technicians also received repair kits: featuring screwdrivers, a multimeter, pliers, hex keys and safety gloves and glasses. The second facet of the project involved hosting "repair days" across the three target districts. On these solar repair days – held in publicly accessible locations in each of the three districts - customers were encouraged to bring along any faulty solar products, and Repair Technicians diagnose and repair the products where possible. These days had multiple objectives. First, there was an effort to foster greater *trust* between households and repairer to help facilitate a greater repair culture. This includes increasing awareness about the possibility of repair. Second, they provided an invaluable data source on what the most common faults with pico-solar lights are, information that SolarAid is using to further their *SunnyMoney Repair Guide*, a mobile app that allows customers and Technicians to troubleshoot problems with their solar lights. Finally, there was an opportunity to repair solar lights and extend the life of off-grid solar products. Throughout the project 296 lights were repaired by Repair Technicians on repair days. A further 798 lights were repaired at the SolarAid office in Lusaka. The large number of repairs conducted in the main workshop in Lusaka reflect the lack of repair centres across several rural sales regions in Zambia – this can result in a protracted and centralised repair process as sales Agents must collect and return products to customers once repairs are completed. "Repair days", training 'Repair Agents' and the inclusion of third-party repairers in this project represent interventions to place less reliance on this centralised approach. In total, 1,094 lights were repaired during the project period (2022-2023). This included SEKs sold by SolarAid (85%), as well as informal SEKs (15%).

To help understand the impacts of the project, baseline and endline research fieldwork was conducted. Baseline research was conducted in March-April 2022, and the endline research was conducted one year later. The field research was conducted in Zambia's Solwezi District, as well as additional research being conducted in Serenje and Kapiri Mposhi districts to provide a broader geographical focus. All three districts are locations where SunnyMoney has sold a substantial number of products. Customers were randomly selected to be a part of the survey based on being a previous SunnyMoney customer physically located in the target district where activities such as repair days and repair shops were situated. The participants needed to have purchased a solar light from SunnyMoney within the past 10 years.

The research targeted three key stakeholder groups, each aligned with the research objectives. The first targeted research group was a household survey with off-grid solar customers to gather insights into what kinds of solar products they owned, their experience with off-grid solar product disrepair, and the strategies and experiences they might have adopted (or not) to mend their solar devices. In total, 483 household surveys were conducted; 238 in 2022; and 245 in 2023. The second target group were Repair Technicians. Structured interviews were conducted with 10 Repair Technicians (5 in 2022; and 5 in 2023) to gather insights on the experiences and challenges of repairing devices that they encountered in their work. The final targeted group were students at the Solwezi Trades Technical School to gauge their knowledge, interest, and experience in repairing off-grid solar products, 44 student interviews were conducted across 2022 and 2023.

Repair Technician Rodgers Mwamba during the Repair days in Kapiri Mposhi, Zambia. Photo: SolarAid/Jamil Banda

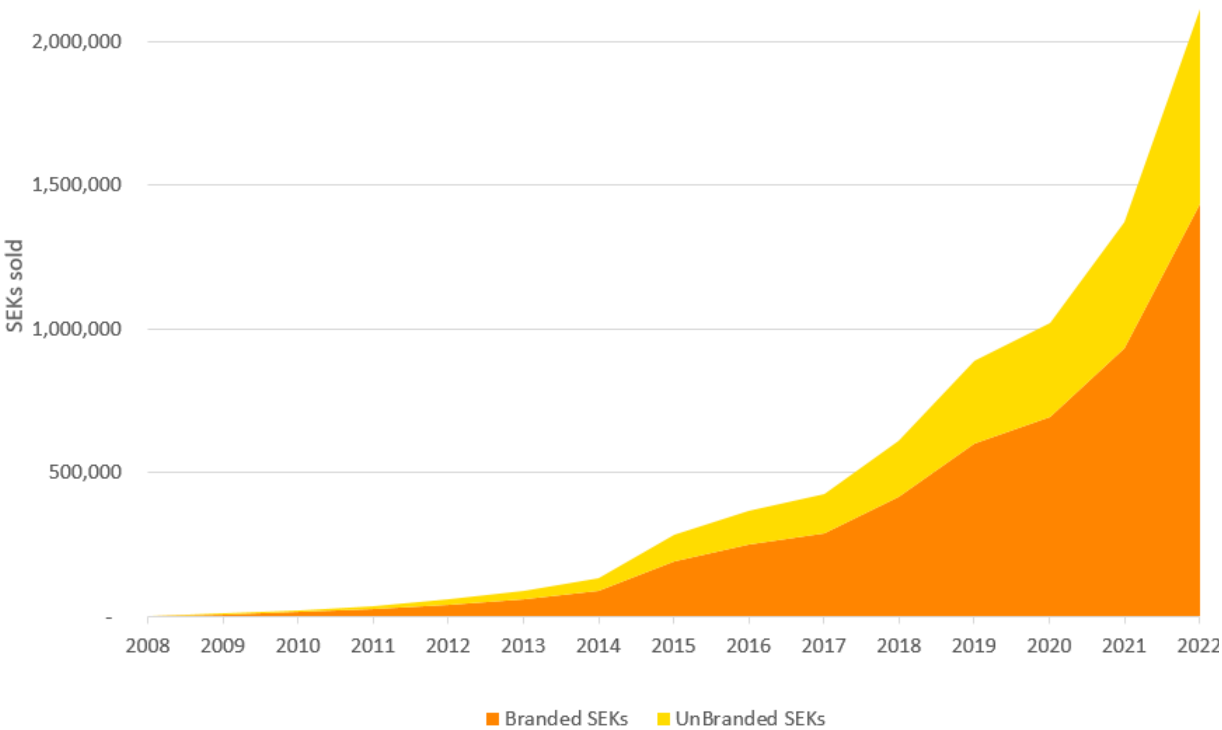


Figure 2 – Cumulative sales of solar energy kits (SEKs) in Zambia: 2008 to 2022.[24]

OFF GRID SOLAR WASTE AND REPAIR IN ZAMBIA

Background

Currently, around 45% of the Zambian population has direct access to the electricity grid,[34] with electricity access rates falling below 15% when just the country's rural population is considered. Around 95% of the country's electricity comes from hydroelectric sources;[35] however, in recent years, this source of electricity has been affected by recurring droughts linked to climate change that have adversely impacted hydroelectric performance.[34] As such, the minority of the population with access to grid-based electricity experience an increasingly expensive and unreliable supply.[34]

In response to these issues of access and reliability, similar to other parts of Africa, a market in the sale of solar energy kits (SEKs) has emerged in Zambia over the past decade. SolarAid, through its enterprise SunnyMoney, has sold SEKs since 2008, and since this time it has been joined by an assortment of off-grid solar companies, including Vitalite, Total, Kazang/Azuri, Fenix International (now ENGIE Energy Access) and WidEnergy. All of them with international financial backing. There is diversity across these companies in terms of their sales and financing strategies, the geographical regions of Zambia they focus their sales in, as well as the size of the SEKs they sell.[24,36]

Alongside and in parallel with the growth of the investor-backed off-grid solar industry has been the emergence of a copycat, non-quality verified SEK market. These products, which often derive their designs from some leading solar product manufacturers, are commonly produced under unrecognised brand names, without quality certifications and warranties, making their quality more ambiguous.[37] They are sold at cheaper price points than quality verified brands by hardware stores, street vendors and informal purveyors.[24] According to one industry estimate, the size of this unbranded solar market in Zambia is said to be 31.8% of solar products sold.[2] It is a similar story elsewhere across Africa, with the rise of unbranded, non-quality verified SEKs within the market creating additional challenges for addressing solar e-waste. Not only do these products tend to have more limited lifespans, but there is also a lack of a central company or organisation to offer reliable warranties and repair.

More than 2 million SEKs – branded and unbranded – have been sold in Zambia since 2008 (see Figure 2).

Households

Off-grid solar products were a prevalent feature of the household surveys, not just in percentage of households using SEKs (every household surveyed owned an off-grid solar product), but also by the prevalence in the number of SEKs owned. Three-quarters (75%) of the households surveyed across field research visits (n=484) reported owning at least two SEKs. An impressive 24% of households stated that they owned five or more SEKs (mostly solar lamps, or small (12Wp or less) SHSs), likely a case of product stacking (using different SEKs for different rooms or different functions). This suggests that the future flow of off-grid solar products into waste has the potential to be immense and is not captured by census data (which only looks at the *main* source of lighting), nor industry sales figures which do not capture the full extent of sales in the informal off-grid solar market.

In terms of product durability, the vast majority of now broken SEKs ceased functioning within three years of purchase (see Figure 3), which aligns with what has been observed in other studies.[17,28] There is some negative bias to the graph, as it only included customers with broken lights (about 50% of those surveyed), 22% reported that their lights were still working, while a further 27% were unsure, so the data for this cohort could not be captured. The SEKs failing within 2 years of purchase are covered by warranty, and the survey included questions with customers about the functioning of this service. Results range from mixed to positive. Around 39% reported that they were still holding onto their receipt, and 57% reported that they knew who to call if they wished to enact their warranty. Nevertheless, in discussion some indicated they would like more information on their warranty, as well as more training on how to best use their products so they would last longer (and thus avoid the need for warranty claims). Some customers also indicated that they wanted to receive a communication reminder when their warranty was approaching expiration.

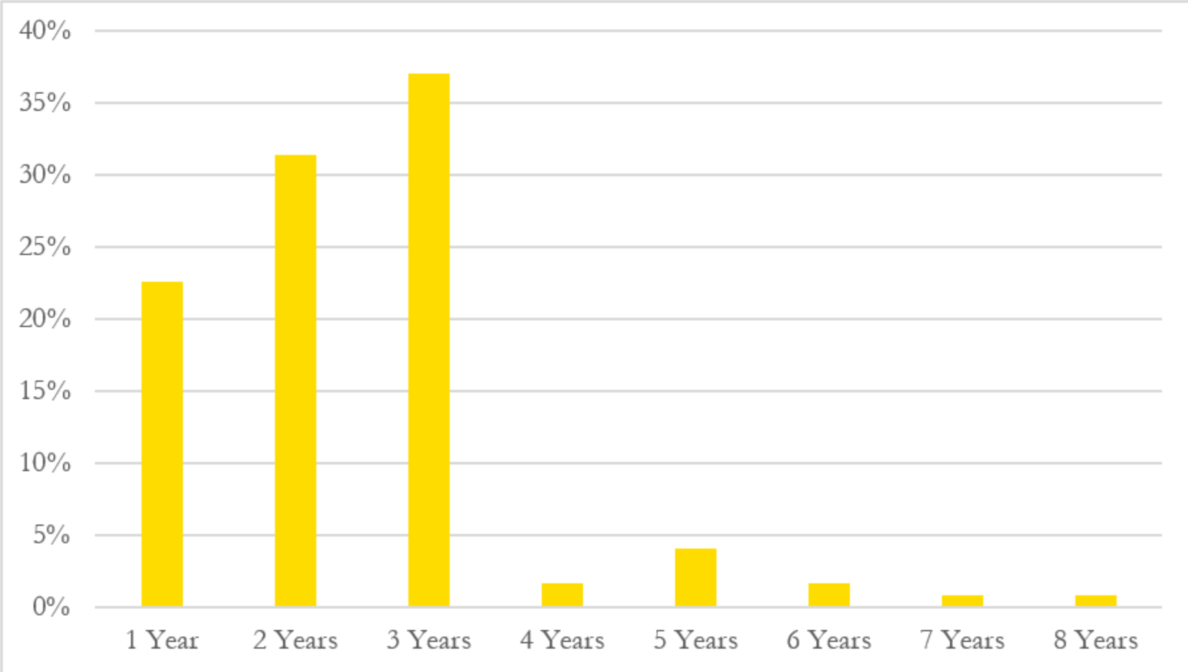


Figure 3 - Response to question (for customers with broken lights) how long did your SEKs last? The vast majority of these products were solar lanterns, with some small SHSs (12Wp of less).

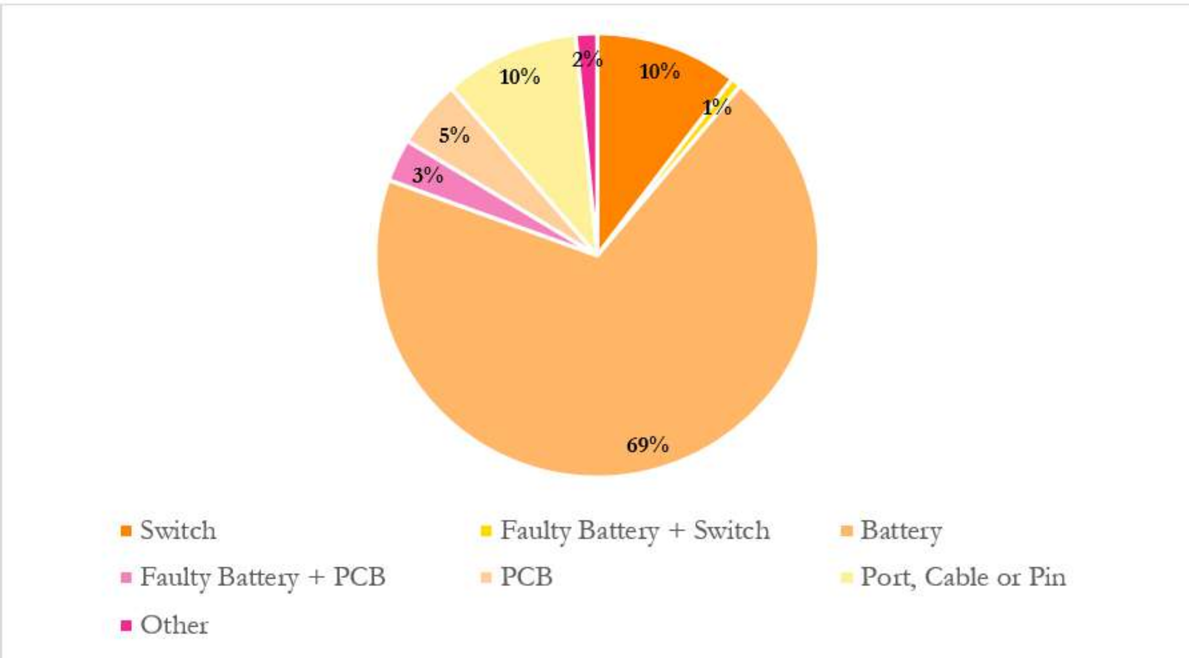


Figure 4 - Diagnosed faults in SEKs by SunnyMoney Repairers.

During the repair days, a nuanced breakdown of the different disrepair issues were identified across the products brought in for repair. Faulty batteries were by far the biggest issue, with 73.1% of products brought in experiencing battery issues. Faulty switches (11.4%) and faulty printed circuit boards (PCBs) (8.0%) were also relatively common issues, as well as problems with charging cables, ports, and pins (9.8%) (see Figure 4). **Impressively, however, Technicians were able to repair 91.3% of these products (e.g., battery replacements, fixing wires, replacing switches), meaning that extending the life of most these products was relatively straightforward when the necessary skills, spare parts and tools were available.** The cost of repairs (including parts and labour) varied between 10 and 280 Zambia Kwacha (US$0.45 to US$13.15), with a median repair cost of 60 Zambia Kwacha (US$2.80). The median cost of repair was 31% of the price of purchasing a replacement product, across a range of 1% to 88% (i.e., repair was always cheaper than replacement).[iv] The 1% cost of repair was simply fixing a wire in a SHS, while the more expensive repair (i.e., around 88%) tended to be for replacing batteries in small solar lanterns.

Since the trained Repair Technicians were able to repair the vast majority of products, there was a significant increase in households reporting that they had functioning products before and after the project. During the baseline survey, only 30.7% of households said their lights were still functioning; however, this figure increased considerably with the endline survey with 89.3% of households reporting that they had functioning lights. This shift is almost certainly the result of the SunnyMoney repair days being successful. Indeed, another significant shift between the two surveys was with respect to the level of trust in (and awareness of) repairers. In the 2022 baseline, 43.1% of households indicated they would consider taking their products to a Repair Technician, which increased to 85.1% in the 2023 endline survey (after the "repair days" had been conducted). However, this "yes" came with caveats from some households, noting they would prefer a SunnyMoney Repair Agent (rather than an independent Technician) to repair their products, as they believe that they had the requisite knowledge. Another notable shift was in households trying to fix their own products – in the baseline survey, 25% claimed they were active in trying to fix their off-grid solar products when they stopped functioning. In the endline, only 2% claimed this. This suggests that overall, households expressed a stronger preference towards using 'experts' (e.g., Repair Agents and Technicians) for fixing solar products. Overall, this is a remarkable shift in repair culture during the short timeframe of the project.

In terms of the households stating that they would not consider repair (across both surveys), many claimed that the Technicians in their area were not competent enough to repair solar lights, while others highlighted that the distance to reach qualified Technicians was too far, making it an inconvenient option. Therefore, even for those not opting for repair, it was not necessarily a question of a lack of interest in repair, but rather a lack of options (real or perceived) in their locales as well as a potential lack of awareness. The need for repair was also less urgent in some households, as they owned multiple solar products (e.g., 24% of households owning five or more off-grid solar products) and therefore having non-function solar products was a part of their household bricolage of electricity infrastructure.[39]

The hibernation of solar products in disrepair (i.e., storing non-functioning off-grid solar device) was widespread in the household survey. In the endline survey, 89% of households stated that they held on to products that ceased functioning. Even then, of the 11% that said they "disposed" of their products, not all end up in the waste stream. Several households perceived the category of "disposal" as including actions such as giving their non-functioning solar products to their children to use as toys. As noted earlier in this white paper, in our review of existing studies, this appears to be the norm across much of Africa – there is a tendency to hold on to non-functioning solar products. There is thus a great stockpile of SEKs in communities that have the potential to be repaired – which would enhance both energy access and reduce waste.

Overall, the information gathered through the household surveys indicates that strengthening cultures of repair around SEKs has the potential for great impact. With just a handful of "repair days" the *Solar Saver: second-generation lights* project was able to engender a significant shift in actions and attitudes for customers in terms of repairing their off-grid solar products. The challenge, of course, is to understand if this is a repair culture that is deeply engrained, or a more ephemeral one, sparked by the project. The high repairability of the products (more than 9 in 10 repaired) also indicates that there is significant sustainable. Thus, while the relatively short working lives of many solar products (as seen in Figure 3), there are clear pathways and opportunities to extend the lives of many solar products (as seen in Figure 3), there are clear pathways and

[iv] A recent study by CLASP in Kenya (albeit focused on appliances, rather than SEKs), founded that 70% of respondents where willing to pay 20% of the appliance cost as the service/repair fee; 25% were willing to pay between 21-40%; and while the remainder were willing to pay more than 40%.[38]

Repair Technician Rodgers Mwamba repairing Peggy Hamalambo's solar light during the Repair days in Kapiri Mposhi Zambia. Photo: SolarAid/Jamil Banda

opportunities to extend lives of many solar products (as seen in Figure 3), there are clear pathways and opportunities to extend the lives of these products substantially given the right local repair geographies and conditions.

Repairers

To gauge the current capacity, the project included structured interviews with informal Repair Technicians working across the three districts (n=10) as well as will students studying at the Solwezi Trades Technical School. In terms of the Repair Technicians, most (n=9) had been working in electronics Repair for more than 5 years (and indeed many (n=7) had been working in the area for more than 10 years). Prior to the SunnyMoney project, however, only about half of the Technicians had formal training repair in off-grid solar products. The others had learnt through experimentation.

The repairers raised numerous issues that shape their ability to conduct off-grid solar repair. **One of the most critical things that they raised (at the start of the project) was a lack of spare parts, particularly batteries.** They noted how obtaining batteries for solar lanterns is a significant challenge, which could ultimately cause delays. A broader issue that they noted in relation to this, is that they did not have direct contact with suppliers in the off-grid sector. Rather, they had to access spare parts through informal supply chains, with many of the Technicians noting that having access to suppliers would enable them to source spare parts quickly and efficiently. This contact would also help them to understand the technical specifications of spare parts better, enabling them to make more informed decisions when selecting components for repairs. This knowledge could ultimately help Repair Technicians become more efficient and effective in their work.

The *Solar Saver: second-generation lights* project helped to address this issue, and as a part of the project batteries and printed circuit boards (PCBs) were imported into Zambia from China (800 batteries and 30 PCBs) and distributed to Repair Technicians. However, even SunnyMoney struggled with access to spare parts as it took a while to source them from 3rd party suppliers (not product manufacturers), resorting to costly (but necessary) air freight to meet project timelines. Technicians interviewed for the endline survey had said their access to spare parts had improved considerably (thanks to *the Solar Saver* project); however, the challenge is in terms of how these supply chains operate in future without the direct support of a targeted project.

The second major issue the Technicians raised was in relation to the availability of tools. Repairing electronic devices requires specialized equipment and tools, which were not readily available to Repair Technicians (at least prior to the project's implementation). This unavailability of tools hindered the repair process and made it more challenging to diagnose and fix the problem. The Repair Technicians also noted that they might require additional training to develop the necessary skills to handle advanced tools and equipment. Again, these issues were addressed by the *Solar Saver: second-generation lights* project, which supplied specialist tools to Repair Technicians (and Repair Agents). The challenge again, however, is to make sure that similar tools are available for any future Technicians looking to move into the solar repair market.

The final issue that the Technicians raised was in terms of how some solar products were more difficult to repair than others. For example, they noted that some solar products were easier to open and repair than others. SEK designs that allowed for ease of opening ultimately allowed for the streamlining of the Technicians' work, reducing the time required to diagnose and fix faults (and ultimately, the cost). As noted earlier in the review of research, this "difficult access" of SEKs is sometimes a purposeful part of solar product design – companies want to "seal-off" internal components for a range of valid quality, warranty, and proprietary reasons. Nevertheless, it is evident that conducive **design is critical for the repairability of a product.** A challenge is to find ways to balance durability and warranty needs (i.e., sealed components) with more options for repairable design.

Beyond the technical, there were some logistical and economic elements that hindered solar repair. Some Technicians raised issues relating to the ability of customers to pay for repair services. They noted that customers can often have financial constraints in affording repair charges, which could hinder the timely fixing of their solar lanterns. They also noted that not all customers had ready access to repair services, many customers live in remote and relatively inaccessible locations, making it a challenge for Technicians to reach some customers in need of repair services.

A couple of considerations around gender emerged during the project. First, there were major challenges in the selection of Repair Technicians. Despite SolarAid's active efforts, they were **unable to find female Technicians that could be assessed and involved in the project** – thus, all Repair Technicians involved in the project were men. SolarAid was, however, able to train some of its women Agents in repair, and subsequently 5 (of the 15) Agents who were trained as "Repair Agents" were women. In interviews, Repair Technicians estimated that the majority of their customers were men (around a ratio of 65:35 men to women). A similar dynamic played out during SunnyMoney's repair days, with 68.7% of customers being men (and 31.3% being women). This ratio potentially sits in tension with the main users of energy products. As a recent study in Kenya has shown, while men are often the main household members involved in purchasing energy products (including solar), it is women and children – who are generally based in the house for much of the day – who tend to be the main users of these products,[40] and therefore have more experience and a nuanced understanding of the functioning of SEKs. Although questions relating to gender and trust in Technicians were not asked as a part of this project, it is possible that having more local women Repair Technicians could increase the confidence of many (female-led) households in engaging in repair practices.[v]

Interviews conducted with students (n=22) at the Solwezi Trades and Technical Institute at the beginning of the project offered some insights into existing off-grid repair knowledge in rural technical training colleges. The students were nearly unanimous in having an interest in learning more about solar repair. Of the 22 students engaged, only 2 had received any formal training in the repair of solar products (and these were the only 2 students who reported themselves as having "expert knowledge" in solar repair). About half of the students (n=10) indicated that they had basic or limited knowledge of solar repair, and that this was learnt informally (i.e., learning from friends and family) or self-taught (watching videos; trial and error). The latter indicates the high applicability of the SolarAid solar repair app, its utility is also reflected in it being downloaded 11,368 times during the project period. Indeed, the Repair Technicians also gave feedback on the app, indicating that they used it regularly during the first few weeks of conducting repairs, and then eventually graduating (after information had been memorised) to only using it to clarify certain fixes. They also advocated for the inclusion of additional SEKs in the app.

Finally, this research also surfaced important considerations regarding b**oth the quality of repairs and safety practices.** Overall, there were significant differences between the repairs conducted by Technicians trained and supported by SolarAid (both in-house and external Technicians) and those that weren't. Most of these differences stemmed from a lack of repair guidance for particular SEKs (e.g., a repair manual), access to specific tools (e.g., hex keys), the availability of spare parts (e.g., batteries), and a lack of safety equipment (e.g., gloves, safety goggles and boots). Interviews with non-trained Technicians revealed that these deficiencies could yield a range of negative outcomes.

[v] There are a number of considerations that need to be taken account. We were informed about another project (not in Zambia) where women Technicians were in great danger of being mistreated when they entered a home of a male customer to check the solar light. So, there are potential safety issues as well.

One example included accidentally damaging internal components during acts of repair, which could also pose safety risks. Another example included resorting to rudimentary practices to overcome a lack of access to spare parts such as the wiring of non-rechargeable batteries to battery terminals (with batteries dangling outside the main body of the SEK) – severely compromising quality, posing safety risks for their customers and damaging trust. There are also concerns around the use of soldering irons,[vi] a critical tool in SEKs repair work, without adequate safety equipment such as gloves and goggles. All this underscores the impact of SolarAid's interventions – to offer training, repair kits and access to spare parts to Repair Technicians – on the quality and safety of local repair services.

Overall, it is evident that there is interest and capacity for SEK repair across Zambia, and with strategic interventions and training this capacity can be further enhanced. The supply of spare parts and tools is an ongoing issue for repairers, and while the *Solar Saver: second-generation lights* project was able to address these issues during implementation, evidently more work is needed in Zambia (and across Africa) to improve these supply chains. The design of solar products is a critical consideration in relation to repair, Repair Technicians had an evident preference for off-grid solar products in terms of their ease of repair. While gender was not specifically targeted in this project, some of the data indicates that this is an area that needs to be explored with more nuance in future – how might having women Technicians shape household responses – especially as men and women tend to experience energy differently within Zambia households.[41,42]

Repair Technician Brian Nongo, Zambia. Photo: SolarAid/Jamil Banda

[vi]New solar-powered soldering iron technologies potentially have a strategic role to play in this repair space.

CONCLUSION AND RECOMMENDATIONS

An estimated 150 million solar energy kits (branded and unbranded) have been distributed across Africa since 2010.[1]

Data on the average lifespan of these products suggests at least 110 million of these SEKs have likely ceased functioning.

The potential to recycle these products is extremely limited and ultimately costly. Unsurprisingly, only around 1% of broken-down solar products find their ways into formal recycling schemes in Africa.[12] There is a pressing need and opportunity to build repair capability across Africa's off-grid solar sector.

A vibrant repair economy across much of Africa and represents an opportunity to extend the life of SEKs across the continent with the potential to benefit millions of customers while also reducing e-waste and improving the sector's overall sustainability.

To achieve this, a range of barriers must be overcome. These include:

- Improved customer access to skilled repairers with both the know-how and tools for solar repair.
- Repair must be affordable for customers while offering a viable business model for off-grid companies and third-party Technicians to adopt. External donor support and supportive policies will be required to strike this balance.
- Quality spare parts need to be affordable and widely available.

Despite these barriers, the opportunities in the SEKs repair space are significant. As observed in this and other studies,[9,30,37] the fact that the vast majority of households tend to 'hibernate' rather than 'dispose' of their non-functioning solar products could mean there are tens of millions of SEKs currently in 'hibernation,' waiting to be repaired, rather than disposed of as e-waste.

With over 90% of the non-functioning products within SolarAid's repair project in Zambia successfully repaired, the potential to bring tens of millions of products back to full functionality is high. There is, therefore, clearly a potential business opportunity focused on repair which needs to be further explored. There is also, arguably, a moral obligation to extend SEK repair services to benefit last-mile customers and an opportunity to reduce the number of non-functioning products contributing to e-waste.

Realising this potential is contingent, however, on repair networks being strengthened through access to necessary know-how, tools, and spare parts. Repair services also need to be both affordable and economically viable.

We offer six key recommendations which will help establish a vibrant repair economy for SEKs in Africa:

1. Repair as a core principle in the off-grid solar sector. The manufacturers and distributors of SEKs need to make repair an integral part of their operations, including when products fall outside of their warranty periods. There are several ways this can be realised:

- Prioritise designing and selling repairable solar products and advocate for repairable designs in local and international forums.
- Distributors can incorporate basic training on repair as a part of sales training and provide pathways for sales Agents to add repair skills to their repertoire of services at the last mile.
- Opportunities to set up decentralised repair training centres, including partnerships with rural vocational training centres/technical colleges, should be explored to enhance repair expertise locally, particularly in rural geographies. This will also help to address the repair of informal SEKs.
- Support supply chains so spare parts and repair tools are readily available in the country of sale.
- Potential for collaboration between competing last-mile distributors to achieve cost efficiencies.

2. Test the economic viability of a range of business models for localised SEK repair. This study has established the *theoretical* scale and potential of a repair business model for SEKs in Africa. The next critical step to test this *empirically* through pilot trials, including a focus on the two models that were experimented in this study – repair through "Repair Agents" (i.e., in-house repair) and repair through "Repair Technicians" (external decentralised repair). Results from future trials should be open access, with insights being used to inform and de-risk broader off-grid solar sector interventions. As recent research has indicated, off-grid solar investors have been reluctant to enforce extended producer responsibility in relation to solar e-waste, largely due to broader struggles with profitability in the sector,[6] although these have been some recent shifts. Open data and evidence from piloted business trials in the repair space will help to sway this reluctance.

N.B. SolarAid is currently in the design phase of its next pilot to test the economic viability of both repair models to share more informed adoption scenarios with the off-grid energy sector. They will seek technical assistance and funding to ensure this phase is delivered for maximum impact.

3. Improve solar product repair standards. There needs to be a greater emphasis on repairability in the design of off-grid solar products. Efficiency for Access is working on a new repairability index for appliances that could be used as additional criteria to complement safety, quality and truth in advertising presently considered in appliance quality assurance frameworks (e.g. Verasol). It is evident that this work needs to be continued and expanded. Standardisation of frequently failing parts such as batteries, cables and connectors should also be considered.

In this study, it was shown that there was substantial variation in the repairability of different SEKs. A publicly available repairability rating of different SEKs would help guide off-grid solar manufacturers, distributors and investors in terms of their actions and operations. Standards can provide a critical structure for industry-wide shifts in repairability practice. GOGLA has done some notable initial work in this space relating to interoperability, with its *Connect White Paper* advocating for universal connector and firmware with SHSs.[43]

4. Enabling environments for repair. Greater collective efforts are needed to ensure spare parts are available in targeted countries. While this has been a recognised need for a long time, it must be revisited. Since 2014, off-grid solar companies, which are GOGLA members, have publicly committed to making spare parts available. However, as has been reported, this does not always happen in practice.[9] Commitment needs to be revisited and restabilised.

There is also an opportunity to support local industry associations to lobby Governments for preferential taxes and tariffs on spares to improve the economic viability of repair. To the greatest extent that is feasible, manufacturers should opt for designs that are amenable to repair and involve components that are widely available in target markets.

5. Expand functionality of the Repair App. Feedback from Repair Technicians in the Zambia project, alongside the increasingly widespread adoption of smartphones across Africa, make a strong case for the continued development of the SolarAid repair app, to help expand repair capability and impact across the continent.

N.B. The repair app has so far catered to products within the rural Zambian context, featuring guidance for both pico solar and SHS products. Within the current design phase of the next project, mentioned in recommendation 2, SolarAid will be engaging with sector partners to explore the continental adoption of this app, which has the ability to feature any product type (including productive use appliances) for repair purposes.

6. Continuing research on solar repair. Good repair interventions need to be informed by rigorous data and context-specific insights. There is great heterogeneity across Africa and within each nation regarding how off-grid solar markets operate and what types of local repair economies and capacities might exist. It is critical that research continues to help understand these intricacies and inform sustainable models to repairing SEKs. The relationship between gender and solar repair, for example, is a noticeable gap in this research. Women are often the main users of SEKs in a household setting; however, in many contexts, men often decide and purchase SEKs and engage solar Repair Technicians (who are mainly men as well). This gendered bifurcation of use and repair could have implications regarding trust and actions taken to repair SEKs that need to be better understood. More research is also needed on the informal SEK sector, and how best to incorporate repair practices in relation to these products.

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