

# REPAIRABILITY INDEX FOR SOLAR FANS, REFRIGERATORS, AND WATER PUMPS



Powerbox technician repairing an appliance

Photo Credit: CLASP

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Efficiency for Access Coalition

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# EXECUTIVE SUMMARY

The reparability of solar appliances is a critical factor in ensuring their sustainability, longevity, and cost-effectiveness, particularly in off-grid and rural areas. If it is difficult, inconvenient, or expensive to repair these devices, customers may dispose of them — often inappropriately — thus resulting in lost productivity and livelihoods and contributing to increased electronic waste (e-waste) volumes and environmental pollution. Further, as most of these appliances are purchased in instalments, if they fail before their intended life span, then consumers do not get full value for their investment.<sup>1</sup>

This report proposes a Repairability Index for three solar appliance types: **fans, refrigerators, and water pumps**. These appliances have a high uptake in key solar appliance markets and often constitute a significant financial investment for their owners,

making it imperative to keep them running for longer and in good condition.

The report findings are based on feedback from over thirty (30) ecosystem players with field experience, including repair technicians, manufacturers, and distributors, and expert consultations on reparability parameters for solar appliances. We have gathered these findings through technical working groups (TWG) with the aim of developing a Repairability Index to promote appliance durability and affordability, while reducing e-waste from the solar appliances sector.

The Repairability Index provides a structured framework to assess how easily an appliance can be repaired across four core parameters:

### Spare parts & tools:

Availability, traceability, affordability, and the tools required to conduct repairs.



### Disassembly:

Whether appliances can be opened and serviced without damage, how modular key components are, and how much time repairs typically require.



### Skills complexity:

The level of technical expertise needed for diagnosis and repair, and the accessibility of structured training pathways.



### Documentation:

The completeness, clarity, accessibility, and tiering of information for end users, technicians, and authorized service partners.



The Repairability Index assigns weighted scores by appliance type, reflecting practical differences in failure modes and repair complexity across fans, refrigerators, and solar water pumps (SWPs).

It is complemented by an interactive **Repair Index Calculator**<sup>2</sup> that promotes consistent assessment, benchmarking, and iterative improvement in appliance design.

1 Efficiency for Access. **“Appliance Impacts Over Time.”** February 2023. <https://efficiencyforaccess.org/wp-content/uploads/Appliance-Impacts-Over-Time.pdf>

2 The Repair Calculator will be launched soon.

## KEY INSIGHTS AND RECOMMENDATIONS



### **REPAIRABILITY IS AN ECOSYSTEM CHALLENGE.**

Even well designed appliances fail in markets with weak supply chains or insufficient technician networks. Effective repairability requires coordinated improvements across appliance design, spare parts stocking, technician training, and documentation. Programs supporting solar appliance uptake should therefore integrate technician training, distributor support, and localized documentation alongside appliance rollout.



### **ECONOMIC FEASIBILITY DRIVES BEHAVIOR.**

Users will only repair appliances when parts and labor are affordable. Across TWGs, a recurring benchmark emerged: when repair costs exceed roughly 30—35% of the appliance's retail price, customers tend to replace rather than repair. The Repairability Index incorporates affordability thresholds and rewards appliance designs whose parts and modules make repairs economically rational.



### **DOCUMENTATION QUALITY IS PIVOTAL.**

A recurring finding across all appliances is that many failures (and misdiagnoses) stem from missing, incomplete, or non localized documentation. Effective documentation must be tiered for different users (e.g. visual guides for end users, structured diagnostic steps for technicians, and firmware/tools for authorized service partners).

The Repairability Index is intended to serve as a practical decision-making tool for manufacturers, distributors, program implementers, and policymakers. By providing a standardized, evidence-based method for evaluating repairability, the Repairability Index helps stakeholders identify design gaps, plan for spare parts stocking, and establish appropriate technician training and documentation requirements. Its appliance specific weighting profiles ensure that assessments reflect real-world failure modes and ecosystem realities, enabling more informed appliance development, procurement, and after sales strategies.

The accompanying digital Repair Index Calculator further strengthens consistency, transparency, and comparability across appliances by streamlining scoring and enabling documentation of the evidence behind each metric. When applied across multiple models and geographies, the Repairability Index generates insights that support benchmarking, guide improvements in appliance design and support systems, and reinforce market incentives for repair friendly appliances. Over time, the Repairability Index aims to contribute to improved consumer protection, reduced lifecycle costs, and a more resilient and circular solar appliance ecosystem.



A Koolboks refrigerator repair technician in Nigeria

Photo Credit: CLASP

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# INTRODUCTION

The limited repairability options for solar appliances often increase ownership costs and consumer dissatisfaction, particularly for consumers with low incomes or those who cannot access local repair services. While growing off-grid solar markets are enabling energy access for millions of vulnerable communities<sup>3</sup>, the proliferation of solar home systems and solar appliances poses a potential threat to the environment and customer satisfaction if not properly managed during failure or end of life.<sup>4</sup>

High costs of recycling remain one of the most significant barriers to improving electronic waste (e-waste) management practices. The lack of e-waste infrastructure and service providers in Africa is another barrier, including the absence of recycling facilities that meet minimum standards and the difficulty of finding the spare parts necessary for repair.<sup>5</sup> Additionally, the growth rate of countries implementing e-waste policy, legislation, or regulation is decelerating.<sup>6</sup>

Improving the repairability of solar appliances offers the off-grid solar appliances sector an opportunity to demonstrate leadership on e-waste management and the circular economy, while enhancing value for consumers and companies. As a process, repair involves the restoration or correction of malfunctioning, damaged, or broken appliances, and aims to bring them back to their original or functional state. Repair focuses on addressing and resolving issues once an appliance has already experienced failure<sup>7</sup>, and is a way to preserve value by slowing down the appliances' economic devaluation.

In the absence of repairable appliances, companies risk losing customers due to low satisfaction levels.

Repair is therefore a promising customer retention / service strategy. A longitudinal study from Efficiency for Access<sup>8</sup> revealed that 49% of respondents reported “appliance breakdown” as the reason why they stopped using their appliance. This survey also showed that households and companies in Kenya face high costs of solar appliances, with over 80% of purchases made on credit, demonstrating the significance and value of these appliances to the owners.

Consumers who cannot afford to replace an appliance with a new one might be able to spend less by repairing it. Repairing the appliance will also help consumers extend the return on their initial investment, all while retaining access to the appliance's service. For companies such as those selling appliances on Pay-As-You-Go (PAYGo), enhanced repair ensures a continued revenue stream; an appliance that is out of action represents lost income and customer dissatisfaction.

Repair offers an untapped collaboration opportunity between appliance manufacturers and distributors that would have multiple positive benefits, including but not limited to:

- Enhanced consumer protection by ensuring appliance usability for the complete lifespan,
- Job creation or enhancement by upskilling and expanding the number of informal repairers who are close to “last mile” areas where appliances are used,
- And reduced e-waste, as there is a need to extend appliance lifetime and reduce pressure on the limited (formal) recycling infrastructure available.

3 GOGLA, Sales and Impact Report, H2 2023.

4 Efficiency for Access, Global LEAP Solar E-Waste Challenge: Lessons on Take-Back, Collection, Repair & Recycling of Off-Grid Solar Products, March 2021, [https://efficiencyforaccess.org/wp-content/uploads/Clasp\\_EforA-SolarEWaste\\_5-May.pdf](https://efficiencyforaccess.org/wp-content/uploads/Clasp_EforA-SolarEWaste_5-May.pdf).

5 Ibid.

6 International Telecommunication Union (ITU) and United Nations University (UNU), Global E-waste Monitor 2024, <https://www.itu.int/en/ITU-D/Environment/Pages/Publications/The-Global-E-waste-Monitor-2024.aspx> GOGLA, Sales and Impact Report, H2 2023.

7 These definitions have been adopted for this paper.

8 Efficiency for Access, Appliance Impacts Over Time, <https://storage.googleapis.com/e4a-website-assets/Appliance-Impacts-Over-Time.pdf>.

The Solar Appliance Repairability Index aims to serve as the foundational building block in guiding decisions related to appliance design interventions, business models, and workforce and skills requirements, with the goal of helping to extend the lifespan of solar appliances.

An introductory paper, “[Closing the Loop: Enhancing Repairability in the Solar Appliance Market](#)”, synthesized field research from Kenya and stakeholder interviews to outline findings of current repair practices and proposed the key criteria for assessing repairability. The information in this paper provided the background context and key factors for consideration that informed the convening of Technical Working Groups (TWG) and subsequent development of repairability indices for key solar appliances.

This paper, a second part of the [Solar Appliance Repairability Index Series](#), discusses key criteria for assessing repairability of solar water pumps, fans, and

refrigerators. It further outlines the methodology for computing the repairability index for these appliances and limiting factors for the criteria discussed. The index incentivizes durable appliance designs and reflects regional and appliance-specific nuances.

To streamline scoring and improve comparability across appliance types, the Repair Index Calculator has been developed to compute the Repairability Index (RI) for appliances. This calculator is intended to simplify the assessment process and encourage self-assessment by appliance manufacturers, distributors, and repair technicians. We encourage use of the tool across multiple appliance models and contexts, recording field evidence (photos, time on task, tool lists), and sharing feedback to refine scoring thresholds and weighting factors. Over time, consistent use of the calculator will support benchmarking, consumer facing disclosure, and procurement decisions that reward repair friendly design.



Solar water pump user in Lundu, Malawi

Photo Credit: CLASP

In most cases, the reported failures with solar refrigerators are not the result of poor appliance quality, but rather external factors and human error. Improper installations can easily create disconnections of sensors and other electrical connectors. Rodent infestation in the main hatch causes damage to electrical cables; improper basic maintenance procedures cause dust and moisture build-up on solar panels, batteries, and circuit boards, leading to poor performance. Other factors, such as overvoltage, undervoltage, accidental tampering, and overheating cause short-circuiting of the controllers. Environmental hazards such as flooding or overheating are recurring challenges that are usually beyond human control.

Interestingly, improper diagnosis of the problem is often recorded as a failure, when it shouldn't be categorized as so, for example, in a scenario where the sensor connection to the main control circuit is loose or has short-circuited. Without a proper diagnosis of this problem, it is easy for a technician to conclude that the whole sensor has failed and needs to be replaced, whereas only the sensor connector needs to be replaced. Some manufacturers have introduced self-diagnosis tools, such as simple step-by-step flow charts and SOPs that help users identify common faults like loose connections. These low-cost interventions have proven effective in reducing unnecessary service calls and allowing general skilled technicians and users to troubleshoot safely.

While additional protective features could safeguard fridges against misdiagnosis, failure, and damage, these enhancements could drive up costs, making them less competitive compared to AC fridges. The recommendation therefore is to emphasize robust design during development, ensuring that the fridge is both durable and easy to repair without significantly increasing cost. An example of this is the integration of remote monitoring for predictive maintenance and repair for appliances.

Solar water pump (SWP) manufacturers highlighted different design philosophies for minimizing repair needs. Some companies focus on durability, integrating features like dry-run protection into the motor to reduce the number of vulnerable components. Others emphasize repairability, opting for modular designs that allow users or technicians to replace impellers, seals, or other high-wear parts with relative ease. For instance, one company removed external dry-running sensors by integrating them into the motor to prevent damage. Another example is a submersible pump with ceramic bearings instead of metal ones to reduce the likelihood of pump failure through bearing failure. Some pumps are designed so users can open and clean parts (e.g., removing blockages) or bundle essential tools and spare O-rings with the pump. In all cases, it was noted that documentation plays a role in prevention: clear do's-and-don'ts can help users avoid common mistakes (for example, always lifting a submersible pump by its handle, not its cable).



Solar water pump user in Lundu, Malawi

Photo Credit: CLASP



Powerbox technician repairing an appliance

Photo Credit: CLASP

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# REPAIRABILITY INDEX PARAMETERS

This repairability index proposes a RAG rating<sup>9</sup> on a 0-5 scale that allows for assessment of the ease of repair by scoring the metrics outlined in tables 3.1 to 3.3 below, organized by appliance type. The index will be presented in a color gradient from red to green, such that if the scoring falls at a decimal, it can be displayed anywhere. Each of these metrics should be assessed and scored based on the level of repair it allows for as outlined below:

- 0 (Red): repair is not feasible. Metric is non-existent or very hard to access.
- 1 (Amber): repair is feasible but very complex. Only possible for manufacturer and authorized service partners. Very low consideration to enable informal repair.
- 3 (light green): repair is feasible and modest. It can be carried out by informal repairers. Adequate access to spare parts, tools and information to facilitate repair.
- 5 (Green): repair is feasible and straightforward. It can be done by a layperson. Full and open access to all spare parts, tools and information needed for repair.

### SCORING & WEIGHTING FOR SOLAR FANS

Solar-powered fans play a vital role in improving comfort and quality of life in low-income regions where access to reliable electricity is often limited. Their affordability and practicality make them a popular choice, yet this very affordability has historically led to limited attention on their repairability. Unlike higher-cost solar appliances, fans are often

considered disposable, and there is currently no clear data on how well they perform when repairs are attempted. This index aims to encourage durability, reduce electronic waste, and promote affordability in low- and middle-income markets, ensuring that these essential devices remain functional for as long as possible.

The ability to repair fans effectively depends on several interconnected factors. Affordability of spare parts is critical; if replacement costs approach the price of a new fan, repairs become economically unattractive, especially in low-income markets. Traceability of parts through clear identifiers like SKUs or QR codes ensures correct replacements and reduces counterfeit risks. Equally important is the ease of procurement, which goes beyond availability to include realistic access in local repair channels without long lead times or bulk order constraints. Tool accessibility also plays a major role; when repairs can be done with common tools rather than proprietary equipment, repairability improves significantly. Furthermore, low skill complexity broadens the repair ecosystem, enabling informal technicians to participate without advanced technical training. Modular design enhances disassembly efficiency and inter-brand compatibility, reducing labor and inventory challenges. Finally, comprehensive documentation, including troubleshooting guides and exploded diagrams, empowers technicians and end-users alike, with open-access digital manuals considered best practice for transparency and ease of repair.

<sup>9</sup> A RAG (Red, Amber, Green) rating is a practical tool for assessing the status of a project or activity.

Table 2.1: Scoring criteria for solar fans

PARAMETER	CRITERIA	VERIFICATION METHOD	SCORE (0–5)	WEIGHT (%)
<b>Spare parts (30%)</b>	Traceability of parts: Major components are the motor, fan blade, and stand. Battery and Printable Circuit Board Assembly (PCBA), if included, are also tagged as major components.	Visual inspection	<p><b>0</b> = No major part is serialized or has a part number (PN).</p> <p><b>1</b> = One major part is labelled or has a PN. If it has a battery and a PCBA, then the major part plus battery and PCBA must be labelled with a serial number or PN.</p> <p><b>3</b> = Two major parts have serial numbers or PNs. If it has a battery and a PCBA, then the major parts plus battery and PCBA must be labelled with serial numbers or PNs.</p> <p><b>5</b> = All major parts have serial numbers or PNs. Battery and PCBA, if included, are clearly serialized with PCBA components clearly labelled.</p>	5
	Compatibility of parts across different models / brands	Visual inspection	<p><b>0</b> = Proprietary major parts only</p> <p><b>1</b> = Mix of proprietary and standard major parts</p> <p><b>3</b> = Standard major parts but variable quality</p> <p><b>5</b> = High quality major parts</p>	5
	Affordability	<p>Manufacturer declaration</p> <p>Market survey</p>	<p><b>0</b> = Spares cost &gt;40% of fan price</p> <p><b>1</b> = 31–40% of the fan price</p> <p><b>3</b> = 20–30% of the fan price</p> <p><b>5</b> = &lt;20% of the fan price</p>	10
	Availability of spare parts: lead time and footprint	Manufacturer declaration	<p><b>0</b> = Spares not stocked in-country; import-only. Lead-time unknown or ≥ 45 days</p> <p><b>1</b> = Imported on order. Lead time ≥ 30 days</p> <p><b>3</b> = In-country wholesaler. Lead time ≤ 14 days</p> <p><b>5</b> = Retail availability in target markets. Lead time ≤ 7 days</p>	5
	Availability of tools	<p>Manufacturer declaration</p> <p>Market survey</p>	<p><b>0</b> = Specialized/proprietary tools only; not available in-country</p> <p><b>1</b> = Standard tools but scarce or expensive.</p> <p><b>3</b> = Standard tools available in the country at fair prices.</p> <p><b>5</b> = Tools widely available at in-country price points.</p>	5

<b>Skills complexity (20%)</b>	Presence of codes or LED to show errors	Visual Inspection  Manufacturer declaration	<b>0</b> = No codes or LED to show errors <b>1</b> = Basic LED / power indicator. No fault semantics <b>3</b> = Distinct fault LED (or similar). Blink patterns are documented in the manual <b>5</b> = On-device codes + QR/printable/ in-manual diagnostic chart linked to common faults and steps and/or remote monitoring integration for predictive maintenance	8
	Time taken to diagnose and fix the fan: major parts should be replaceable within an hour when available.	Market survey	<b>0</b> = Greater than 3 hours <b>1</b> = 2–3 hours <b>3</b> = 1–2 hours <b>5</b> = Less than 1 hour	7
	Knowledge / skill level required	Manufacturer declaration	<b>0</b> = No training available. Must return to the manufacturer <b>1</b> = Requires technical training or higher education <b>3</b> = Apprenticeship / training with skilled repairer <b>5</b> = Minimal training without any formal training (do-it-yourself)	5
<b>Disassembly (25%)</b>	Ease of removing fasteners	Market survey	<b>0</b> = >3 types of tools needed to access major components <b>1</b> = ≤ 3 types of tools needed to access major components <b>3</b> = ≤ 2 types of tools needed to access major components <b>5</b> = ≤1 type of tool needed to access major components	5
	Labelling and markings on fan components	Visual inspection	<b>0</b> = No labelling and markings on fan components <b>1</b> = Minimal labelling and markings on the fan and components <b>3</b> = Labelling of parts without labelling electronic components <b>5</b> = Components and printable circuit boards properly labelled	7.5
	Number of steps to complete disassembly of major parts: the average number of steps has been determined to be five for most fans.	Market survey	<b>0</b> = > 10 steps <b>1</b> = 8–10 steps <b>3</b> = 5–7 steps <b>5</b> = < 5 steps	5
	Types of connectors used	Visual inspection	<b>0</b> = Completely soldered joints and cables <b>1</b> = Screw fasteners and soldered joints <b>3</b> = Use of fasteners like screws and nuts for connectors <b>5</b> = Plug-and-socket connectors without the use of tools	7.5

<b>Documentation (25%)</b>	Provision of repair manual	Visual inspection	<p><b>0</b> = No manual, or manual provided in a non-local language, e.g., Chinese for appliances sold in Africa</p> <p><b>1</b> = Only hard copy manual provided in local / regional language, e.g., English, French, etc.</p> <p><b>3</b> = Hard and soft copy manuals provided; accessible through QR codes, websites, etc.</p> <p><b>5</b> = Hard and soft copy manuals provided, complemented with videos and other media; accessible through QR codes, websites, etc.</p>	5
	Level of detail	Visual inspection	<p><b>0</b> = Full of technical terms with no graphics for clarity and unclear language</p> <p><b>1</b> = Technical with few pictures/graphics</p> <p><b>3</b> = Clear language with few pictures</p> <p><b>5</b> = Clear language with pictures, videos, and troubleshooting charts. Exploded view with part numbers included</p>	10
	User and repair warnings, safety dos and don'ts	Visual inspection	<p><b>0</b> = No warnings provided</p> <p><b>1</b> = Repair warnings provided but no explanations</p> <p><b>3</b> = User and repair warnings only, without safety warnings</p> <p><b>5</b> = User and repair warnings with safety dos and don'ts provided in the repair manual. Warnings in case of breach of warranty</p>	5
	Warranty terms including parts/ after-sales service + helpdesk	Manufacturer declaration	<p><b>0</b> = No warranty period or terms stated</p> <p><b>1</b> = 1 year replacement warranty without details of help desk</p> <p><b>3</b> = &gt; 1 year replacement warranty with help desk details.</p> <p><b>5</b> = Greater than 2-year replacement warranty with help desk and part details.</p>	5

## SCORING & WEIGHTING FOR SOLAR REFRIGERATORS

Access to tools and the dependency of specific repair jobs on certain types of tools are among the determinants of the repairability of solar refrigerators. While specialized tools such as vacuum pumps, leak detectors, gram scales, and brazing tools are a necessity for refrigeration-specific repairs, the reality is that these tools are not always available when faults occur. This results in a greater reliance on generic tools to handle most repair jobs in the field. In this case, technician competence is much more urgent compared to sophisticated tools.

Comprehensive documentation can guarantee that appliances are correctly installed, operated, and maintained, while ensuring that technicians with varied skills can perform timely and effective repairs. It must consider the different stakeholders in the repair

ecosystem, including users, technicians, and service providers/distributors, and clearly outline who should perform what level or repair. Documentation must be comprehensive, sufficient, and multi-lingual, catering to the varied accessibility needs of users across different regions and literacy levels.

Proposed minimum documentation should cover operations, diagnostic standard operating procedures (SOPs), exploded view diagrams, information on warranties and authorized service centers, and safety requirements. Historically, documentation has been provided primarily in print. This index proposes that companies continue to provide this information in print, as well as access via digital formats such as web- and QR-based repositories. The key factors to consider when assessing documentation are sufficiency and completeness, accessibility, inclusivity and format, and safety.

Table 2.2: Scoring criteria for solar refrigerators

PARAMETER	CRITERIA	VERIFICATION METHOD	SCORE 0—5	WEIGHT (%)
Spare parts (25%)	Ease of access to high-failure parts: number of days required to acquire and deliver critical parts from distributor/manufacturer to the client/service site	Supplier records  Market survey	<b>0</b> = No spares available in the country. Must be imported <b>1</b> = spares available in-country; takes more than 7 days <b>3</b> = spares available in-country; takes 3 to 7 days <b>5</b> = spares available in-country; takes less than 3 days	10
	Affordability	Manufacturer declaration  Market survey	<b>0</b> = Spares cost >30% of the price of a new refrigerator <b>1</b> = 21—30% of a new refrigerator <b>3</b> = 10—20% of a new refrigerator <b>5</b> = <10% of a new refrigerator	5
	Tool dependency i.e., specialized tools vs. generic tools	Visual inspection  Market survey  Technical maintenance logs	<b>0</b> = Repairs are possible only with specialized tools <b>1</b> = Most repairs possible with specialized tools and a few generic tools <b>3</b> = Most repairs possible with an equal mix of generic and specialized tools <b>5</b> = Only generic tools for solar photovoltaics (PV) and refrigeration needed for repair	5
	Tools accessibility	Manufacturer declaration  Market survey	<b>0</b> = Not available in country/region <b>1</b> = Difficult. Accessible only to manufacturers/distributors <b>3</b> = Moderate. Only available in specific stores nationwide <b>5</b> = Easy. Can be found locally at electrical / general supply shops	5

<b>Skills complexity (20%)</b>	Diagnosis capability	Market survey	<p><b>0</b> = No diagnostic tools; trial and error diagnosis</p> <p><b>1</b> = Diagnosis requires remote support or manufacturer input</p> <p><b>3</b> = Technicians can diagnose common faults with minimal guidance using available tools</p> <p><b>5</b> = Technicians can independently diagnose most faults using clear diagnostic tools and SOPs, and/or remote monitoring integration for predictive maintenance</p>	10
	Skill accessibility and competence	Market survey	<p><b>0</b> = No local technicians or programs.</p> <p><b>1</b> = Only foreign trainers or technicians available</p> <p><b>3</b> = Technician must have mandatory formal certification from a specific institution or a manufacturer program</p> <p><b>5</b> = Skills can be acquired through training from local/regional institutions, or remote courses</p>	5
	Manufacturer support and knowledge transfer	Verifiable training curricula, course outlines, and partnerships  Market survey	<p><b>0</b> = No training ecosystem supported by the manufacturer</p> <p><b>1</b> = Only remote training</p> <p><b>3</b> = Local certified training provided by local institutions in partnership with the manufacturer</p> <p><b>5</b> = In-person and online courses available</p>	5
<b>Disassembly (25%)</b>	Modularity	Visual inspection  Market survey	<p><b>0</b> = Fully integrated. Parts cannot be removed for repair without complete destruction</p> <p><b>1</b> = Parts can be removed with partial repairable destruction/replacement of components</p> <p><b>3</b> = Parts can be accessed and repaired through various access panels built into the design</p> <p><b>5</b> = Fully modular. All parts can be accessed independently</p>	10
	Tamper-proofing and security	Visual inspection  Market survey	<p><b>0</b> = System built for no override</p> <p><b>1</b> = Only the manufacturer can override security</p> <p><b>3</b> = Technician can override security</p> <p><b>5</b> = Fully accessible</p>	5
	Repair time: time it takes a trained technician to conduct a diagnosis, repair, and post-repair test	Visual inspection  Market survey	<p><b>0</b> = &gt; 3 hours</p> <p><b>1</b> = 2–3 hours</p> <p><b>3</b> = 1–2 hours</p> <p><b>5</b> = ≤ 1 Hour</p>	10

<b>Documentation (30%)</b>	Sufficiency and completeness: availability of manuals for all actors - Distributors (+ service centers), technicians, and customers covering basic operational guidance, step-by-step troubleshooting/ diagnostic, warranty, service locations, and non-serviceable parts	Visual inspection  Market survey	<b>0</b> = No documentation <b>1</b> = Basic customer and warranty manuals only <b>3</b> = Manuals for any two sets of audiences <b>5</b> = All three audiences covered	10
	Accessibility, inclusiveness, and format: availability of printed hard copy in the box + QR codes + web pages/ app with repair library content + Language considerations	Visual inspection  Market survey	<b>0</b> = No print manual <b>1</b> = Print manuals available only in one language <b>3</b> = Print and digital manuals available in multiple languages <b>5</b> = Availability of print and digital manuals in multiple languages, plus web-based libraries and pictorials	10
	Safety and quality assurance: top three safety warnings: refrigerant risks + battery/electrical risks + ventilation placement guidelines	Visual inspection  Market survey	<b>0</b> = Zero safety warnings <b>1</b> = Basic. One safety warning <b>3</b> = Sufficient. Two safety warnings + color code <b>5</b> = Best practice. All safety warnings with pictorials, color codes + language translations	10

## SCORING & WEIGHTING FOR SOLAR WATER PUMPS

For solar water pumps, equal importance is placed on empowering customers, specifically farmers, to conduct routine maintenance with ease, and on ensuring technicians have access to spare parts, modular components, and more complex repair information. With a high diversity of pump technologies available, there is a wide range of common failure modes, from impeller wear to dry-run damage. This diversity makes it impractical to adopt a one-size-fits-all approach to standardizing spare parts. Instead, companies must tailor their spare parts strategies to each appliance line, ensuring that the most failure-prone components are available locally and affordably. Moreover, robust design practices, such as modular components, ensure protection against common failures, and bundled toolkits can dramatically reduce repair cost.

A skilled and supported technician workforce is equally vital. The need to differentiate between simple maintenance tasks or field-level fixes and complex repairs requiring advanced technical skills was highlighted. Many pump failures can be prevented through basic routine maintenance and proper handling if the knowledge is available. Other issues, such as internal motor or impeller failures, demand trained

technicians with the proper tools and guidance. Even “plug-and-play” systems benefit from user training and basic operating guidance, as these measures prevent avoidable breakdowns and reduce pressure on service networks. Companies adopt different approaches to service, from encouraging self-repair to maintaining centralized service centers or hybrid technician networks; however, all agree that clear roles and training are essential to improving overall repairability.

The importance of modularity, standard fasteners, and non-destructive sealing approaches was emphasized. A well-designed pump should allow routine maintenance tasks to be completed in less than 20 minutes with standard tools, without compromising safety or quality. Modularity not only simplifies repair work but also makes spare parts logistics more predictable and cost-effective. However, the economic dimension of modularity is just as important as the technical one: if a sub-assembly costs nearly as much as a new pump, customers are unlikely to repair it. The need for companies to balance technical accessibility with economic practicality was underscored. Given the complexity and multi-audience nature of documentation, the criteria ultimately merged detailed requirements like minimum content and accessibility into audience-focused segments.

Table 2.3: Scoring criteria for SWPs

PARAMETER	CRITERIA	VERIFICATION METHOD	SCORE (0–5)	WEIGHT (%)
Spare parts (25%)	Availability & distribution of spare parts	<p>Manufacturer documentation</p> <p>Site audits at distributor/service centers.</p> <p>Market survey</p> <p>Warranty and maintenance documentation</p>	<p><b>0</b> = No spares available; replace whole pump.</p> <p><b>1</b> = Spares are only available in the central warehouse abroad. Lead time to receive spares locally is more than six weeks.</p> <p><b>3</b> = Limited in-country stock. Lead time to receive spares locally is two to five weeks.</p> <p><b>5</b> = Tiered access (end-user/service center/distributor) with active stock monitoring. Most spare parts are locally available. Ones which rarely fail have a short lead time of less than two weeks.</p>	10
	Standardization & quality of common replacement parts	<p>Manufacturer documentation.</p> <p>Visual inspection of connectors; check for ISO certification labels.</p>	<p><b>0</b> = All components are proprietary, and no material or quality information is available.</p> <p><b>1</b> = A mixture of proprietary and standard parts, but there is no evidence of testing or compliance with quality standards.</p> <p><b>3</b> = Some commonly replaced parts, such as connectors or seals, are standardized, and partial information on material or quality assurance is provided.</p> <p><b>5</b> = All frequently replaced parts are standardized or justified proprietary components, supported by documented quality ratings (e.g., IP certification or endurance tests).</p>	10
	Affordability & total spares cost	<p>Manufacturer documentation.</p> <p>Market survey</p>	<p><b>0</b> = No pricing information is available for spare parts.</p> <p><b>1</b> = Only partial pricing is available, and the total cost of all spares exceeds 150% of the cost of a new pump.</p> <p><b>3</b> = A complete price list is provided, but the total cost of all parts exceeds 125% of a new pump.</p> <p><b>5</b> = A transparent and publicly available price list exists, and the total cost of all spares is less than or equal to 125% of the retail price of a new pump, making repair financially viable</p>	5

<b>Skills complexity (20%)</b>	Installation & end-user orientation	<p>Training manuals, attendance logs, user feedback surveys, and site observations.</p> <p>Market survey</p>	<p><b>0</b> = No installation support or appliance manual is provided to users.</p> <p><b>1</b> = Only a short, text-based leaflet is included, typically in English, with no visuals or maintenance guidance.</p> <p><b>3</b> = Users receive basic installation support and a simple guide covering setup, maintenance, and warranty information.</p> <p><b>5</b> = Comprehensive installation and orientation are provided, including hands-on training or demonstrations, pictorial and local-language manuals, safety labelling, and a responsive customer helpline.</p>	8
	Basic field repairs (end-user / local tech, non-authorized)	<p>Repair manuals or quick start guides to confirm clarity of repair instructions.</p> <p>Visual inspection</p> <p>Market survey</p>	<p><b>0</b> = The appliance is completely sealed and cannot be repaired in the field.</p> <p><b>1</b> = Only simple fixes can be made and only by technicians based in formal service centers.</p> <p><b>3</b> = The appliance includes clear instructions that distinguish simple repairs, which can be done in the field using common tools, from complex repairs that must be done by certified technicians.</p> <p><b>5</b> = The manual provides clear, visual instructions for field-level repairs. Users and local technicians can complete common fixes safely, and certified technicians are available nearby for complex issues.</p>	7
	Advanced repairs & training ecosystem	<p>Verifiable training curricula, course outlines, and partnerships</p> <p>Technician certification records or registries.</p> <p>Market survey, training attendance or audit reports.</p>	<p><b>0</b> = There is no structured training or support system for technicians.</p> <p><b>1</b> = Training occurs irregularly through one-off workshops or online sessions without certification.</p> <p><b>3</b> = The manufacturer or a local institution offers a formal appliance-specific training program with certification for technicians.</p> <p><b>5</b> = A structured training ecosystem exists, offering tiered certification, blended learning (online and practical), refresher courses, and an updated registry of certified technicians.</p>	5

<b>Disassembly (20%)</b>	Non-destructive access (common parts)	Market survey  Warranty documents and records of orientation sessions.	<b>0</b> = The pump's housing is permanently sealed and cannot be opened without damage. <b>1</b> = Some access is possible but involves breaking seals or casing. <b>3</b> = Common parts can be accessed with care using ordinary hand tools like screwdrivers and wrenches. <b>5</b> = All commonly replaced parts are easily accessible through non-destructive means, and the process is clearly documented in the manual or videos.	5
	Modularity	Repair manuals or quick start guides.  Visual inspection  Market survey	<b>0</b> = The pump is fully integrated and cannot be serviced. Failure in any component requires full replacement. <b>1</b> = Only a few external modules, such as cables or controllers, can be replaced. <b>3</b> = Most major sub-assemblies are modular and replaceable, but some internal parts remain sealed. <b>5</b> = The pump is fully modular; each component and sub-assembly can be independently replaced using unique part codes, and the cost of modules is proportional to their value.	10
	Maintenance / Common repair time	Market survey  Lab testing	<b>0</b> = Routine maintenance tasks take more than an hour and require specialized tools. <b>1</b> = Maintenance tasks take 30–60 minutes and instructions are unclear. <b>3</b> = Routine tasks such as cleaning or replacing filters can be completed in 15–30 minutes using basic hand tools. <b>5</b> = Maintenance takes less than 15 minutes, with clear, illustrated instructions and common or tool-free fasteners.	5

<b>Documentation (35%)</b>	Minimum standards — Customer	Visual inspection  Market survey	<b>0</b> = No manual or user guide is provided. <b>1</b> = A text-only manual exists but is incomplete, not translated, or not easily understandable. <b>3</b> = A basic pictorial or localized guide is provided, including key safety and warranty information. <b>5</b> = A comprehensive pictorial, multilingual manual is provided, containing clear step-by-step setup, safety instructions, warranty details, and contact information for after-sales support.	15
	Minimum standards — Field technician	Visual inspection  Market survey  Manufacturer documentation.	<b>0</b> = No documentation exists for technical repair or diagnostics. <b>1</b> = Only a dense English text manual with minimal diagrams is available. <b>3</b> = A clear technician guide, available offline, includes wiring diagrams, diagnostic flowcharts, and part lists. <b>5</b> = A comprehensive technical manual or app provides illustrated repair procedures, wiring diagrams, and diagnostic tools, with multilingual and offline access and an active helpdesk.	8
	Minimum Standards — Repair center/ distributor	Visual inspection  Market survey  Manufacturer documentation.	<b>0</b> = Only one general manual is available for all audiences. <b>1</b> = Two-tier documentation exists but lacks technical depth. <b>3</b> = Separate manuals are provided for technicians and service centers, including calibration and diagnostic procedures. <b>5</b> = A full three-tier documentation system (end-user, technician, authorized service center) exists, with advanced calibration, firmware tools, and secure update systems.	7
	Innovation (digital & interactive)	Visual inspection  Market survey	<b>0</b> = No digital materials or QR codes are available. <b>1</b> = Only static PDF manuals are provided. <b>3</b> = QR codes or links give access to online troubleshooting videos or digital guides. <b>5</b> = A comprehensive digital platform or mobile app provides multilingual, offline-capable, interactive tutorials, diagnostics, and update notifications.	5

## NOTES FOR ASSESSORS

- Each parameter should be scored independently based on evidence gathered from appliance documentation, direct observation, and market surveys/stakeholder interviews.
- Where physical inspection is not feasible, verification can rely on manufacturer submissions (manuals, training materials, toolkits) combined with field validation by technicians.
- Scores should always be assigned conservatively, only when clear, verifiable proof exists for the stated level of performance.
- For digital innovation scoring, assessors should confirm functionality directly rather than relying on manufacturer claims.



Powerbox technician repairing an appliance

Photo Credit: CLASP



Solar appliance repair technicians in Nigeria  
Photo Credit: CLASP

# CALCULATION OF THE REPAIRABILITY INDEX

Following the appliance characteristics and parameters to be evaluated as outlined in section 3 of this report, a summation of the scores for each individual metric should then be computed to give the overall repairability score for a given appliance. The total score will be given by computing the sum of the score for individual metric per appliance multiplied by individual weighting factors, i.e.,

Total score = (metric #1 x weighting factor #1) + (metric #2 x weighting factor #2) ... + (metric #n x weighting factor #n)

This can be simplified as, the reparability index (RI):

$$RI = \sum_{m=1}^n S_m \cdot W_m$$

where,

$S_m$  is the score of criterion m as assessed for an appliance (given from 1-5)

$W_m$  is the weighting factor of criterion m assessed at parameter level (given in %)

$n$  is the is the number of individual metrics to be assessed

To streamline scoring and improve comparability across appliance types, the Repair Index Calculator is available as an interactive digital tool to compute the Repairability Index (RI). Users of this tool can select the relevant appliance weighting profile (fans,

refrigerators, or water pumps) and enter scores for each metric under the four parameters: Spare Parts & Tools, Skills Complexity, Disassembly, and Documentation. The tool then automatically applies the parameter weights and computes the overall score which is then presented as the Repairability Index alongside a RAG interpretation (Poor, Moderate, High). This supports faster, more transparent assessments and reduces manual errors in calculation.

Scores should be evidence-based and traceable to ensure consistency and credibility, i.e.,

- For parts and tools, verify affordability with a documented price list and lead-time commitments.
- For skills, confirm diagnostic aids (e.g., fault codes, SOPs) and training pathways (local or manufacturer-supported).
- For disassembly, this should be judged on non-destructive access, fastener types, and realistic repair times.
- For documentation quality, it must reflect tiered audiences (end-user, technician, authorized service), language accessibility, and safety content.

When information is incomplete, assessors should assign conservative scores and highlight assumptions. Where variability exists (e.g., some repairs need specialized tools while others do not), score the priority repairs and high-frequency failure modes first, then note exceptions. The calculator prompts for these considerations and includes fields to attach references (manuals, SOPs, training certificates, supplier records) to improve auditability.

## INTERPRETING AND USING YOUR RESULTS

The higher the score, the more repairable the appliance is.

Table 3.1: Interpretation of repairability index scores

REPAIRABILITY SCORE	INTERPRETATION	EXPLANATION
0–1.9	Poor	Repair is not feasible, or is feasible but very complex. It's only possible for manufacturer and authorized service partners; very low consideration to enable informal repair.
2–3.9	Moderate	Repair is feasible and modest. It can be carried out by informal repairers, adequate access to spare parts, tools, and information to facilitate repair.
4–5	High	Repair is feasible and straightforward. It can be done by a layperson, full and open access to all spare parts, tools, and information needed for repair.

The calculator displays the weighted RI, a RAG color bar, and a breakdown by parameter to show where repairability is strong or weak. This helps manufacturers prioritize design-for-repair interventions (e.g., modular subassemblies and standard connectors); distributors plan spares stocking and service footprints; and programs/policymakers identify ecosystem gaps (skills, documentation, supply chains). We encourage use of the tool during validation pilots across multiple models and contexts, recording field evidence (photos, time-on-task, tool lists) and feedback sharing to refine scoring thresholds and guidance. Over time, consistent use of the calculator will support benchmarking, consumer-facing disclosure, and procurement decisions that reward repair-friendly design. A sample repair assessment for a fan is included in the annexes for reference.



Consistent Energy solar refrigerator consumer, Helen Obina, in Nigeria

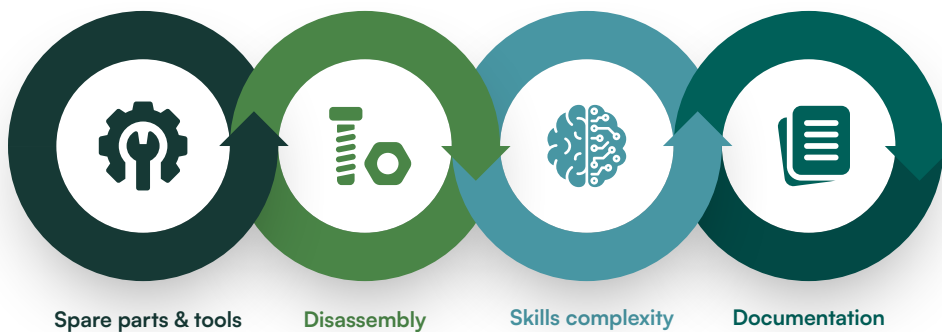
Photo Credit: CLASP

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# NEXT STEPS

A functioning repair ecosystem depends on multiple interconnected elements: availability of spare parts, technician skills, ease of disassembly, and accessible documentation on safe and effective repair. These factors go beyond good design and shape and look at whether an appliance can be fixed quickly and affordably, or else ends up damaged and abandoned, leading to wasted investment and increased e-waste.

**A functioning repair ecosystem depends on multiple interconnected elements:**



This report, the second in the [Solar Appliance Repairability Index Series](#), translates the foundational insights of *Closing the Loop: Enhancing Repairability in the Solar Appliance Market* into a practical, appliance-specific methodology for fans, refrigerators, and solar water pumps (SWPs). The first paper documented an informal, fragmented repair ecosystem, with barriers in spare parts availability and pricing, skills and training, appliance disassembly, and documentation access, all of which undermine consumer value, increase downtime, and contribute to e-waste in off-grid appliance markets.

Building directly on those findings, this index operationalizes repairability into four measurable parameters: Spare Parts & Tools, Skills Complexity, Disassembly, and Documentation. The index defines appliance-specific weighting profiles to reflect practical repair realities (e.g., higher documentation weighting, greater end-user guidance, etc.). The proposed scoring scheme enables comparable, evidence-based assessments across appliance lines while remaining sensitive to context and failure modes highlighted in field interviews and TWGs.

Across appliances, the Repairability Index consistently shows that repairability is ecosystem-dependent: design-for-repair features and modularity are necessary but not sufficient without *credible* supply chains for priority parts, *accessible* skills pathways,

and *tiered* documentation in relevant languages. For fans, affordability and traceability of common parts (motor, blades, PCB, batteries) often determine whether users repair or replace. For refrigerators, the highest repair burden sits in electrical/control subsystems, making diagnostic aids, SOPs, and safe access to trained technicians crucial. For SWPs, diversity of pump designs precludes one-size-fits-all spares; instead, modular subassemblies, standard fasteners where appropriate, and realistic lead times (plus clear end-user guidance) anchor repairability. These appliance-level nuances echo barriers catalogued in *Closing the Loop*, notably knowledge gaps, limited repair service access, and missed job opportunities, and confirm that sustained improvement requires coordinated action among manufacturers, distributors, technicians, and policymakers.

The Repairability Index is designed to serve not merely as a compliance standard but as a structural tool intended to guide appliance design interventions, refine business models, and establish clear standards for workforce training. The overarching principle as established by key sector experts is that effective repairability must be assessed through the lens of tiered expertise and accountability, necessitating clear definitions for end-users, informal field technicians, and authorized service partners.

## LIMITATIONS OF THE REPAIRABILITY INDEX

1. This index recognizes the risk of penalizing markets that lack formal repair networks. Future strategies must aim to create a tiered market scoring framework that accounts for mature, mid-level, and nascent markets.
2. Certain factors, such as cross-border complexities and supply chain delays, have not been accounted for in this index; yet they impact the sourcing of spare parts and tools. Future strategies could assess cross-border supply chain performance and include scoring for manufacturer response time, supply-chain pathways, and regional or central warehouse logistics.
3. Finally, the index does not define a general basepoint for a country's technician capacity. Future scoring should allow for the assessment of the presence of training programs or the density of the technical capacity in a country.

By pairing a transparent scoring methodology with a digital repair index calculator, the Index offers a replicable and scalable way to (i) prioritize design changes (e.g., modular controllers, service access panels), (ii) plan spares stocking and service footprints, (iii) target technician training and certification, and (iv) standardize documentation practices for end-users, technicians, and authorized partners. Routine use of the tool in procurement, validation pilots, and labelling can create market incentives for repair-friendly designs, mirroring how disclosure has historically pushed efficiency gains in other appliance segments.

# RECOMMENDATIONS AND NEXT STEPS



## VALIDATION & CALIBRATION

1. **Pilot scoring** on real appliances across multiple geographies and service models (PAYGo, cash sales, distributor networks). Capture time-on-task, tool lists, and parts costs/lead times; attach evidence (price lists, SOPs, photos, manuals) to reduce scoring subjectivity. This will allow for confirmation of whether the scoring ranges applied to each parameter capture sufficient variation and reflect meaningful differences in repairability performance.
2. **Calibrate thresholds/weights** using pilot data, particularly affordability cut-offs, repair time bands, and documentation sufficiency, for each appliance category. Adjustments may include calibrating score thresholds, refining weightings, or re-defining certain metrics to more accurately reflect field realities. This adaptive iteration will strengthen the technical reliability of the index.
3. **Publish a validation memo** outlining adjustments to criteria, examples of borderline cases, and guidance on conservative scoring when information is incomplete. Validation using actual appliances is essential to assess how well the index functions as a screening tool in real market conditions.



## LEARNING AND REPLICATION

1. **Publish public guidance** materials summarizing actionable steps manufacturers can take to improve the repairability of their appliances. This could include best practice examples, design-for-disassembly principles, standardization of parts, recommended documentation formats, and guidance for local spare part channels. By making such recommendations public, the index can serve both as an evaluative tool and a constructive mechanism that helps industry improve, rather than simply rank repairability.
2. **Expand methodology for additional appliances**, including electric cooking, walk-in cold rooms, ag-processing equipment, and more.



## MARKET SIGNALING AND CAPACITY BUILDING

- 1. Introduce a repairability disclosure:** Display RI scores (and parameter breakdowns) in procurement documents, distributor portals, consumer-facing labels and digital appliance information platforms. This would enable consumers to consider repairability in purchasing decisions, increasing transparency and rewarding brands that design for repairability. Over time, such labelling could drive market incentives for manufacturers to improve repair design and support a circular economy ecosystem, similar to how energy efficiency labels influenced appliance efficiency upgrades globally.
- 2. Sector feedback loop:** Convene a Technical Working Group cadence (post-forum) to update criteria, weights, and examples bi-annually; share anonymized scoring data to improve benchmarks and reduce assessor variability.
- 3. Hybrid service models:** Manufacturers should combine authorized service centers with vetted independent technicians, audits, and helpdesk support (e.g., ticketing, remote diagnostics) to extend reach without compromising safety or accountability, responding to “closed vs. open” repair philosophies.



## ENABLING ENVIRONMENT (POLICY & PROGRAMMATIC SUPPORT)

- 1. Tiered training pathways:** Develop and implement short courses for routine maintenance and field diagnostics; advanced modules for refrigeration and pump internals; recognition/alignment with national certifications where feasible (e.g., PV installation exams) to normalize quality and safety.
- 2. Align import duties:** To prevent parts from being disproportionately expensive and slow to import, align import duties for spare parts with whole-appliance exemptions where applicable. This issue was flagged by practitioners and is consistent with supply-chain barriers.
- 3. Fund integrated interventions:** Pair parts warehousing with technician training and documentation localization in program grants; require RI scoring and evidence attachments in funding and procurement criteria to mainstream repairability at scale.

## ANNEXES

### 1. KEY FINDINGS AND INSIGHTS FROM TECHNICAL WORKING GROUPS

Even with good design, broken pumps need replacement parts. It was highlighted that some distributors struggle to maintain an adequate stock of spare parts. International sourcing of common failure parts (especially batteries) introduces profound logistical friction. Distributors and repair organizations face substantial challenges, as customs processes vary widely across African markets, making it impossible to guarantee swift delivery. Large regional distributors can ship spares within weeks, but small local stores in remote areas often stock only the cheapest parts. Specialty items may be delayed for months due to customs and shipping. Establishing regional service hubs and forecasting demand from installed pumps were therefore recommended. However, this was seen to be impractical when distribution partners in new markets are unwilling to stock spare parts. This is because they are unable to forecast the need for spares, given that they have never sold the appliance before.

Another recurring industry challenge that undermines repairability is the common practice of manufacturers discontinuing older appliance models while a substantial user base remains active. To counteract this, some manufacturers implement design strategies that incorporate retrofittable components in new models, ensuring that older appliance versions can be repaired or upgraded using newer parts, thereby extending their lifespan.

## SPARE PARTS AND TOOLS

### SOLAR FANS

The **affordability** of common spare parts, such as motors, fan blades, stands, batteries and Printable Circuit Board Assembly (PCBA), is a critical determinant of whether repairs can be carried out or not. Even if a part is physically available, if the cost of replacing it approaches the cost of buying a new fan, customers are more likely to dispose of the appliance rather than repair it. In low-income contexts, this effect is magnified. Therefore, a reasonable affordability threshold (i.e., repair costs less than 30% of total fan price) is essential to encourage repair



Fan in use in Pakistan

*Photo Credit: CLASP*

rather than replacement.

**Traceability** of parts, (i.e., clear identification, such as part numbers, stock keeping units (SKUs), QR codes, or serial numbers) is essential. Without traceability, it becomes challenging for technicians to order the correct replacement parts, especially in markets where many models look similar but have different internal components. Traceability also reduces counterfeit substitution risk, which can lead to safety failures and diminish post-repair appliance life.

**Ease of procurement** refers not only to whether a part exists, but also whether it can realistically be obtained in field conditions. Many spare parts require bulk import, large minimum order quantities, or long lead times, making them impractical. A highly repairable fan is one in which common parts are accessible through common repair channels, such as informal kiosks, local markets, or original equipment manufacturer (OEM)-authorized centers.

**Tool availability** determines whether fan repairs can be performed by typical repair technicians or only by OEM-authorized centers. When standard screwdrivers, pliers, and basic multimeters are sufficient to repair a fan, its repairability increases. When specialized proprietary tools are required for repairs, repair is possible only by a small group with specialized equipment; this increases costs and reduces repairability.

## SOLAR WATER PUMPS

Pumps come in many types (surface vs. submersible, piston vs. centrifugal), each with its own weak points. For example, screw pumps wear quickly in sandy water, while piston pumps tolerate dry running better. This diversity means it is impossible to define one universal spares kit for all SWPs. Instead, each pump design must have a tailored spare parts strategy. Understanding which parts fail most often for which pump type(s) (e.g., impellers, seals, or motor brushes) is the first step to deciding what spares to stock.

The use of standard or generic parts (e.g., MC4 connectors, common hose fittings) for electric connectors and other common fittings to simplify repairs was highlighted. While 64% of the TWG participants favored standard electrical connectors for ease, manufacturers warned that a “one-size-fits-all” plug could be unsafe or fail in heavy-duty pumps. The consensus was to include only quality-tested parts that meet each pump’s requirements. In practice, many pump manufacturers use some generic parts (like MC4 solar cable connectors) precisely because they can be found locally. The TWG noted that the repairability index should reward use of such common parts, but only if they are durable and readily available, avoiding the pitfall of “lowest common standard” failures. On the same note, the use of proprietary parts should also be weighted the same as when readily available parts are used, but only if the details on availability are clearly documented. This avoids penalizing manufacturers who use proprietary parts for a justifiable reason.

**The use of proprietary parts should also be weighted the same as when readily available parts are used, but only if the details on availability are clearly documented.**

The TWG underscored that repair must make financial sense. One major finding was that the average repair cost is about 30–35% of buying a new off-grid solar appliance. To make repairs attractive, some manufacturers ensure that the combined cost of all spares is not more than 120% of the cost of a new pump. For very cheap pumps, users might still choose replacement over repair if parts are relatively expensive. Some companies therefore perform a cost-benefit analysis per pump: if a pump is low-end, they may sell a replacement at a small premium instead of doing a costly repair. For SWPs funded by development programs or on financing plans, keeping pumps running is usually more cost-effective than replacing the entire system.

Finally, it was noted that even with spare parts in hand, repairs need the right tools and information. Basic toolkits such as ratchet sets and wrenches should ideally accompany pumps or be available locally. More importantly, having detailed diagrams, parts lists, and troubleshooting guides in English or local languages is critical. Pumps sold with detailed manuals or how-to videos are much easier to service. Clear documentation not only helps order the correct parts but also empowers local technicians to avoid mistakes.

## SKILLS COMPLEXITY

Repairability of solar-powered appliances extends beyond hardware and depends significantly on the skills, knowledge, and technicians' confidence in providing repair support. Historically, the best designed systems fail when local repair ecosystems are weak, or when technicians do not possess the essential diagnostic systems. Low skill complexity directly supports higher repairability. If common appliance repairs can be executed by non-specialized individuals (or informal repairers and users with basic experience), the repair ecosystem becomes broader, more distributed, and more resilient. However, when repairs require advanced electronics knowledge, or formal technical certification, repair becomes constrained to a small and often expensive service pool. These considerations help manufacturers and service providers design appliances and support systems that enable safe, efficient, and inclusive repair practices. This criterion evaluates the necessary expertise required for installation and

repair, emphasizing structured training, effective decentralization, and robust technical support mechanisms.

### SOLAR FANS

Repairing a fan involves a combination of mechanical and electrical skills, supported by safety awareness to prevent hazards. The complexity of the repair depends on the fault: simple issues like fixing a fan guard can be handled with basic instructions, while problems involving electronic components such as printed circuit boards (PCBs) require specialized knowledge. Informal technicians generally manage common repairs. Features such as modular parts and LED indicators for diagnostics make troubleshooting easier and reduce reliance on advanced skills or equipment.

For most fan models, non-invasive repairs are often feasible, especially when supported by clear manuals or online tutorials.



Institutional eCooker assembly of an Ecobora model in Kajiado, Kenya

Photo Credit: CLASP

However, inclusion challenges, such as language barriers and access to smartphones, affect the reach of these resources. Safety remains a critical concern, as improper clamping or incorrect battery connections can lead to hazards. Manufacturers and organizations sometimes provide training and certifications for local technicians, ensuring quality and consistency in repairs.

To enhance repairability, several strategies are recommended. First, the presence of online or offline resources, such as manuals or apps, is essential for guiding repairs. Second, diagnostic aids like fault codes or LED indicators improve efficiency and reduce skill requirements. Third, the time taken to diagnose and fix a fan (ideally under 30 minutes) should serve as a benchmark for ease of repair. Finally, the level of skill required is a key determinant: appliances that demand specialized training or certification score lower on repairability, especially when they lack clear guidance and resources on how to acquire these.

## SOLAR REFRIGERATORS

Manufacturers have often expressed concerns about the risk of equipment damage, especially of sensitive parts such as control circuits, when untrained technicians are involved. These kinds of unauthorized repairs cause more harm than good, prompting manufacturers to rely on their own trained technicians to repair high-risk parts. However, this limits access to localized repair support, leading to prolonged downtime and even higher maintenance costs. Building a strong skills ecosystem that allows technicians to diagnose, service, and maintain solar refrigerators safely and confidently is a key determinant of long-term sustainability.

The ease and possibility of repair of a solar refrigerator are directly tied to the technical competence of the technician handling it. Hence, the key factors to address are diagnostic skill, technical training, and access to information.

The greatest gap in delivering a robust repair job lies in identifying the exact problem in the first place. Diagnostic errors occur more often than actual failures. Technicians frequently misinterpret faults, assuming refrigeration system faults when the issue mostly lies in the power system, and sometimes, vice versa. This mostly occurs because of limited

access to diagnostic tools and procedures from the manufacturer or the supplier. When standard operating procedures (SOPs) for diagnostics and other repair manuals are missing, the technician is likely to resort to trial and error for diagnostics and repair, which could lead to extensive or irreversible damage. For instance, a simple sensor fault, a broken connector, or a short circuit might lead to a complete replacement of a functioning component, simply because the technician could not diagnose the problem accurately. This often inflates repair costs and affects equipment uptime.

## Diagnostic errors occur more often than actual failures.

Access to skills and skilled technicians varies from one country or region to another. Many solar refrigerator distributors report a constant struggle to find qualified technicians who can both install the fridge and provide maintenance. Some programs, such as the [Africa Centre of Excellence for Sustainable Cooling and Cold Chain](#) in Kigali, Rwanda, and the [Strathmore Energy Research Centre](#) in Kenya, have tried to address this gap. These programs have made strides in building capacity for basic refrigeration and diagnosis, but in comparison to the continent's needs, they are fragmented and insufficient. On the other hand, countries with limited training infrastructure depend heavily on imported skills, contrary to countries with strong local technical and vocational education systems that integrate solar refrigeration modules. Manufacturers then play a critical role in ensuring skills availability by:

1. Training local technicians through short workshops,
2. Guiding users and technicians on where to find authorized repair services, SOPs, and trained personnel,
3. Providing warranty-based repair support,
4. Offering a post-warranty service contract.

## SOLAR WATER PUMPS

Manufacturers or trained partners often install the pump. About 70% of organizations offer free installation or sell “plug-and-play” pumps meant for simple user setup. The key point was that even “easy” systems benefit from some user training. Companies reported investing in brief training at the point of sale or installation for all customers to teach safe use and basic checks. Prominently displaying “do’s and don’ts” on the pump or packaging to reinforce this guidance was suggested.

A central insight was that a clear distinction must be maintained between routine setup and maintenance done regularly by customers (simple field repairs often related to external accessories like panel connections, hoses, leaks, etc., vs. complex repairs, such as internal motors, impellers, or controller issues). Simple issues are expected to be handled by users or technicians with basic training, while complex repairs demand specialist training and central support. The implication is that the repair index should reflect whether simple issues can indeed be handled easily.

Industry repair philosophies vary significantly based on appliance design and perceived risk:

- **Encourage self-repair:** Some manufacturers encourage customers to perform basic repairs, relying on straightforward component replacement design to mitigate concerns about further damage and prioritizing reduced customer downtime.

- **Centralized control and accountability:** Other manufacturers favor central service centers using reverse logistics. This preference is rooted not primarily in technical difficulty, but in risk and accountability management. By centralizing repair, manufacturers ensure consistent application of skills and proper waste management. It also protects PAYG revenue streams and brand reputation from the potentially damaging work of unqualified freelance technicians.
- **Hybrid model:** This approach entails training a vetted network of freelance technicians, using audits and clear scope-of-work agreements to maintain standards. A “repair-friendly” model (broad training and networks) should therefore score higher than one with closed-off service channels.

A foundational electrical or electronic background (diploma or certificate) is considered the minimum standard for SWP technicians. Training focuses on technical customization for specific appliances and crucial soft skills (customer engagement, clean workspace maintenance) deemed essential for customer satisfaction. Preparation for national certifications, such as the Energy and Petroleum Regulatory Authority (EPRA) exam<sup>10</sup> in Kenya, often serves as a proxy for minimum PV installation competence. Several major universities offer short courses on solar energy. Some universities and polytechnics in East Africa offer solar PV courses that include pumps.

<sup>10</sup> Energy and Petroleum Regulatory Authority (EPRA), Electricity and Renewable Energy License Application Guide, accessed February 10, 2026, <https://www.epra.go.ke/sites/default/files/Documents/Electricity-and-Renewable-Energy-License-Application-Guide.pdf>.  
Efficiency for Access, Global LEAP Solar E-Waste Challenge: Lessons on Take-Back, Collection, Repair & Recycling of Off-Grid Solar Products, March 2021, [https://efficiencyforaccess.org/wp-content/uploads/Clasp\\_EforA-SolarEWaste\\_5-May.pdf](https://efficiencyforaccess.org/wp-content/uploads/Clasp_EforA-SolarEWaste_5-May.pdf).

**Below is a sample of the courses offered by some universities:**

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Strathmore Energy Research Centre (SERC) by Strathmore University has a solar water pumping course<sup>11</sup> in Kenya.



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Solar Academy by the University of Nairobi's physics department<sup>12</sup> has a short professional course for solar PV in Kenya.



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The University of Makerere has a short course titled Solar Water Pumping and Solar Powered Irrigation Systems via the CREEC academy<sup>13</sup> in Uganda.



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The Renewable Energy Technology Training Institute offers solar PV design and installation courses in Nigeria.



Manufacturers often provide free service training on their appliances, both as customer support and a way to ensure a qualified service network. There are also online courses, such as an industry-wide pumping systems course on Thinkific (part of GIZ's SUN4WATER project). International agencies run programs too, like the World Bank's SWP training in the Sahel and UNIDO's development of artificial intelligence or virtual reality training tools for appliance repair. However, it was unclear whether national licensing boards recognize certificates from all these programs. This gap could limit technicians' ability to use their skills professionally; development program implementers should therefore consider supporting standardized certification pathways.

Technicians need ongoing support in the field. Some companies run dedicated hotlines for technicians such as an online ticket system for tracking repair cases and remote diagnostics via a smartphone app, which can warn a technician of a fault before it occurs. SolarAid offers a mobile "repair app" that walks agents through fixes. Informal networks also help: SolarAid's WhatsApp groups and monthly calls share tips with freelance technicians.

When working with independent technicians, companies worry about loyalty and quality. To maintain confidence in decentralized repair, hybrid models which implement stringent quality control measures, such as audit sessions involving video calls with technicians on-site, or require video uploads of appliance functionality, linking payment directly to customer sign-off on satisfactory repair outcomes, should be embraced. This defines a clear "scope of work" to manage technician liability and prevent over-complex, unauthorized interventions.

11 Strathmore Energy Research Centre (SERC), "Solar Water Pumping Training," accessed February 10, 2026, <https://serc.strathmore.edu/solar-water-pumping-training/>.

12 University of Nairobi, "Solar Academy," accessed February 10, 2026, <https://physics.uonbi.ac.ke/basic-page/solar-academy>.

13 CREEC Academy, "Solar Water Pumping and Solar Powered Irrigation Systems (SPIS)," accessed February 10, 2026, <https://www.creecacademy.com/solar-water-pumping-and-solar-powered-irrigation-systems-spis/>.

## DISASSEMBLY

Disassembly moves beyond merely being able to open an appliance; it evaluates the design choices that facilitate efficient, non-destructive component replacement, while managing the tension between ease of access and the requirements of safety, durability, and the manufacturer's intellectual property (IP) protection.

Modular designs allow components to be extracted and replaced without effecting other assemblies. High modularity reduces labor input, shortens repair time, and makes repairs more economically viable. Inter-brand compatibility is especially valuable in markets where repairers hold limited inventory. Standardized sizes and mounting systems allow spare parts to be pooled across multiple models and even multiple manufacturers. In contrast, glued assemblies, non-reversible clips, inaccessible fasteners, or single-piece PCB-mechanical integration result in a higher disassembly burden and lower repair rates.

### SOLAR FANS

Ideally, accessing key components such as the motor, capacitor, or switch should require no more than five to six steps, with fewer steps being preferable for efficiency. Easy accessibility of these components allows for quicker diagnosis and repair, reducing downtime and costs. Similarly, fasteners should be non-destructive and easy to remove, as

components like fan blades often need periodic cleaning. Using standard fasteners such as flathead screws is recommended because they are widely available and simple to handle. Proprietary fasteners may be justified in cases where tamper prevention is necessary, such as PAYGo systems, but they generally reduce repairability.

The design of internal connections and layouts also influences the ease of repair. Modular connectors are preferred over soldered ones because they simplify troubleshooting and replacement. Internal components should be removable and replaceable independently. Cable routing should be intuitive, supported by grooves, channels, and color coding to guide reassembly. Labels and diagrams inside the unit, along with markings on PCBs, further enhance repairability by helping technicians identify and replace faulty components accurately. These design choices not only make repairs faster but also minimize the risk of errors during reassembly.

The number of steps required for disassembly, accessibility of key components, and ease of removing fasteners without damage are key considerations. Additional considerations include whether repairs can be done at the component level, intuitiveness of cable layouts, and the presence of labels or technical markings. Appliances that minimize proprietary fasteners, reduce tool requirements, and incorporate clear labeling and modular design score higher on repairability, making them more user-friendly and sustainable.



Powerbox technician repairing an appliance

Photo Credit: CLASP

## SOLAR REFRIGERATORS

For solar refrigerators, disassembly can be a bit more complex than conventional AC fridges due to the presence of additional components, such as power supply from the solar system and monitoring and payment systems.

In modular designs, components such as compressors, batteries, fans, sensors, evaporator plates, and controllers can be replaced independently, improving accessibility and lowering maintenance costs. Embedded designs have components such as evaporator coils and sensor foams in the structure, while components such as ice linings and phase change materials are completely enclosed within the body, making repairs nearly impossible without destroying the unit. While modular systems promote longevity and ease of service, some manufacturers have implemented proprietary designs that set them apart in the market through embedded components. Thus, to reduce the risk of damage, manufacturers are encouraged to provide access panels to allow for repair.

Refrigerant leakages are rare, but when they occur, they tend to happen outside the evaporator coil area rather than within the insulated casings. In cases where leaks occur within the insulation, the entire body may need replacement due to extensive damage. Manufacturers also noted that 90% of the repair or maintenance work involves electrical or control systems, such as power supply checks, controller and battery assessments, and connector replacements or adjustments, rather than full mechanical disassembly.

Some refrigerator designs include tamper-proofing mechanisms, intended primarily to protect intellectual property and revenue models (such as PAYGO), rather than to prevent repair. Other models use self-locking control circuits that disable functionality once opened, requiring manufacturer intervention to restore operation. Tamper-proofing must balance security with practicality; the implemented systems should allow authorized technicians or partners to override locks safely and without voiding the warranty during diagnosis and repair.

Time taken to diagnose, disassemble, repair, reassemble, and conduct post-repair testing should also be considered. An average repair time of three hours is considered reasonable. Technicians with extensive experience can troubleshoot and repair the refrigerator within two hours, while less experienced ones may take longer and may not successfully conduct the repair without guidance from the manufacturer. When disassembly takes more than three hours, it indicates design complexity and unclear instructions or limited skills, all of which reduce repairability and increase repair costs. It is prudent to note that successful disassembly also depends on the availability of training, SOPs, and repair documentation. When these are missing, technicians can easily resort to guesswork, increasing the risk of damage to the appliance.

## SOLAR WATER PUMPS

Generally, using standard/common connectors, such as power plugs and hose fittings, made basic field repairs like swapping a hose easier. Manufacturers raised concern that mandating standardization risked enforcing a “lowest common standard”. Given the wide variance in SWP size, power requirements, and ingress protection thresholds, forcing a universal, low-cost connector could compromise the appliance’s long-term performance and, potentially, the safety of larger, more powerful units. Therefore, the repair index should reward standardization only when coupled with appropriate quality; that is, the part must meet the pump’s specifications and be available locally.

**The repair index should reward standardization only when coupled with appropriate quality.**

Modularity is the capability to replace individual components, such as the controller, pump head, and motor, without disassembling the entire unit. Three-quarters of participants voted that pumps with easily replaceable modules or subassemblies should be scored highly. However, simply being “modular” isn’t enough—the replacement parts must also be affordable. A key insight was shared: if a single controller board costs half the price of a new pump, customers will just buy a new pump instead of repairing. Thus, the index should consider both how many independent modules a pump has and whether their prices are reasonable relative to the whole unit. Furthermore, for components like sealed controllers, manufacturers argue that if a sealed unit is engineered for long life (e.g., brushless motors with 20-year lifespans or IP68 rating), penalizing its

non-destructive nature is illogical, provided the unit itself is modularly replaceable. The metric focuses on accountability for ensuring non-destructive access, primarily to parts that experience common failure.

Distinction was made between the time required for common maintenance and simple repairs, such as cleaning, swapping seals, and addressing blockages, and that for complex workshop interventions. A 15-minute threshold was set for routine maintenance, which should be rapid to help minimize farmer downtime, and designed to reward exceptional efficiency, promoting tool-free or minimal-tool interventions. This rewards design features that reduce complexity, such as intuitive labelling, standardized fasteners, and the avoidance of permanent adhesives like glue and ultrasonic welding.



Powerbox technician repairing an appliance

Photo Credit: CLASP

## DOCUMENTATION

Documentation acts as a bridge between appliance design and field operations for effective repair. When complete and accurate documentation is missing, even well-trained technicians may struggle to execute efficient and safe repair jobs. Documentation must be audience-specific and tiered to prevent user-induced faults and ensure professional efficiency:

- **End-user** requirements (Tier 1 — Publicly available): Documentation must be simple, visual, and highly accessible. This tier requires quick-start pictorial guides (often on the appliance packaging), clear instructions for simple maintenance tasks like solar panel cleaning, and prominent warnings regarding hazards like electric shock. Critical “dos and don’ts” should be transitioned from the manual to durable stickers placed directly on the appliance for maximum visibility and safety.
- **Technician** requirements (Tier 2 — Professionally accessible): This tier supports efficient service management and component-level repair. It includes detailed spare parts lists with specifications, structured service procedures, wiring diagrams, and diagnostics guides, including error codes. Access to this sensitive information must be controlled via certification schemes so that only qualified professionals attempt complex repairs, managing safety and IP risks.
- **Authorized partner** requirements (Tier 3 — Manufacturer-authorized): This tier is reserved for the most proprietary and sensitive information, such as firmware updates, diagnostic tools, and specialized calibration instructions, only available to the manufacturer’s internal staff and authorized service centers.

Each tier “speaks to” its user: simple visuals for customers and in-depth instructions for technicians. Comprehensive documentation leads to improved diagnostic practices, reduced downtimes, and a standardized maintenance process.

## SOLAR FANS

Documentation determines whether technicians can correctly identify faults, source appropriate parts, and confidently perform replacements. In many of the off-grid markets, OEM manuals provide only guidance on operating the device, not repair steps, leaving technicians to rely on guesswork and experimentation. High-scoring documentation includes troubleshooting logic, wiring diagrams, exploded views, step-by-step process guides, and part numbering references.

Open-access documentation, ideally in multiple languages, increases transparency, reduces information asymmetry, and supports informal technicians. It also helps de-risk repair for customers attempting simple fixes. Providing QR-linked digital manuals on the appliance chassis is considered international best practice.

## SOLAR REFRIGERATORS

To enhance consistency and inclusiveness, this index proposes a minimum standard package of documentation for all solar refrigerators as follows:

1. Operational manuals should explain how to use the refrigerator, maintain temperature, and handle power interruptions.
2. Step-by-step troubleshooting guidance/diagnostic tools that include flowcharts and checklists for common faults.
3. Exploded-view diagrams that show component layout, wiring, and assembly procedures.
4. Authorized service information section that provides contact points for verified service centers and repair networks.
5. Safety information outlining the three key risks: refrigeration, electrical (plus battery), and ventilation and placement warnings. Best safety measures should comply with IEC 0335-2-24.
6. Warranty information clearly detailing what is covered by the warranty, end-user claim procedures, and conditions or activities that void the warranty.

The documentation provided should be accessible to a wide range of users, considering their literacy levels, language(s) spoken, and technical background. This index recommends the following accessibility measures:

1. Manuals should primarily be in hard copy. Digital formats such as QR codes and web-based repositories should be included to offer richer content such as videos, visual guides, and troubleshooting libraries. They must serve as living repositories, regularly updated to reflect design changes and new training materials.
2. Documentation should be available in English, French, or Portuguese for continental coverage. It also recommended that they should have a translation in one regional language, such as Swahili, Amharic, Hausa, or the most commonly spoken language in the target region.
3. Documentation should implement visual communication tools using icons, pictograms, and color codes to accommodate users with limited literacy.

This index highlights the need for parts labelling and sourcing instructions, which can guide technicians on how to procure genuine, high-quality parts, supporting the growth of decentralized and effective repair ecosystems.

## **SOLAR WATER PUMPS**

Good manuals and guides help identify parts, train technicians, and prevent user errors. A pump could be designed for easy fix, however, without instructions, repairability remains theoretical.

Providing documents is not enough; they must be usable (e.g., a Chinese-language manual is as bad as none for an African farmer). Therefore, pumps should include at least some pictorial guides and, where feasible, multilingual or local-language content. Digital formats can be helpful: a QR code or a simple app linking to online tutorials with downloadable options for use when one is offline can deliver multiple languages and updates without bulky printing. In scoring terms, a pump with only a PDF online might get a middling score, whereas one with fully accessible multimedia instructions scores higher.

While there was support for the principle of open repair information, it was acknowledged that giving all technical details to untrained users could be unsafe or damage appliances and could hurt brand reputation. The tiered model helps here: information is gated by user skill. Detailed schematics would only be available to certified technicians, while end-users get safe-to-open visuals. This compromise balances customer empowerment with safety and IP protection.

Modern aids, such as QR codes linking to step-by-step videos were cited as an easy win. Mobile apps like SolarAid's SunnyMoney App mirror repair manuals and deliver on-demand help in the field. It was suggested that the repairability index should give bonus points for such innovations that go beyond static PDFs and invest in truly helpful content.

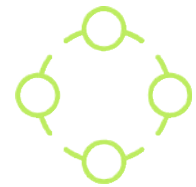
## OVERARCHING INSIGHTS & CONSIDERATIONS

Improving appliance repairability is not just about optimizing any single factor but about strengthening the entire ecosystem that supports long-term functionality. Appliances that are easy to service, backed by reliable parts supply chains, supported by skilled technicians, and paired with clear, accessible information deliver more value to users and manufacturers alike. Investing in these elements ensures that solar appliances remain usable for longer, maximizing impact, minimizing waste, and supporting sustainable development objectives. A few additional overarching insights on appliance sustainability are discussed below:

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### REPAIRABILITY IS HOLISTIC:

A well-designed, modular appliance still fails if parts cannot be sourced or technicians are unavailable. Conversely, an appliance with plentiful spares is useless if local technicians lack basic training. TWGs emphasized that design, supply chain, skills, and information must all be addressed together. Development programs should therefore fund integrated solutions that both subsidize spare-part warehouses and sponsor technician training.



### USER CONTEXT MATTERS:

How people use and maintain appliances in rural settings strongly influenced the findings. Cultural factors (e.g., many end-users expect to hire help, manuals often gather dust) and practical barriers such as limited literacy and poor internet access should be considered. The group recognized that a densely written manual means little if users can't read it, which makes visual aids critical. This insight suggests that program implementers adopt user-centric approaches: creating local-language posters, training community “pump champions,” and embedding repair apps in local languages.



### ECONOMIC REALITY:

Repair cannot be promoted on principle alone; it must make financial sense. Throughout the spare-parts and modularity discussions, the TWG repeatedly circled back to cost (i.e., repair prices vs. new appliance prices, cost of modules, and distributors' finances). They found that when repair costs approach the price of a new appliance, users lose the incentive to repair. Development programs that offset parts costs or develop bulk-spares procurement can tip this balance in favor of repair.



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### **CONTINUOUS IMPROVEMENT:**

Several manufacturers described how they adapt appliances based on field failures (e.g., redesigning parts that break frequently). This learning loop is a form of improving repairability upstream. Program implementers can support this by facilitating feedback channels (e.g., data collection on appliance failures and shared lessons between companies). The TWG noted that one reason for high SWP uptake is ongoing research and development driven by real-world data. A repair index can encourage such innovation.



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### **REAL-WORLD PRICING DATA IS INCOMPLETE:**

Pricing data for spare parts is not consistently available, and in many cases, it is entirely absent, especially in markets where manufacturer-supported distribution channels for spares do not exist. Because of this variability, affordability scoring is based on indicative benchmarks rather than statistically grounded price curves.



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### **POTENTIAL SCORING SUBJECTIVITY:**

Certain aspects of the scoring methodology inevitably require judgment, especially in borderline cases. For example, determining whether documentation is “adequately detailed” versus “moderately useful”, or whether a spare part is “meaningfully affordable” relative to the appliance cost, may vary significantly between raters. While the index recommends clear guidelines and scoring criteria, human interpretation cannot be eliminated entirely. Over time, increasing the availability of empirical benchmarks and reference scoring libraries may reduce variation and subjectivity.



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### **SCORING DRIVES BEHAVIOR:**

Building a transparent repairability index helps to create market incentives. If program implementers and buyers recognize high-scoring pumps (through reports or labelling), manufacturers will compete on repair-friendly design. Documentation discussions framed scoring to encourage “a race to the top” in making user guides more interactive. For program implementers, this means that investing in index development and publicity is as important as technical measures, as visibility of scores can shape manufacturer priorities.



## 2. SAMPLE SCORING EXAMPLE

The table below shows a sample reparability index scoring for a fan model.

Table 5.2.1: Reparability scoring example calculated for a solar fan

PARAMETER	CRITERIA	MAX SCORE	WEIGHT (%)	MAX WEIGHTED SCORE	ACTUAL SCORE	WEIGHTED SCORE
Spare parts (30%)	Traceability of major parts	5	5	0.25	3	0.15
	Compatibility and modularity of parts across different models / brands	5	5	0.25	4	0.2
	Affordability	5	10	0.5	2	0.3
	Availability of spare parts: lead time and footprint	5	5	0.25	1	0.05
	Availability of tools	5	5	0.25	2	0.1
Skills complexity (20%)	Presence of codes or LEDs to show errors	5	8	0.4	5	0.4
	Time taken to diagnose and fix the fan: major parts should be replaceable within an hour when available.	5	7	0.35	4	0.28
	Knowledge / skill level required	5	5	0.25	4	0.2
Disassembly (25%)	Ease of removing fasteners	5	5	0.25	3	0.15
	Labelling and markings on fan components	5	7.5	0.375	2	0.15
	Number of steps to full disassembly of major parts	5	5	0.25	2	0.1
	Types of cable connectors	5	7.5	0.375	3	0.15
Documentation (25%)	Provision of repair manual	5	5	0.25	4	0.2
	Level of detail	5	10	0.5	3	0.2
	User and repair warnings, safety dos and don'ts	5	5	0.25	3	0.15
	Warranty terms incl. parts/ After-sales service + helpdesk	5	5	0.25	2	0.1
Total			100%	5		2.88
Reparability Index (0–5)		2.875				

## NOTES

- The maximum score and weight are based on the assigned values in the repairability index.
- The maximum weighted score = maximum score X weight (weight being a percentage).
- The actual score is based on the assessment using the Repairability Index.
- The weighted score = actual score X weight (weight being a percentage).
- Repairability Index = Sum of the weighted scores for each parameter.



Efficiency for Access trip to Kisumu, Kenya in 2024

Photo Credit: CLASP

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