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STATE OF REPAIR IN THE OFF-GRID SOLAR SECTOR



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Glossary of Terms

Component-based system - A solar system that is composed of distinct, interchangeable components e.g. a solar panel, inverter and battery, that can be individually selected, assembled, and replaced as needed

Distributors - Companies or entities that purchase solar products from manufacturers and sell them to retailers, installers, or end-users

Donors - Organisations or individuals that provide financial or material support for off-grid solar projects, often with a focus on social impact and sustainability. Donors can include NGOs, foundations, and philanthropic entities

Investors - Individuals or entities that provide capital for off-grid solar projects or companies, through debt or equity investments, in exchange for financial returns. Impact investors may trade lower financial returns for demonstrated social or environmental impact.

Manufacturers - Include companies that produce off-grid solar products such as solar lights and solar home systems. It can also include companies that produce solar components such as panels, inverters, batteries, and other related equipment. They are responsible for the design, production, and quality control of these products

National Renewable Energy Associations (NREAs) - Organisations at the national level that promote the adoption and development of renewable energy technologies, including solar power. They often engage in advocacy, policy development, and industry support.

Original Equipment Manufacturer (OEM) - A company that produces complete solar systems, parts or components that are used in another company's solar products

Pay-As-You-Go (PAYG) - A financing model that allows customers to pay for solar energy systems in small, regular instalments rather than upfront. This model is particularly popular in off-grid markets, as an approach to make solar energy more accessible to low-income households.

Plug-n-play Solar Systems - A complete pre-packaged solar system that can be easily installed and used without extensive technical knowledge

Productive Use Technologies - Technologies that enable the use of solar energy for income-generating activities, such as solar-powered irrigation systems, refrigeration for agricultural products, and solar-powered machinery.

Solar Energy Kits (SEKs) - Pre-packaged off-grid solar kits that include all necessary components for setting up a basic solar power system.

Verasol - VeraSol is a quality assurance program that ensures that off-grid solar products meet international standards for quality, durability and performance.

Vertically Integrated Company - A vertically integrated solar company is a company that controls multiple stages of the solar energy supply chain, from the production of solar panels to their sale and distribution.

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Executive Summary

Of the 375 million solar energy kits that have been sold and distributed to off-grid populations around the world by the formal off-grid solar sector since the early 2000s, more than 250 million are estimated to have fallen into disrepair. Thus, while the sector has made some notable contributions to the United Nation's Sustainable Development Goal 7 of "affordable, reliable, sustainable and modern energy access for all" by 2030, the widespread presence of broken-down products tarnishes this achievement. This is particularly problematic for an industry that prides itself and trades on being sustainable. The recent expansion and growth in the adoption of off-grid solar appliances is further exacerbating this sectoral e-waste challenge.

The positive news is that many of these broken products are readily repairable (more than 90% according to a recent study), and most households tend to hold onto broken solar products in the hope they can be fixed in future. Therefore, there are clear opportunities for the sector to expand its work into solar repair, which would result in improved household energy access, enhanced sector reputation and more sustainable praxis.

There are many companies, investors, organisations and people within the off-grid solar sector who have been experimenting with remarkably innovative approaches for enhancing repair in their operations. Yet the sector needs to improve the ways in which it openly shares experiences - its challenges, its failures, its breakthroughs and successes. This formed the impetus for this study and report, to provide a snapshot of what the sector is currently doing in terms of off-grid solar repair, as well as to serve as a catalyst for developing new ideas and recommendations for off-grid solar repair, paving the way for sector-led initiatives to collaboratively address these pressing challenges. The research basis of this report draws from a sector-wide survey conducted in September 2024, which 75 different stakeholders – from companies and organisations operating in 31 countries – responded to.

Key insights from the survey include:

- 90% of all off-grid distributors are already delivering some kind of repair service as a part of their operations (most of the other 10% expressed a desire to deliver these services, but were early-stage firms that were not yet in financial position to do so).
- Batteries are by far the most likely failure point in off-grid solar products, sometimes causing a product to become obsolescent even when all other components are perfectly functional.
- Access to spare parts is a major logistical challenge for off-grid solar distributors across the Global South.
- New, replicable, business models are needed to increase repair services to the last mile.
- There are differing perspectives between manufacturers and distributors in terms of how repair is currently operating, and who should be conducting repairs – this has resulted in some tensions.
- There is an increasing interest in repairable design as a core approach for the sector.

Key recommendations emerging from the survey include:

1. Strategies are needed to ensure there is better access to spare parts;
2. Integrate more repairable design across the sector and enhanced consumer protection; and
3. Business model testing, training and sharing for a range of different repair approaches.

A sector-wide effort involving multiple workstreams is required to ensure these recommendations translate into action and address the urgent needs within the industry. This report is the necessary step to capture current voices, ideas and recommendations on off-grid solar repair. The organisations authoring this paper propose to evolve their current program into a partnership-led 'Repair Lab' for the off-grid solar sector to ensure the leading organisations focusing on off-grid solar repair can act as one – for the customer, the environment, sector and for SDG7.

Introduction

Since the early 2000s, more than 375 million solar energy kits have been distributed to off-grid populations around the world, extending lights to more than half a billion people,¹ thus making notable, if still insufficient, contributions to the United Nation's Sustainable Development Goal 7: "affordable, reliable, sustainable and modern energy access for all" by 2030. This off-grid solar boom has been underpinned by a rapidly growing off-grid solar private sector industry, which has attracted more than US\$3 billion in investment since 2010.² As the sector has grown, so has the array of products on offer, with an increasing range of technologies (e.g. televisions, radios) and productive use appliances (e.g. fridges and water pumps) now available to off-grid households.

Hampering this energy access achievement, however, is the reality that many of these solar products – usually with limited 1–2-year warranties – have expected product-life spans of a few years. As such, it is estimated that of the 375 million sold over the last two decades, around 75% of them have fallen into disrepair.³ The recent growth in the adoption of off-grid solar appliances is exacerbating this sectoral e-waste challenge. This is a major concern and requires urgent attention. Product failure can create reputational issues for off-grid solar companies, result in customer dissatisfaction, undermine efforts to combat climate change, present waste challenges for governments and result in negative environmental impacts. Therefore, it is in everyone's interest that off-grid solar products last as long as possible.

There are clear opportunities to address this pressing challenge. In a recent whitepaper on *Off-Grid Solar Repair in Africa*, for example, field research in Zambia showed that more than 90% of non-functioning off-grid solar products could be fixed at low cost with relative ease.³ Furthermore, the vast majority (89%) of households tend to hold on to their broken solar products, seeing them as holding value and perhaps being repairable in the future.³ Repair is therefore a salient approach to addressing the rise of broken-down solar products. This approach is also the most environmentally sustainable (compared to programs focused on recycling) while extending customer value for money and supporting the development of a local repair and reuse economy.

Indeed, there are many companies, investors, organisations and people within the off-grid solar sector who have been experimenting with remarkably innovative approaches for minimising and avoiding solar waste. This has generated new insights and has surfaced financial, logistical, technical and/or social challenges. Yet the sector needs to improve how it openly shares experiences – from its challenges and failures to breakthroughs and successes. The purpose of this *State of the Repair* report is exactly this – to create a space where experiences around solar repair and e-waste management can be widely shared and analysed, establishing a basis for visioning and charting out potential routes to enhance the sector's sustainability credentials through exemplary repair policies and practices.

The evidence basis for this report is the results of a survey conducted in September 2024. An impressive 75 organisations responded to our call-out for sector stakeholders to share their experiences, insights and data – spanning different facets of the off-grid solar sector ecosystem. The responses we received have helped to deepen our understanding of the current cross-sector challenges for off-grid solar repair, and provide insights into where the sector might go next, including salient avenues for collective action.



Photo: UNSW / Shanil Samarakoon

Methodology

The primary data for this report was collected through a survey, co-designed with input from a diverse range of stakeholders from the off-grid solar ecosystem. This survey focused on the dissemination of off-grid solar products through *formal* markets (companies affiliated with industry associations and meeting quality standards) that are sold on a cash and pay-as-you-go (PAYG) basis – particularly as they have clearer after-sales service obligations. The collaborative design process ensured that the survey focused on the most salient aspects of repair and captured a wide array of sectoral perspectives.

There is, however, an *informal* off-grid solar sector operating across energy-poor-markets, with complex trading networks, which also presents a major challenge for solar waste. Given its ephemeral nature, it was not directly engaged with as a part of this research, nevertheless, many of the recommendations will provide indirect impacts in addressing some of the solar repair and e-waste issues associated with this parallel off-grid sector.

Survey Design and Development

The initial draft of the survey was developed the by the research team at the University of New South Wales drawing on existing literature, fieldwork experience, and preliminary discussions with stakeholders. This draft was then presented to a panel of industry experts, including representatives from distributors, investors, and non-governmental organisations (NGOs). Their feedback was instrumental in refining the survey questions to ensure relevance, clarity and comprehensiveness.

Distribution and Data Collection

The finalised survey was distributed through targeted industry networks to maximize reach and response rates. This included direct engagement with industry associations that enabled engagement with association memberships, and sending personalised email invitations to a wide range of stakeholders such as distributors, manufacturers, investors, consultants, international NGOs and institutions, through partner organisations in the sector. Data collection was conducted over three weeks in September 2024, with regular follow-ups to encourage participation. A total of 75 survey responses – from companies and organisations operating in 31 countries – were then compiled and analysed using both quantitative (descriptive statistics) and qualitative methods (thematic analysis) to provide an overview of current practices, challenges, and opportunities in the off-grid solar repair sector.

Type of organisation	Core Activities	No. of responses
Off-Grid Solar Manufacturers	Companies involved in the design and manufacture of off-grid solar products	8
Vertically Integrated Company	Company involved in the design, manufacture and distribution of off-grid solar products	13
Off-Grid Solar Distributors	Company involved in the distribution of off-grid solar products	36
Investors	Companies investing in the solar sector, either through debt or equity investments, for commercial and/or social-impact purposes	5
Donors	Bilateral or multilateral organisations providing funding for the off-grid solar sector.	2
Other	Included in this category are consultancies, waste management companies, and industry associations	11

Figure 1 – Types of organisations represented

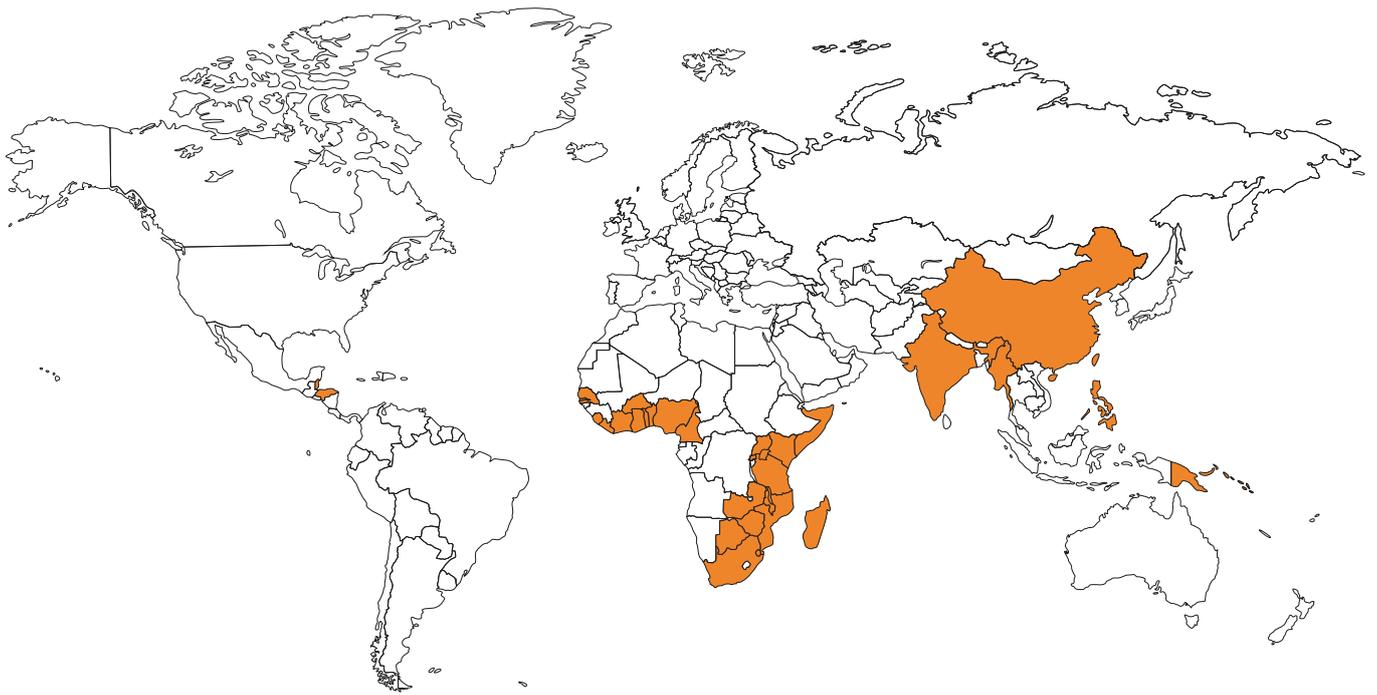


Figure 2 – Geographic scope of respondents



Photo: UNSW / Paul Munro

Current Practices in Solar Repair

Overview

This section of the report focuses on the experiences of companies that are at the frontlines of selling off-grid solar products – off-grid solar distributors and vertically integrated companies – who tend to be the first port of call for dealing with off-grid solar repair.

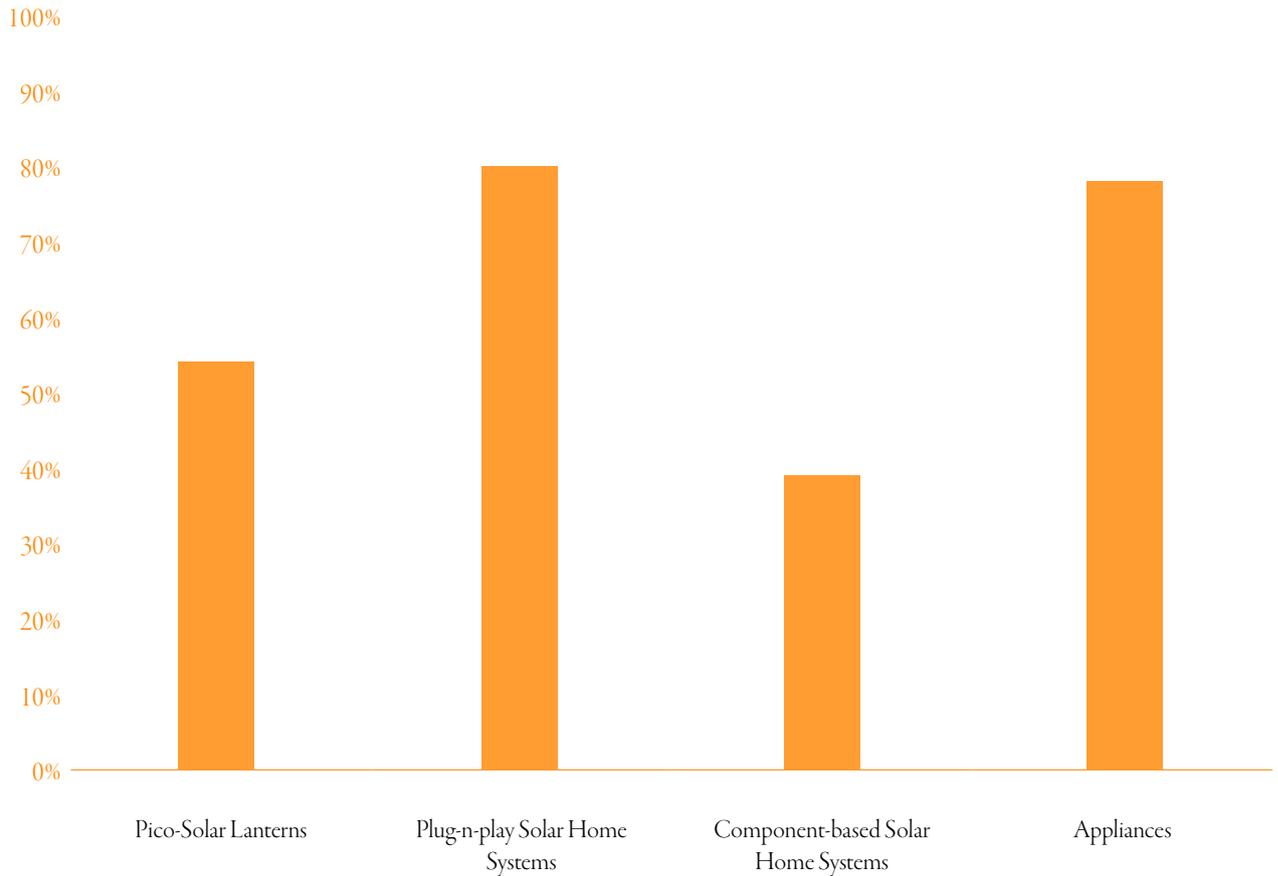


Figure 3 - Types of products sold by surveyed off-grid solar distributors and vertically integrated companies.



Photo: UNSW / Shamil Samarakoon

Figure 3 shows the breakdown of the different products sold by the companies surveyed. The most common were plug-n-play solar home systems with more than 80% including these as part of their portfolio of sales, which is unsurprising as it is these systems, so often paired with pay-as-you-go (PAYG) fintech, that have arguably been the backbone of the sector's growth, attracting significant investments. Nevertheless, there is also a good representation of companies distributing pico-solar lanterns and large component-based systems, as well as those selling household and productive use appliances (PUE). Most companies' products were either fully or partially Verasol quality verified (86.1%).

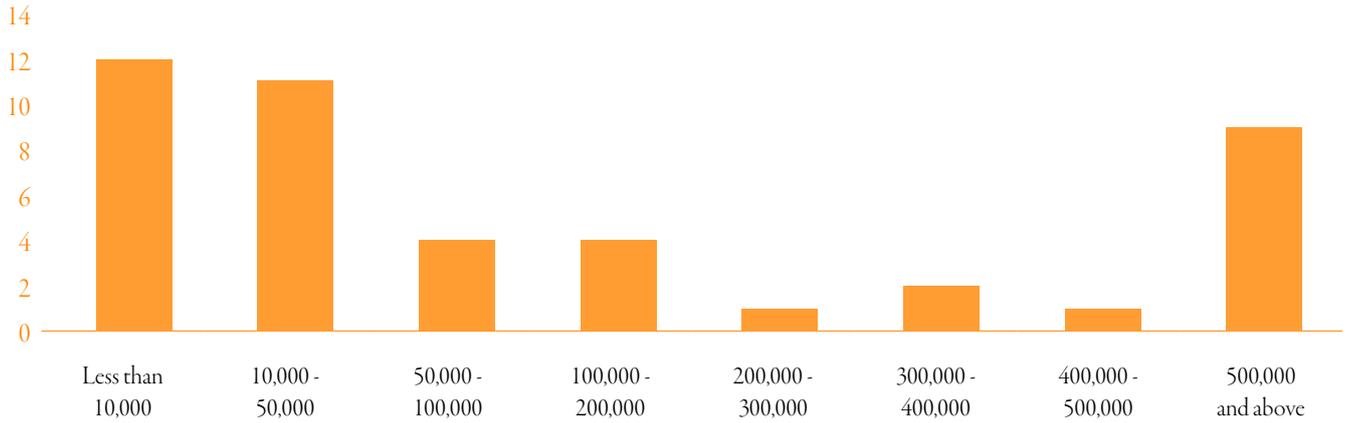


Figure 4 - Size of different companies, based on their total number of off-grid solar product sales since their founding

The respondents were an excellent cross-section of companies in terms of their size and time working in the sector. As Figure 4 shows, companies surveyed include startup and/or small companies with less than 50,000 products sold, as well as mid-range operations, and large-scale enterprises.

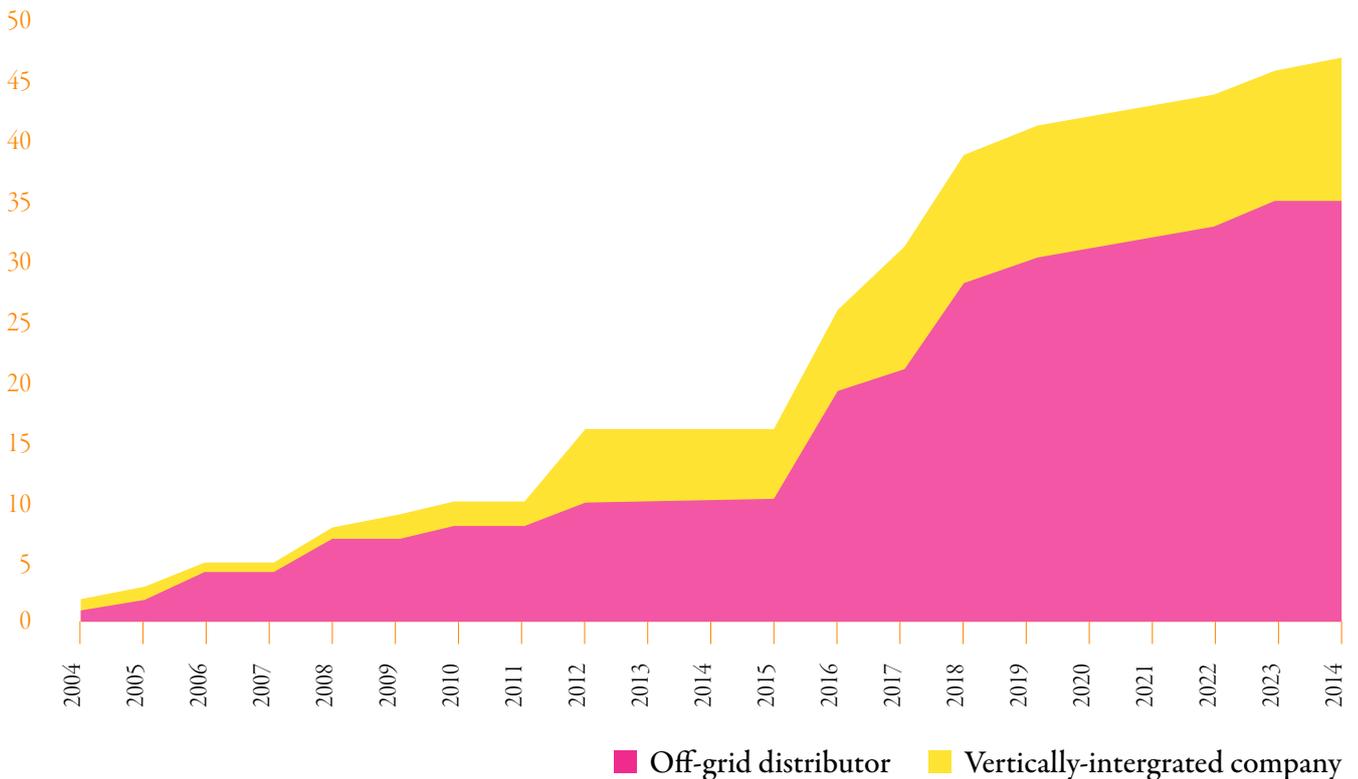


Figure 5 - Founding year of distributing companies surveyed

As illustrated in Figure 5, there was also good diversity in terms of the experience of the companies, including a number stretching back to the early 2000s, with the vast majority being founded during the PAYG solar investment boom between 2014 and 2018.⁴

Repair Service and Motivation

Ninety (90%) of companies involved in the distribution were involved in offering some kind of repair service. The minority (10%) that did not offer repair services were predominantly smaller companies that did not yet have the capacity and/or economies of scale to incorporate repair into their business models. Most, nevertheless, were proactive in considering repair for the future: **“Our organization does not currently offer the repair option to customers because we are still trying to figure out the logistics, processes and pricing structure to be used”** (Distributor).



Photo: SolarAid / Jamil Banda

Generally, if the system breakdown occurs when the product is still in warranty, then most manufacturers opt to replace (rather than locally repair) the product that breakdown within a warranty.

“we try replacing if it’s under warranty”

Manufacturer

“we ask the customer to give it back to the outlet where it was purchased and replace the same at the counter itself, we replenish it to the partner where we sell the same”

Manufacturer

“a product replacement. This ensures less time is spent within the process and customers are resolved in a timely fashion.”

Manufacturer

This approach is seen as the most effective in terms of resolving customer issues rapidly, especially given their deep reliance on these products for core energy services. Although, from a sustainability perspective, it is perhaps less efficient than directly repairing, especially if the issue is minor. Manufacturers will then usually refurbish the broken product for re-sale at a later date. There are some other inefficiencies in this approach. As we explore more below, customers often have a sentimental attached to their already purchased off-grid solar products, often wanting the same product back. While refurbished products can sometimes be hard to sell.

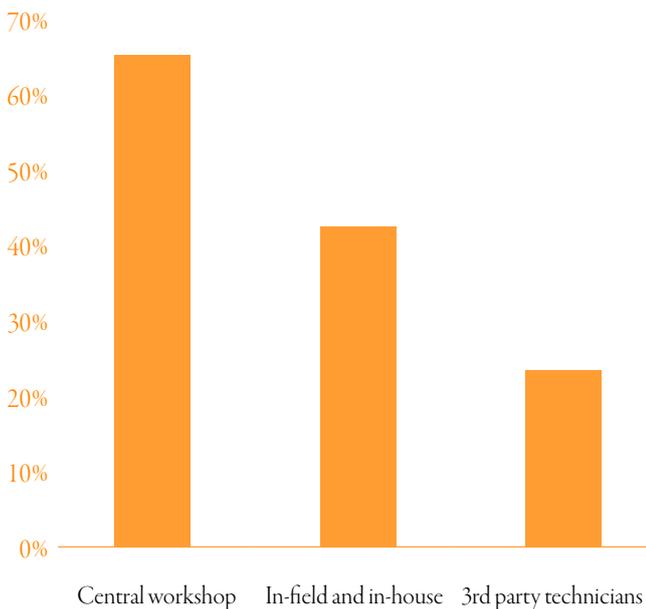


Figure 6 - Approaches to repair by distributors and vertically integrated companies.

Overall, the most common strategy adopted for repair was the use of an in-country centralised workshop. Technicians in their workshops generally being trained in repairing the company’s portfolio of products, with manufacturers sometimes offering standard operating procedures for the repair of different products. The preference for a centralised approach appears to be driven by several factors, including alignment with warranty procedures (which require formal product assessment), access to skilled technicians and manufacturer requirements of who should be doing repairs (especially with Verasol-verified products). Many companies nevertheless used their field agents (including sales agents) to be the first port of call to try and **“resolve the issue when it’s minor”** (Distributor). Call centres also play an important role in troubleshooting problems with customers.

In the case of products with expired warranties some distributors noted that some manufacturers were becoming more controlling of repairs around their products. Even beyond the warranty period, it was noted that manufacturers were increasingly pressuring distributors to refrain from repairing their products. The reasons were not always clear, but this strategy may be driven by intellectual property and quality concerns.

Only a minority of distributors and vertically integrated companies used third-party technicians, with a small number of companies recently looking to expand this effort, motivated by cost efficiencies - **“in future, to reduce costs and increase repair coverage, [we are] seeking to partner with organisations with particular agreements to cover last mile repairs”** (Vertically Integrated Company). Many other companies were open to similar arrangements in future. Significantly, most companies (63.6%) surveyed that were involved in distributing products were happy to repair products that were outside of warranty and did so by charging a small fee.

In terms of the employment of in-house repair technicians, most companies (61%) said they had employed 10 or fewer. There was a notable gender imbalance with 33.5% citing that they had no women technicians employed, this primarily consisted of smaller distributors with five or fewer technicians employed in total. Across the survey sample, it is estimated that the median representation of female technicians as a

proportion of all technicians employed is 30%. The relatively low number is not just an issue in terms of technicians, but the energy sector as a whole, where women are severely under-represented. A recent initiative to train women technicians in Kenya shows some of the potential benefits of training women technicians, most notably in rural areas where they tend to remain with communities post-training.⁵

With respect to training, several companies referenced the need for technical qualifications/certifications as a prerequisite for undertaking repairs. The majority outlined targeted in-house training efforts based on their product portfolio. This included product training programs provided by some Original Equipment Manufacturers (OEMs) for their products, along with diagnosis and repair videos and manuals for broader in-house training. Notably, one organisation has created an open-access repair app (available on Android), that provides step-by-step guides on how to repair a range of products. While some manufacturers were happy to provide blueprints and/or guidance, one survey respondent also noted that one manufacturer was resistant to having their products listed on the app and wanted them to be removed.

Quantitative assessments of success with repair varied widely with several companies having no clear data, and others citing successful repair rates between 60-100% (of products returned).

Why repair?

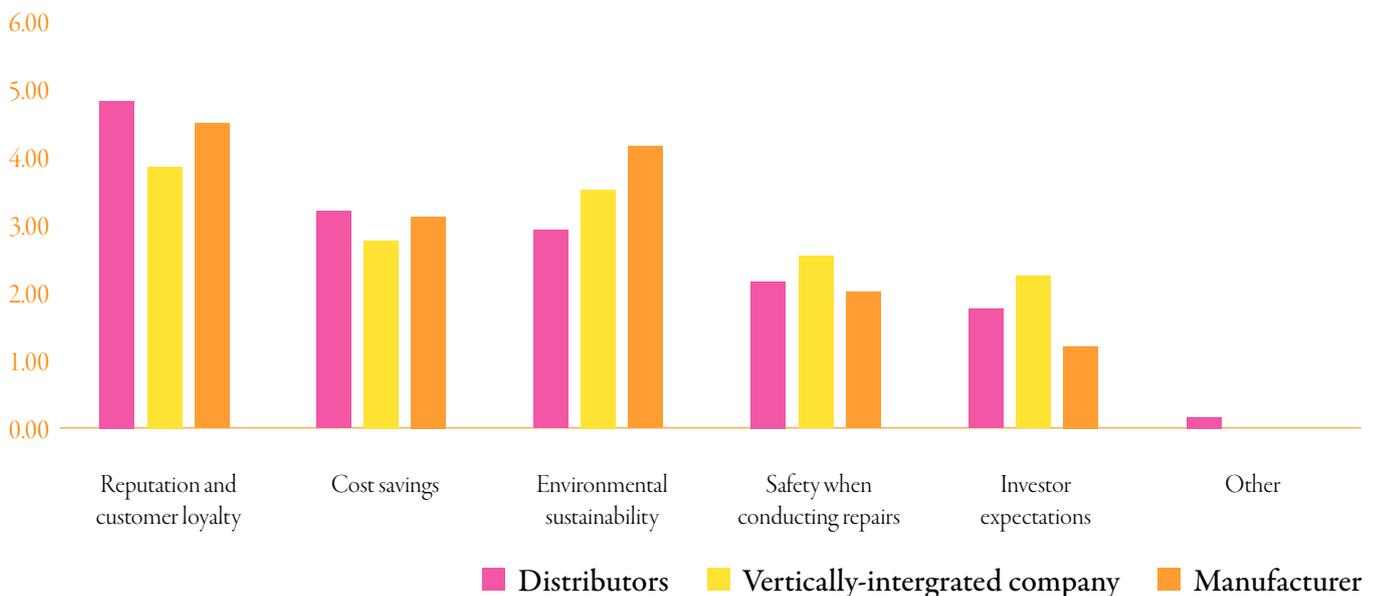


Figure 7 - Reason for repair; ranked by Distributors, Vertically Integrated Companies and Manufacturers

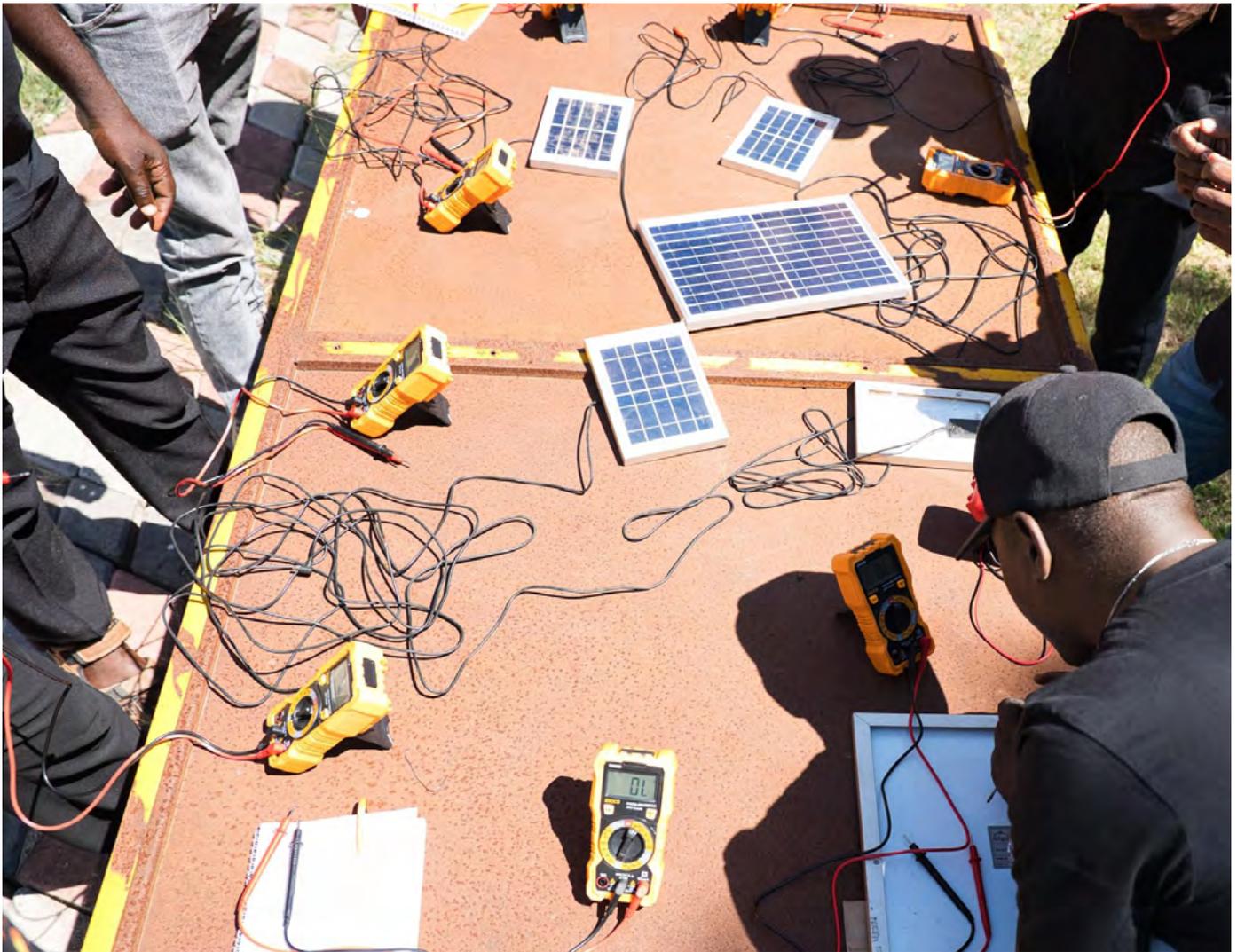


Photo: SolarAid / Jamil Banda

When asked about the motivations to pursue repair, “**reputation and customer loyalty**” was ranked (relative to the other options) the highest by distributors, vertically integrated companies and manufacturers (Figure 7). Distributors were the most emphatic with their ranking, understandably as this business model is heavily grounded in building and maintaining a large and diverse customer base. This was discussed in terms of quality repair services being an important pathway to building credibility, trust, satisfaction and thereon, loyalty. A core part of repair also involves establishing and maintaining personal relationships. As succinctly expressed by one distributor, “**reputation drives sales**”. This is something that 60 Decibels noted in their *Why Off-Grid Energy Matters 2024* report, that functional off-grid solar products that meet customer expectation is the cornerstone of the industry, and underperforming or broken products can affect satisfaction, and then affect “**word of mouth, referrals, and scale**” in off-grid distribution operations.⁶

Notably, off-grid solar manufacturers rated environmental sustainability relatively high compared to companies operating in distribution. This is perhaps a reflection of how there might be slightly different emphases in missions. The off-grid sector is arguably built on two key moral economies – the social objective of reducing energy poverty, and the environmental objective of promoting green energy. The latter objective potentially has a great pertinence and emphasis among manufacturers. Overall, those discussing the benefits of repair from an environmental standpoint were of the view that their commitment to sustainability “**does not start and end at distribution**” (Distributor). Repair was thus seen as a means to extend product life and reduce e-waste. There is therefore a strong moral economy within the off-grid sector for solar repair from an environmental standpoint, which has the potential to be translated into a greater emphasis on sustainability and off-grid products – not just in the provision of green energy – but through to the end of their product life cycles.

Common Repair Issues

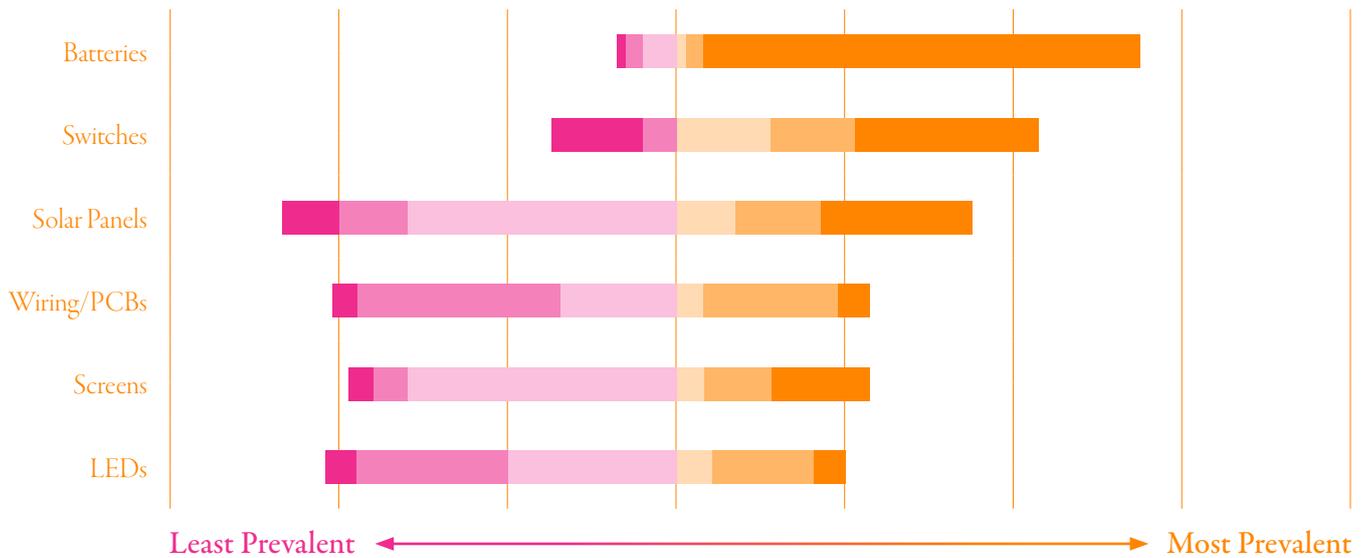


Figure 8a – Most common repair issues as ranked by distributors

The most common component, identified by the survey respondents, that caused failure and repair challenges were batteries. Notably, batteries (usually) cannot be repaired, but rather need to be replaced, so repair challenges relating to batteries tend to be articulated in terms of availability or replacement, and whether they can be easily removed and replaced without damaging casings, electrical systems and other aspects. Switches, wiring, internal components and LED lights were also highly ranked as challenges but with batteries, their failure, and attempts to replace/repair them were where most companies expressed their frustration.

As one distributor noted, “Batteries are not available once the manufacturer replaces products with new models which are very frequent as they keep updating designs.” Another distributor experiencing similar issues noted: “It appears that manufacturers are going the route of the cell phone and designing products just for the life of the battery. They do not expect the customers to open the units to change batteries which is the most common failure point and shortest life component in our view.” There is an expected obsolescence for the product based on battery life for solar lamps and smaller plug-n-play solar home systems.

Overall, the slow replacement of batteries, and preference for more centralised approaches to repair by manufacturers, was particularly frustrating for both customers and distributors, as in most products, batteries are relatively easily to replace. To resolve this issue, some companies are looking to third-party suppliers to help resolve their battery supply issues.

Nevertheless, despite efforts to use third-party suppliers, distributors are highly reliant on off-grid manufacturing companies and original equipment manufacturers for their spare part supplies. As one distributor suggested: “you can’t get PCBs, switches, etc from anyone but the manufacturer.” More than three-quarters of companies surveyed were completely reliant on manufacturers/OEMs for their spare supplies (see Figure 8b). This issue is most likely related to the solar lanterns and plug-n-play solar home systems, as there is more flexibility with component-based off-grid solar set-ups.

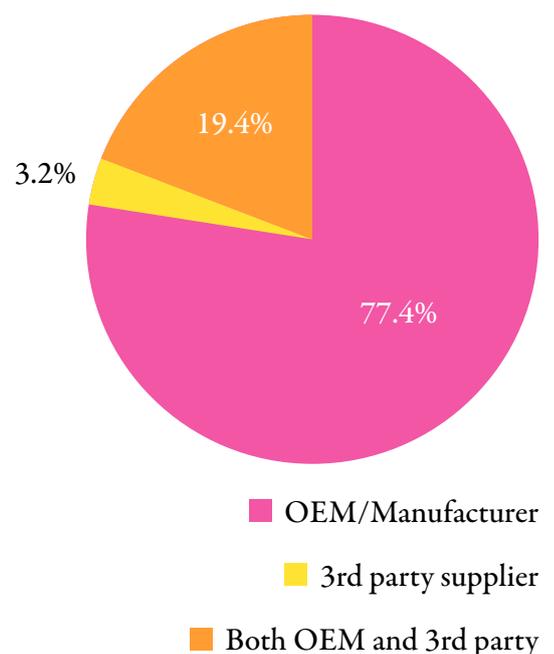


Figure 8b - Source of spare parts

Rating different facets of repair

Respondents were asked to rate (out of 5) their experience of different facets of repair, with results between distributors, vertically integrated companies and manufacturers showing some stark differences (See Figure 9). Distributors rated themselves the lowest across all categories, whereas manufacturers, in sharp contrast, rated themselves the highest across all categories. This dynamic could speak to how repair challenges are most acutely experienced by companies dealing most directly with energy users. There was some consensus that the sector was perhaps doing best in areas of “safety compliance”

and “customer satisfaction” (although distributors were more hesitant with their ratings), while success in the “timely collection” of off-grid solar products generally being rated lower by all. The starkest difference was in manufacturer support, with distributors rating this as their lowest (2.6 out of 5), and manufacturers rating it as their highest (4.8 out of 5). Evidently, there are vastly differing perspectives in this context, and tensions from this disparity are explored further in subsequent sections of this report.

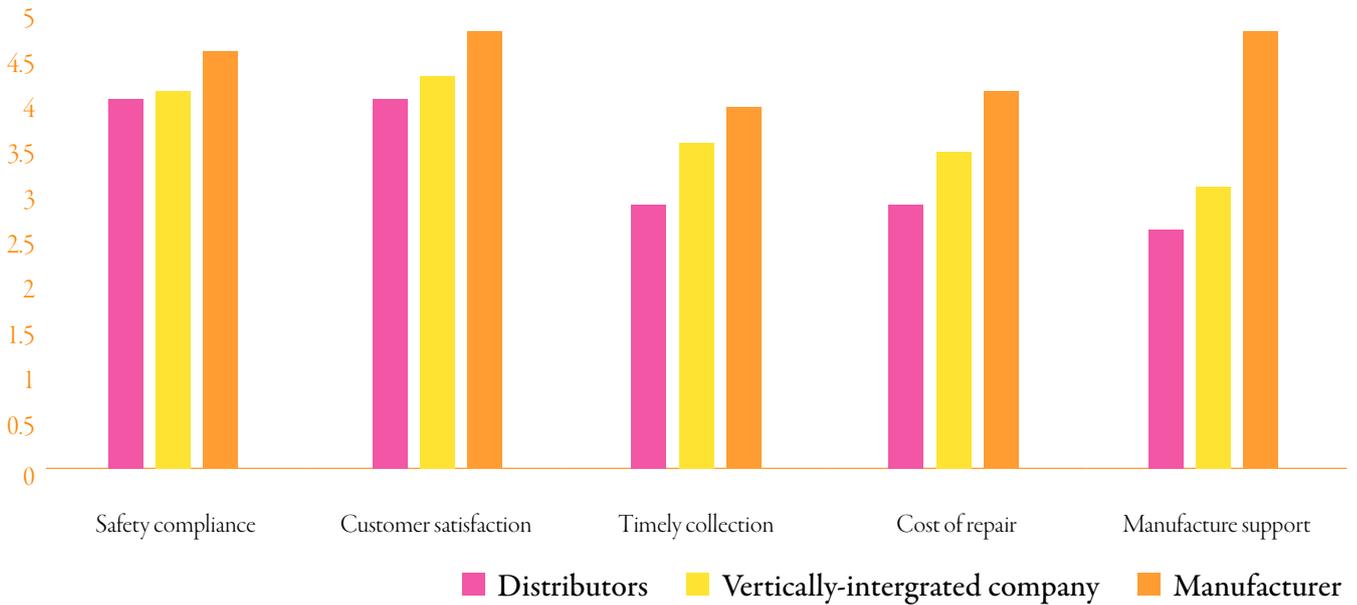


Figure 9 - Rating of different facets of repair by stakeholders

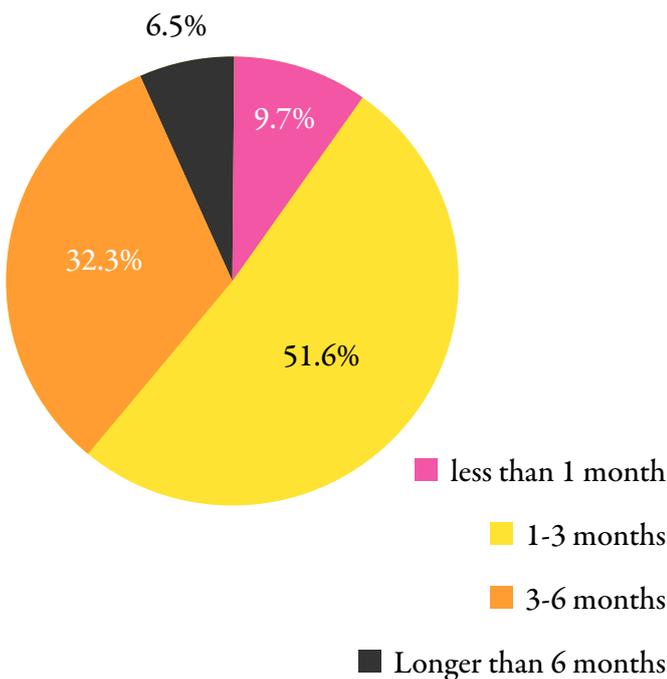


Figure 10 - Time to secure spare parts (distributors)

One theme that emerged from this frustration, was the often-long lead times it took to secure spare parts (see Figure 10). Manufacturers acknowledge the challenges around shipping times, and how these logistics were the “main challenge”, particularly due to cost “One specific challenge is access to battery spare parts as we cannot ship it easily only for repair. It has to be included in [a] bigger shipment” (Manufacturer).

Waste Management

In terms of waste management, 85.3% of distributors reported that they had a waste management strategy. Mostly, this tended to involve collecting broken products, harvesting them for spare parts and then storing the remainder in a central warehouse before sending them to a (usually certified) local e-waste recycling facility. How effective these recycling facilities are, however, was beyond the scope of this report. Given this limitation, it is highly unlikely that most recycling facilities can recycle any of the more complex or hazardous components (e.g. lithium-ion batteries, panels) and thus not all components would be effectively recycled. Local capacity for e-waste disposal and recycling is also highly variable by country, and in particular batteries offered a challenge in this space:

“There is no local company that recycles the [lithium ion] batteries”

Vertically Integrated Company

“We are currently storing lithium-ion batteries since we do not have a recycling option”

Distributor

“We normally store our dead batteries in a dry wood box in a technician’s office”

Distributor

“We collect and store [lithium ion] batteries. This is getting larger, and we have no safe method of disposal available”

Distributor

These challenges are a concern, as across the respondents, it was lithium-ion batteries that were by far the most common component of waste (See Figure 11). The minority of companies that did not have a waste management plan tended to mainly just stockpile broken products, hoping they could come up with a coherent strategy at a later date. This approach poses eminent health and safety risks, particularly in the case of lithium-ion batteries which are prone to overheating and leakage in storage.

Some companies note that it was a challenge to collect products as “most customers do not want [to] let go of their products, even if they are faulty” (Distributor). People still value broken-down products, as something to keep in case they are of some use in future. This is a challenge that will only grow as the sector reaches more remote, conflict and disaster-affected areas, which is a part of current initiatives around ‘Leave no one behind.’⁷ However, it also presents an opportunity to fulfil the customer’s preference and improve brand loyalty by repairing a broken-down product, if it is indeed repairable.

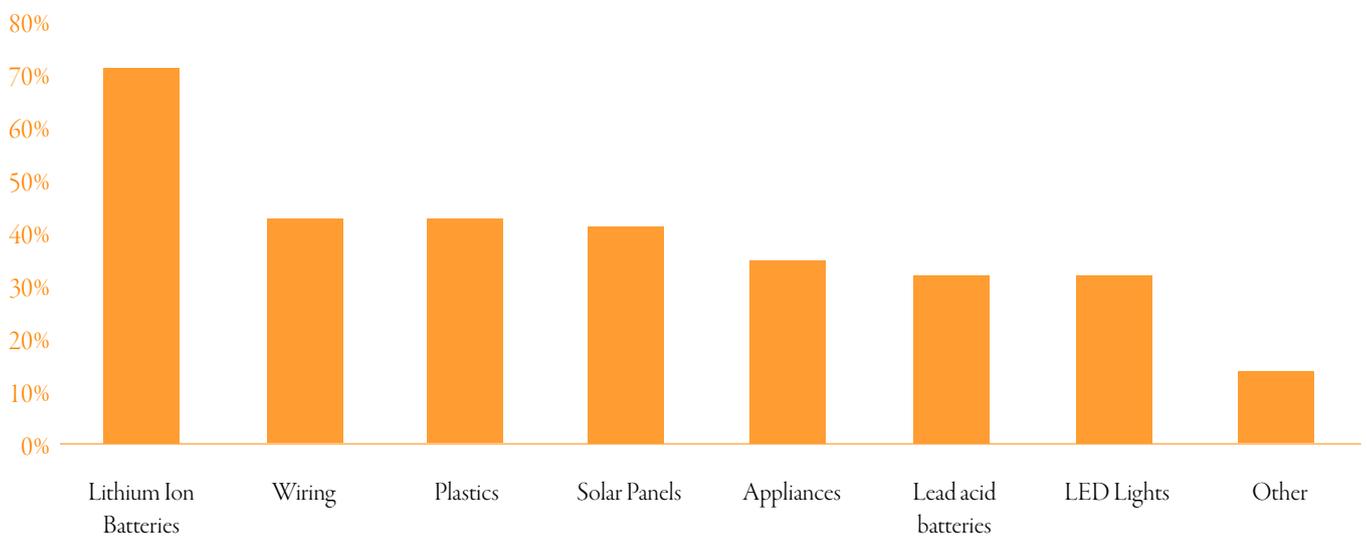


Figure 11– Most common waste components, as rated by distributor and vertically integrated company respondents.

Challenges in Solar Repair Services

Respondents outlined a diversity of challenges that impact the effective and efficient repair of off-grid solar products. Notably, many of these challenges are interrelated and share features of repair challenges across a range of sectors.

Access to spare parts

Echoing the issues identified, getting access to spare parts promptly was the highest-ranked challenge for companies involved in distributing off-grid solar products:

“Spares are purchased in China where the suppliers are based, with the scarcity of forex in the country, orders take time to be honoured, further, since they take time there is a need to buy in large quantities which also requires more funds”

Distributor

“The biggest challenge we currently face is access to high-quality spare parts which are not readily available from the manufacturers of the products making it difficult to get the repair business to run smoothly”

Distributor

“The lead time in spare part delivery from China can be 3-6 months”

Vertically Integrated Company



Photo: SolarAid / Jamil Banda

Cost of product repair

Related to this, survey respondents point to the fact that the cost of engaging in and completing repairs can be prohibitive and challenge current business models:

“High costs are the single largest challenge to our after-sales service”

Vertically Integrated Company

“Sourcing of parts at a price that makes it affordable for the customer is an issue”

Vertically Integrated Company

“Maintaining a robust customer service and repair function is exceptionally expensive”

Vertically Integrated Company

Various factors drive up these costs. These include, prices paid for shipping replacement parts, as well as government regulations and taxation. For example, some countries have tariffs on battery replacements for solar products.



Photo: SolarAid / Jamil Banda

Last mile logistics

Exacerbating the cost of repair challenge is the difficulty and expense of working in last-mile spaces, especially given that most companies are opting for a centralised repair approach (rather than using, more decentralised approaches such as the use of third-party technicians):

“...the last mile, requires an extensive network and logistics set up, however brings in no revenue.”

Vertically Integrated Company

“...logistics can be very complex when products are distributed last mile”

Manufacturer

“Given the remoteness and sparse population of the rural areas and farming communities, ... time, costs, availability and logistics become a huge challenge”

Distributor

As one respondent noted, many distributors are already struggling financially, and the added burden of setting up off-grid product collection and repair can often be a stretch too far. Another company noted that ultimately their repair operations had to run at a fiscal loss, while also noting there were likely indirect benefits including building more trust with their customer base.

As noted above, only a few companies are using third-party technicians. Therefore, distributors are limited to the reach of their agent networks and in-house technicians (typically in centralised workshops) to diagnose issues and perform repairs – a significant limitation in last-mile contexts where logistics are both time consuming and costly.



Photo: UNSW / Paul Munro



Photo: SolarAid / Jamil Banda

Product tampering

As one respondent noted, delays in repairing can often result in customer frustration, which can lead to customers choosing to tamper with and attempt to repair products themselves. This can cause greater issues and warnings related to the possibility for voiding of warranties. Furthermore, customers tampering and misusing solar products can often be the source of the failure in itself:

“Customers ‘fiddling’ is the biggest cause of failures”

Distributor

“Customer behaviour is the tampering of solar lights, most commonly to try to use the battery of the pico-solar light to charge something else like a phone”

Distributor



Photo: SolarAid / Jamil Banda

Restrictive product design

Several distributors noted that restrictive product design by manufacturers caused repair challenges. This could, for example, be difficulties in terms of physically repairing the product itself, or with manufacturers increasingly wanting to control product repairs (even out of warranty), rather than allowing distributors or third-party technicians to conduct them:

“...getting a product deployed that is hard to repair due to the way the manufacturers designed the product. This in turn pushes the customers to either dirty sources or completely in darkness and continue the cycle of energy poverty”

Distributor

“Restrictive product design doesn’t give the company the right to do manual repair but instead do direct product replacement”

Distributor

“Since each supplier has its own policies, some don’t allow us to repair their products”

Distributor

There is a growing trend towards more modularity in project design by some companies, so there is potential for changes in this space in future.

Training

While many companies indicated that they were satisfied with their in-house expertise in terms of repair some indicated that had struggles in terms of attracting quality technicians:

“[we struggle in] securing quality technicians, who are easy to train and have a customer-centric approach when interacting with customers”

Vertically Integrated Company

“Maintaining trained technicians closer to markets without adequate incentives is a challenge”

Distributor



Photo: SolarAid / Jamil Banda

There were also challenges concerning third party repairers. While many companies were interested in exploring opportunities in this space, they noted that capacity was a major issue:

“[third-party technicians are] unsatisfactory, not skilled enough, no replacement parts, no special tools”

Distributor

“We tried outsourcing a third party to assist with repairs of solar PV panels. However, the repairs were not done to our standard”

Distributor

Opportunities in Solar Repair Services

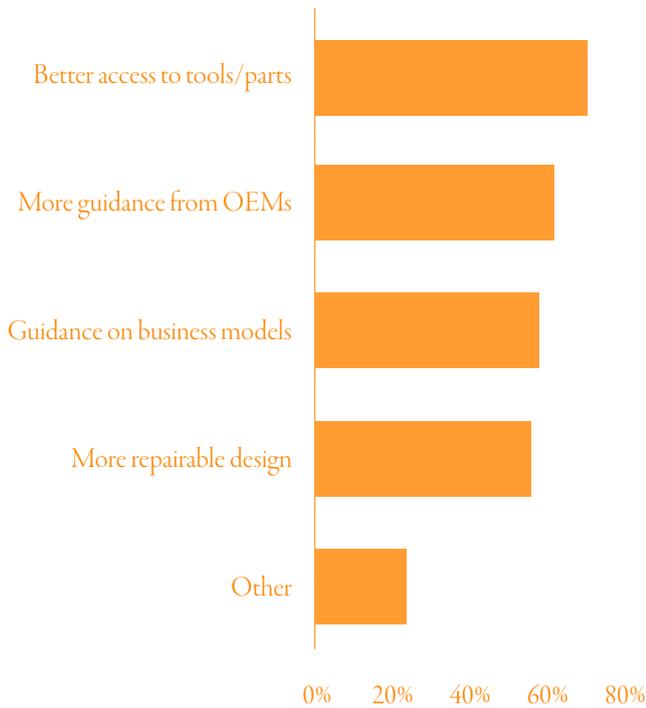


Figure 12 – Ways companies can be supported to prioritise repair

We asked companies to indicate how they could be best supported to prioritise repair (Figure 12) and to outline any salient plans for repair. Consistent with the previously discussed challenges around the costs and logistics of repair, distributors and vertically integrated companies had a broad interest in receiving guidance on how they could best incorporate repair services in their current business model (59%).

Respondents also outlined more specific opportunities to help advance off-grid solar repair in the sector under the following themes.

Better product design

“A lean product portfolio with repairable product designs”

Vertically Integrated Company

An emphasis on the need to streamline product portfolios and feature more repair-friendly designs (58%). This is closely allied with the most impactful area for repair support, better access to tools and spare parts (69%).

Educational and support resources

The development of high-quality and accessible educational resources to aid repair e.g. detailed video tutorials. This relates to the expressed need for more repair guidance from OEMs/manufacturers (62%). These efforts may require collaboration to cover a range of products, expedite development and share costs.

After sales and customer support

Proposed initiatives ranged from training agents to diagnose and perform basic repairs in the field to the implementation of after-sales software to improve transparency and customer engagement in the repair process.

Battery refurbishment and replacement

These opportunities centred on improving access to replacement lithium-ion batteries from OEMs or third-parties. Related opportunities involved encouraging customers to bring faulty or “dead” batteries to be checked and repaired or returned to the distributor for safer e-waste management.

Skill development and training

These opportunities focused on enhancing the skills of technicians and field agents to improve the scope and quality of repair. This related to the need for higher quality training at two levels, between the manufacturer and distributor, and between the distributor to technicians in the field. In addition to the aforementioned educational and support resources, opportunities being pursued included partnerships with local technical schools to recruit qualified technicians– **“We are working on a MOU local technical schools to recruit qualified technicians”** (Distributor), as well as engagements with schools: **“We have technical super-agents who schedule repair sessions in schools”** (Vertically Integrated Company). Initiatives like this could play an important role in ensuring that there is a strong base of competent, and geographically dispersed, technicians. One distributor noted that – with grant support – they were able to conduct upskilling and trainings with both internal and external technician, and are currently monitoring the long-term efficacy of this work.

Conclusion

In their recent report *Why Off-Grid Energy Matters 2024*, 60 Decibels provide a poignant reminder of why making sure off-grid are functioning effectively is essential: the user. While broken-down products create economic challenges for distributors, logistical challenges for manufacturers and planning challenges for a range of different actors in the sector, it is the households using solar products that ultimately feel the greatest brunt of broken-down products. As 60 Decibels succinctly puts it “you can’t rely on your product, or worse, you do and then it breaks, then it could impact your income”.⁶ There is thus a powerful moral argument to why repair should occur. The moral obligation is not just social, but there is also an important environmental objective; the off-grid solar industry is in the business of promoting green energy. The proliferation of products with short-term lifespans, and the resultant creation of substantial waste streams tarnishes this image. Failing to address these moral obligations could significantly impact the future of the off-grid solar sector if we do not act.

This survey has shown there is widespread agreement across the industry that repair needs to be improved. The vast majority of off-grid solar companies are doing something – or have aspirations to do something in the near future – in the repair space. There are opportunities to learn from this work, and then augment and improve it. Batteries and accessibility of spare parts are key driving issues, and there are opportunities for distributors, vertically integrated companies and manufac-

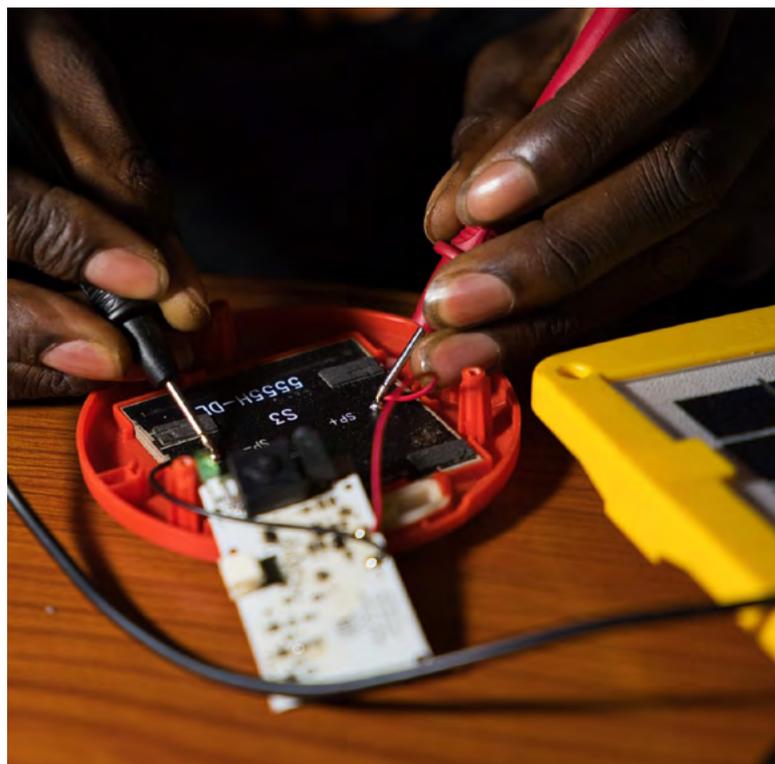


Photo: SolarAid / Jamil Banda

turers to come together and work out more effective strategies to address these major pain points. Increasing interest in repairable design as a core approach is a potential avenue to help address some of these issues, suggesting there could be promising trends in future. Likewise, openly sharing emerging business models, particularly decentralised approaches in last mile areas, and establishing tools for all provides an opportunity to solve some of the major operational and knowledge challenges while reaching those currently being left behind. There is then the potential of different approaches such as Energy-as-a-Service models which challenge the expectation of who owns the assets and therefore is obliged and incentivised to provide repair responsibilities in perpetuity. Investors and donors can play a major role here, making sources of resources available for experimentation and learning in these kinds of initiatives.

This report has highlighted the urgent need to act and the frustration of those trying to deliver off-grid repair services for their customers, but also the desire to change and solve the challenges we face.

With a diverse set of stakeholders to bring together and a distinct yet varied set of challenges, we are calling for the sector to unite behind a common cause – prioritising robust repair services. By doing so, we can better ensure that off-grid solar products deliver lasting and meaningful impact to households.



Photo: SolarAid / Jamil Banda

Recommendations and Solutions

The organisations authoring this paper have been working on repair solutions for multiple years together and with key sector partners. The launch of the *State of Repair* report comes not only with clear recommendations but an opportunity to solve them.

With many solutions already in development or planned by us or our partners, the recommendations are referencing a potential path forward. To ensure unity, cohesion and collaboration, we are announcing the intention to form a sector-embedded 'Repair Lab' to solve these challenges as a collective group of action-orientated stakeholders. With many different workstreams to address, grouped below into three main areas, it will take all of us to affect the change we need.

1

Better access to Spares

A greater commitment to ensuring the availability of spare parts.

Technically, since 2014, off-grid solar companies that are members of GOGLA members, have publicly committed (via a vote on industry opinion) to making spare parts available.⁸ However, as is evident from this survey, this commitment has fallen well short in practice. This commitment needs to be revisited, revised and established. Spare parts should be made available in more generous volumes, shipped in parallel with stock to save on transport costs and fine-grained data should ideally be used to pre-empt what kinds of spare parts are likely going to be used in future. There is a question of who should pay for these spare parts, and potentially it is a cost that both distributors and manufacturers need to build into their business models. We have been engaging with GOGLA to table a renewed commitment to making spare parts available for industry discussion.

Directory of spares and NREA-based aggregate orders

Many distributors rely on securing spare parts from third-party companies in China. This involves a complex process of identifying reputable and reliable suppliers, finding the right parts, and meeting minimum order levels. We are proposing the creation of a sector-wide directory for accessing quality spares within the Repair Lab, while also working with National Renewable Energy Associations (NREAs) to create the same capability within their specific geographies. This proposal focuses on strengthening the supply chain for spare parts from both OEMs and third parties. The additional benefit of working with NREAs at the national level is to enable aggregate orders where multiple distributors can pool their needs together to meet minimum order levels. We have begun this exploration within Zambia. This also brings an opportunity for businesses seeking to address this need as an intermediary – like the online marketplace for spares in Kenya, Revivo.

Removing tariffs on spare parts

One simple and effective measure that policymakers could take is to remove all tariffs on off-grid solar product spare parts. The revenue loss for governments would be minimal, and in the long-term would be cost-positive as it will help to reduce future waste streams (which have various economic, social and environmental costs). In some countries, these tariffs have already been removed, in others they have not. We did not collect fine-grained data on this as a part of the survey, but it would be useful to get a snapshot of different tariff approaches adopted by nations and use this data to lobby governments where tariffs are undermining repairability. We have discussed capturing best practices and impacts of adopting such measures with GOGLA to support NREAs advocating for their adoption within countries that still implement these tariffs.

2

More repairable design and consumer protection

Incorporate more repairable product designs

Where feasible, without compromising the durability of off-grid solar products and the integrity of their fintech systems, off-grid solar manufacturers should incorporate repairable design as a core philosophy in the development of their off-grid solar products. This should include easily removable replaceable components, and attempts to use common (and, ideally, locally available) components and tools as much as possible. The use of universal ports on battery hubs could also increase interoperability and reduce both replacement costs and flows of e-waste. There needs to be funding to support research and development around this, which is an area in which donors and investors in particular could become involved. Modularity and more repairable product designs are increasing trends that can be seen across other electronic goods (e.g. laptops & phones). It is important that the off-grid sector goes beyond merely keeping up with such trends and strives towards leading best practice, especially given the social and environmental objectives (i.e., green energy and eliminating poverty) that underpin their operations.

CLASP's soon-to-be-published paper on a 'Repairability Index' will advocate for solar appliances to be measured for repairability as part of the quality assurance process. This will inform distributors which products and companies are better equipped to handle repair effectively and efficiently. As distributors value this, we could see a shift away from products that are difficult to repair. Critically, this is a sector-led initiative to improve our practices, which could reduce the need for external legislation with the potential to damage our sector much more suddenly. While welcomed, we can collaborate to improve our practices first.

Standardising parts - batteries

Batteries were the most common source of issues relating to repair, both in terms of what broke down with off-grid solar products, but also as a component that many companies struggled to replace in a timely manner. Where possible, the types of batteries used in off-grid solar products must be consistent across brands as much as possible (without stifling innovation). It should be easy to a) remove an old battery from

an off-grid solar product; and b) be able to replace this battery with a readily available replacement.

Replacement and repair

If easily done within a product's design, battery swaps, for example, should be recognised as replacements rather than repairs. While some vertically integrated companies offer this service to their customers, ensuring the customer retains the same product, it is not common practice for distributors. If high-quality, affordable replacement is possible by the distributor or a third-party and accepted by the manufacturer, there is a potential incentive for the manufacturer to provide fewer replacement products and increased loyalty from customers because they have a fast resolution, and their product returned.

Explore opportunities to extend warranties for longer periods

While all the companies in the survey offered warranties, the period for these is arguably too short from a sustainability perspective. No pico-solar products had a warranty longer than two years (about 27.3% only had a one-year warranty), and 78.2% of plug-and-play products had warranties under two years. One distributor noted that there were even further restrictions on these – that they had to sell the product within six months of stocking the item for the warranty to remain valid. While there are clear financial implications for extending warranties, ideally longer warranties – especially around batteries – should be explored by the industry. A product that fails after three years (outside the vast majority of warrantees), is a poor outcome for both sustainability and customer satisfaction. Recent pilots of the Energy-as-a-service (EaaS) model for households – where distributors retain ownership of solar products supplied to customers – shift repair burdens from customers to distributors. The obligation and incentive for the service provider is to include the replacement of components and repair (replacement products when necessary), within the service to ensure indefinite service to the end-user - which removes the need for the customer to purchase a new product when theirs reaches its end-of-life without repair. This is particularly impactful in the high-poverty areas where EaaS is targeted. In addition to minimal access and PAYG SHSs being largely unaffordable, aftersales care (warranty claims and repair) is not as accessible, which can leave customers stranded with broken systems, in or out of warranty.

Civic education on off-grid solar maintenance and consumer rights

As evidenced by the survey results, poorly informed customer practices can exacerbate the need for repair and replacement – resulting in costs and inconvenience for both the customer and the distributor. While distributors invest in various forms of customer onboarding and it could be more effective, there is a clear need for more comprehensive civic education programs to build broader local knowledge and capacity across important topics such as preventative maintenance and consumer rights e.g. warranties. Programs consistent with national policies can help inform better adoption decisions, and usage experiences, and reduce rates of product failure, - thereby enhancing trust in the off-grid sector. There is an opportunity for such tools as the SolarAid’s ‘SunnyMoney mobile repair app’ to be provided to end-users as its current iteration provides basic diagnostic guidance for a customer and/or technician to understand when there may be no fault.

The customer voice - end-user research

Our collective evidence on the customer opinion towards repair and its current availability is minimal. We know there is a vibrant repair economy across the Global South and are forming an understanding, through small-scale empirical research, that customers want their products repaired. Among those who attempt to repair products themselves, or through third parties, early evidence suggests that their satisfaction and loyalty increase and self-repair attempts decrease, once repair services are offered. The level of data is insufficient, and we need to understand the customer voice more deeply to inform the creation of suitable solutions. We will be undertaking a multi-country end-user survey with 60 Decibels to gain a much more detailed and practically applicable understanding from the most important stakeholder we have. This is while inviting other companies or research institutions to submit their insights to build a more comprehensive and diverse data set.

3

Business model testing, training and sharing

Business model testing

There is evidently a lot of interest and passion among off-grid solar distributors toward establishing greater reparability within their operations. Donors and investors that responded to the survey indicated that they had an interest in the quality of repair services offered by their grantees/investees, with some already factoring it in their assessments of risk and sustainability. However, many of these companies are still establishing themselves and building towards profitability, meaning that experimenting with and learning from, different approaches to repair in their operations is a luxury they cannot afford. As expressed by a donor, “**repair services are often overlooked when providing support to [off-grid solar] markets**”. Thus, financiers should ideally support a range of contextually appropriate interventions that companies can adopt to enhance their repair services with open access results to facilitate learning and broader adoption. SolarAid is already testing and measuring the feasibility of the following models, localised to rural areas, to form best practices and open access to distributors: decentralised repair (rural sales agents and third-party repair technicians), localised repair hubs, and Energy-as-a-Service - the latter has the backing of the Malawi Government for scale and is being tested with partners across multiple countries. These models are all designed to solve the challenge of last-mile logistics by localising costs, operations and utilising and building local expertise for sustained access to repair, providing a much better service to the customer.

We are committing to sharing this knowledge and working with partners across the sector to understand their models so that companies can adopt repair into their operations efficiently and effectively – thereby improving their sustainability profiles significantly.

Technical training in-country

There is a need to provide financing for the development of in-country off-grid solar repair. This can help ensure that off-grid solar repair is something that is offered across (especially rural) technical colleges and even senior secondary school courses. This will ensure that there are ready supplies of third-party technicians with high-quality training. As a part of this high-quality materials should be developed that can be used to assist with this training. SolarAid has provided

this training to technical schools (inc. woman-only technical schools), sales agents and third-party repair technicians and is currently working with Global Distributors Collective members providing similar technical assistance. Many others are offering such training, and we are planning to develop best-practice ‘training of trainers’ materials and technical assistance services with partners to improve access to training more broadly.

More guidance on how to do repairs

More readily available training materials (e.g., guides, videos, etc), in accessible formats, must be developed to demonstrate how to conduct repairs. While manufacturers undoubtedly have a key role to play in this, it would also be beneficial if different off-grid solar companies had an ‘open access’ approach to how they conduct their repairs and share strategies amongst each other. The ‘SunnyMoney mobile repair app’ is an example of a repository where guidance for repair has been stored and shared successfully, and there are opportunities to build on this work. The intention is to build the app to become the ‘encyclopaedia’ for diagnostic and repair guidance - developing its capabilities and product range - introducing PUE with partners such as CLASP.

Last mile collection and processing facilities.

Collecting last-mile products is a logistical challenge and high costs for off-grid solar distributors. Policymakers could potentially help to facilitate this work by setting up collection points through existing government infrastructure and

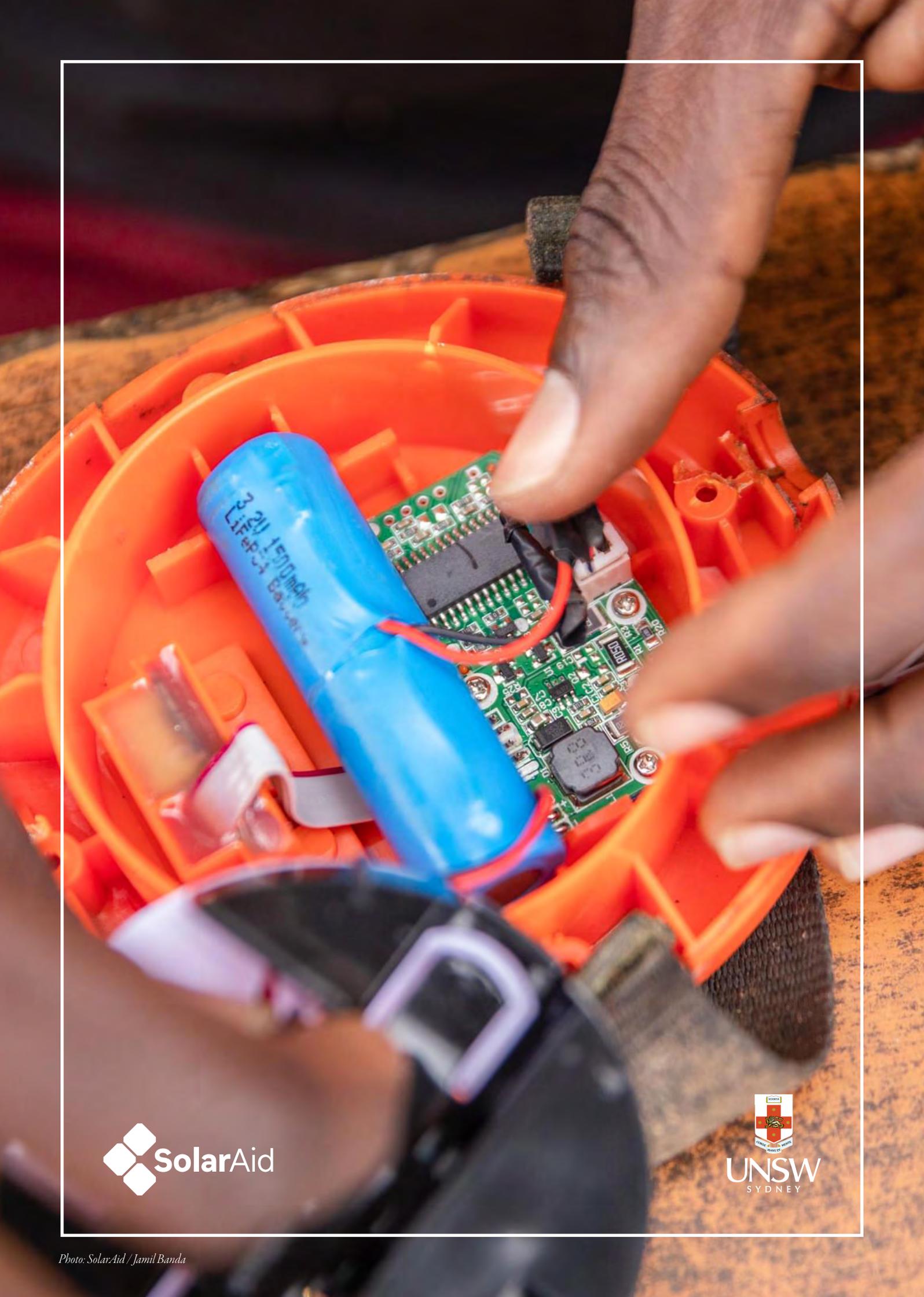
networks. This can include the development of conducive e-waste transportation and collection policies, making sure that producer responsibility organisations are activities and providing support, creating favourable policies to support repair facilities and the developing of more physical infrastructure for storage and disposal. Organisations such as SolarAid run awareness-raising Repair Days where a take-back scheme is offered and 25% of the products brought were sold by other companies. They have been requested to explore this within the NREAs of Zambia to define collective, distributor-led, approaches to solve this issue. If successful, we will work with GOGLA to share with other NREAs.

Repair-friendly financing models

When investing in new off-grid solar enterprises – whether through debt, equity or grant financing – the estimated costs for repair (e.g., cost and time required to collect broken products, repair and return them) should be incorporated into financing arrangements. Even if this means a slightly longer road to profitability or scaling up of operations. There are of course challenges, with this, and it will be a complicated balance to ensure competitive prices, profitable margins and financial resources for repair operations. While helping to equip distributors to affordably adopt proven repair models within their supply chain, we will also be working with institutions as well as investors to explore different sources of financing and mechanisms to incentivise the adoption of repair services and infrastructure, with the potential to subsidise last-mile services, where necessary.

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