



Powering Renewable  
Energy Opportunities

# Second life batteries: Unlocking the next phase of productive energy scale





# About PREO and this report

This research examines the emerging challenge of battery end-of-life in productive use of renewable energy (PURE) markets across sub-Saharan Africa. Drawing on case studies from seven companies supported through the [PREO](#), [Energy Catalyst](#) and [EEP Africa](#) portfolios, it explores how second-life batteries can retain value within productive energy systems and identifies the infrastructure, financing, and market conditions needed to enable reuse and repurposing at scale.

The Powering Renewable Energy Opportunities (PREO) programme is a demand-led productive use of renewable energy (PURE) initiative that stimulates partnerships, innovation and learning to improve the livelihoods of communities in sub-Saharan Africa and Pacific Island Countries. Co-funded by UK aid via the [Transforming Energy Access](#) (TEA) platform, the flagship FCDO research and innovation platform for clean energy access, and the [IKEA Foundation](#), PREO is delivered by the [Carbon Trust](#) and [Energy 4 Impact](#), Mercy Corps' platform for shaping clean energy market systems.

PREO's mission is to enable businesses to harness renewable energy to improve incomes, build climate resilience and reduce reliance on fossil fuels, supporting progress towards Sustainable Development Goals 7 (affordable and clean energy), 8 (decent work and economic growth) and 13 (climate action).

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Cover image: AceleAfrica, Kenya (2024)

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## Glossary

Battery-as-a-Service (BaaS)	A model in which an operator retains ownership of battery systems and provides storage to customers through service agreements, converting a capital purchase into a managed operating expense
Battery management system (BMS)	Electronic controls integrated into a battery pack that monitor performance, manage charging and discharging, and protect against faults
BESS	Battery energy storage system: an integrated system that stores electrical energy in batteries for later use, typically combining battery packs, power conversion equipment, and control systems
Cell-level testing	The process of dismantling battery packs and individually assessing each cell for remaining capacity, voltage stability, and charge-discharge efficiency before grading and reassembly
Circular economy	An economic model that retains the value of products and materials through reuse, refurbishment, repurposing, and recycling, rather than disposing of them after first use
Concessional finance	Funding provided on terms more favourable than prevailing market rates, typically by development institutions or public funders, to support early-stage or high-risk activities
Conversion rate	In battery processing, the proportion of incoming cells or packs that pass testing and are ultimately deployed into second-life systems
Cycle life	The number of complete charge-discharge cycles a battery can perform before its capacity falls below a specified threshold, typically 80% of original capacity
Distributed energy system	A network of small-scale electricity generation and storage assets located close to the point of use, rather than centrally generated and transmitted
E-waste	Discarded electronic and electrical equipment, including batteries, that may contain hazardous materials and recoverable resources
End of first life	The point at which a battery no longer meets the performance requirements of its original application, typically at 70 to 80% of original capacity, though it may retain usable capacity for less demanding uses
Feedstock	In battery processing, the incoming supply of used batteries or cells available for testing, grading, and repurposing
First-life battery	A newly manufactured battery deployed in its original application for the first time
Lead-acid battery	An older, lower-cost battery chemistry widely used in solar and backup power across sub-Saharan Africa, characterised by shorter lifespan and lower efficiency than lithium-ion
Lease-to-own	A financing arrangement in which a customer makes regular payments over a fixed term, after which ownership of the asset transfers to the customer
Lithium iron phosphate (LFP)	A lithium-ion battery chemistry valued for its stability, long cycle life, and safety characteristics
Lithium-ion battery	A rechargeable battery technology using lithium compounds, widely used in electric mobility, solar storage, and productive use applications due to its high energy density and long cycle life
MSME	Micro, Small, and Medium Enterprise
OEM	Original Equipment Manufacturer: a company that produces the original product or component
PAYGo	Pay-as-you-go: a financing model in which customers make incremental payments for an asset or service over time, common in solar home system and appliance markets
Residual value	The economic or functional value remaining in an asset after its initial deployment period
Results-based financing	A funding mechanism in which payments are linked to verified achievement of pre-agreed outcomes rather than inputs or activities
Second-life battery	A battery that has reached the end of its first operational life but retains sufficient capacity to be reused or repurposed in a less demanding application
State of health (SoH)	A measure of a battery's current capacity relative to its original rated capacity, expressed as a percentage



# Foreword



In nascent clean energy markets, commercial systems rarely evolve at the same pace as technology. By the time a solution has proven technically viable, the standards, financing, and institutions needed to deploy it at scale are often still taking shape. That dynamic is now playing out in productive energy markets across sub-Saharan Africa. The first generation of batteries used in electric mobility, irrigation, cooling, and distributed energy is reaching the end of its operational life just as the market for second-life batteries is still being formed.

The timing matters; as more battery-based systems are deployed, the volume of batteries requiring repurposing or replacement will continue to grow. Yet the testing, certification, financing, and regulatory systems needed to support a mature second-life market remain underdeveloped. End-of-life-recycling is practically non-existent on the continent. This report argues that the next phase of market development will be shaped less by advances in battery technology than by the commercial environment surrounding it.

Several of the companies featured here have already demonstrated the technical viability of second-life battery applications. The opportunity now lies in building the market infrastructure that enables those solutions to be deployed confidently and at scale: trusted testing and grading processes, regulations that enable regional collaboration, certification frameworks that reduce procurement risk, financing models that reflect residual asset value, and ownership structures that allocate performance risk appropriately.

Together, these systems form the foundation of a functioning market. They do not emerge automatically. Historically, similar market infrastructure has been built through deliberate coordination across industry, finance, and policy.

The experiences documented in this report show how that infrastructure is beginning to take shape across seven companies operating at different points along the second-life battery value chain. They also raise a broader question: can standards, regulation, and finance evolve quickly enough to keep pace with the growing supply of batteries entering their second life?

That is the challenge, and the opportunity, facing policymakers, investors, developers, and industry alike.

**Tombo Banda**

Managing Director, CrossBoundary

# 01



Photo: AceleAfrica, Nairobi, Kenya (2026)

## Accelerating productive energy markets and the unintended consequence of scale

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### 1.1 From product-market fit to performance under scale

The early phase of productive use of renewable energy (PURE) markets in sub-Saharan Africa (SSA) was less about technology viability and more about product-market fit under constrained conditions. Technologies such as electric mobility, refrigeration, solar irrigation, and energy for SMEs (among others) were already proven in other contexts. In SSA markets, the question was whether they could deliver reliable performance at a price point and user experience that matched local economic realities.

PREO's early capital and technical assistance were therefore directed at validating this fit and supporting companies to refine business model design, test willingness to pay, and demonstrate that these solutions could generate tangible income or cost savings for end users. Across several sub-segments within PURE, this validation has now moved beyond pilots.

Electric mobility provides a clear example. According to official figures<sup>1</sup>, the number of registered electric vehicles has grown rapidly, reaching over 25,000 units by the end of 2025 in Kenya, from ~5,000 units in 2024. This has been accompanied by significant capital inflows. Companies such as Spiro, Ampersand and Dodai, among others, have successfully raised capital, leading to over US\$100m flowing into the sector across 2025 and early 2026<sup>2</sup>. These are no longer experimental deployments but are representative of early-stage commercial scale. Similarly, solar water pumping has seen widespread adoption in markets where irrigation demand is structurally embedded, supported by strong growth in results-based financing mechanisms and increasing private-sector participation. Distributed cooling solutions are also demonstrating repeatable demand, with leading cooling companies reaching thousands of unit sales annually, indicating a transition from pilot to early scale.



At the same time, it is important to note that PURE markets have not scaled smoothly. Progress is segment-specific and conditional, shaped by three interdependent demand-side factors that determine the pace and depth of adoption:

- Price parity with incumbent alternatives
- Ease of financing, particularly for upfront capital costs
- Market concentration, enabling efficient customer acquisition and distribution

Mobility, particularly in two- and three-wheel segments, aligns well with all three factors. Cost parity is within reach, financing models are evolving rapidly, and demand is concentrated in urban and peri-urban transport corridors. As a result, adoption has accelerated.

Solar water pumping, by contrast, benefits from strong underlying demand but faces more fragmented customer bases, increasing customer acquisition costs and slowing scale despite technical viability. Cooling solutions face a different constraint. While the demand noted above is clear, cost parity with conventional alternatives has not yet been reached, requiring financing innovation or cost reductions to unlock broader adoption.

## 1.2 What scale implies: from deployment to system capacity

PURE markets are not moving uniformly from one stage to another. Instead, individual sub-sectors are transitioning at different speeds, with some approaching early scale while others remain constrained by structural factors. Even within this uneven landscape, a clear pattern is emerging. Deployment volumes are increasing across multiple applications, and in several segments, they are approaching thresholds where system-level effects begin to matter. The implications of this shift are best understood through trajectories rather than static numbers.

In Kenya, for instance, electric mobility adoption has moved from negligible levels to several thousand registered vehicles within a few years, supported by policy incentives, private investment, and new business models. Projections associated with national e-mobility strategies suggest hundreds of thousands of vehicles over the long term<sup>3</sup>, with a corresponding increase in battery stock. Even under more conservative scenarios, the number of batteries deployed across mobility, cooling, and energy backup (amongst others) is expected to increase significantly over the next decade.

At this scale, the nature of the challenge changes. The constraint is no longer centred on deploying additional units. It shifts toward how the system performs under accumulated deployment including maintenance, replacement cycles, asset utilisation patterns and lifecycle management.

Every unit deployed carries within it a battery with a finite operational life. Depending on the application and how intensively the battery is cycled, these batteries typically reach their first end-of-life within three to ten years<sup>4</sup>. As cumulative deployment increases, so does the volume of batteries approaching this threshold.



### 1.3 Why this pressure is emerging now

The emergence of battery end-of-life as a system issue is directly linked to the timing of market development. The first meaningful wave of PURE deployments across multiple sectors occurred in the 2020–2025 period, supported by catalytic capital, policy support, and early commercial traction. These assets are now beginning to reach the end of their initial operational lifecycle.

At the same time, new deployments continue to accelerate. This creates a compounding dynamic: a growing stock of new assets entering the system, alongside an increasing volume of assets exiting first life. Importantly, the ecosystem required to manage this transition—including collection, testing, repurposing, and redeployment—has not developed at the same pace. Existing end-of-life pathways remain limited because:

- Recycling infrastructure is capital-intensive and dependent on large, aggregated volumes;
- Collection and aggregation systems are fragmented across geographies;
- Testing and certification frameworks are underdeveloped; and
- Ownership and responsibility across the lifecycle are often unclear.

This misalignment between front-end growth and back-end preparedness is what transforms battery end-of-life from an operational issue into a system-level stress. The current end-of-life pathway for many batteries remains poorly defined. In several markets, batteries are stored indefinitely, informally dismantled, exported through opaque channels, or disposed of without structured recovery processes. Beyond the environmental risks associated with hazardous materials, these pathways also result in the permanent loss of usable storage capacity and embedded economic value.





## 1.4 A hidden tax on productive energy systems?

If unmanaged, this stress manifests not as a visible market failure, but as a series of incremental costs that accumulate across the system. This can be understood as a hidden tax on productive energy use.

The concept is not unique to energy systems. In other sectors, similar dynamics are observed when lifecycle costs are not fully internalised. For example, in diesel-based irrigation, poorly maintained engines lead to higher fuel consumption and frequent breakdowns. These costs are not immediately visible at the point of purchase, but significantly increase total cost of ownership over time. Similarly, in PAYGo solar, weak after-sales servicing historically led to asset failures that eroded customer trust and repayment rates, effectively increasing the cost of customer acquisition and capital.

In PURE systems, battery end-of-life introduces a comparable dynamic. As batteries degrade without structured pathways for reuse or repurposing:

- ❗ **Replacement costs increase**, as systems rely on new batteries rather than lower-cost second-life alternatives;
- ❗ **Downtime can increase**, as delays in replacement or servicing affect income-generating activities;
- ❗ **Financing conditions can tighten**, as lenders face uncertainty around asset lifecycles and residual value; and
- ❗ **Usable capacity is lost prematurely**, reducing the overall efficiency of capital already deployed.

Individually, these effects may appear marginal. At scale, they compound, raising system costs, reducing reliability, and increasing perceived risk. This does not automatically render PURE models unviable. However, it can directly affect their long-term cost competitiveness and scalability, particularly in markets where affordability and financing are already constrained.

This contrasts with earlier distributed energy access models. Solar home system (SHS) markets, despite achieving much larger deployment volumes, have not experienced the same degree of system stress. This is largely due to structural differences: vertically integrated business models, standardised hardware, smaller cost share of batteries, and more predictable usage patterns. These features enabled companies to manage battery replacement cycles more systematically.

PURE sectors, by contrast, are often characterised by more fragmented value chains, a larger number of specialised market actors who are primarily distributors, and more intensive utilisation patterns by end users. Unlike vertically integrated SHS models, responsibility for battery lifecycle management is distributed across OEMs, distributors, financiers, operators and end users, making coordinated replacement and second-life strategies more difficult to implement.

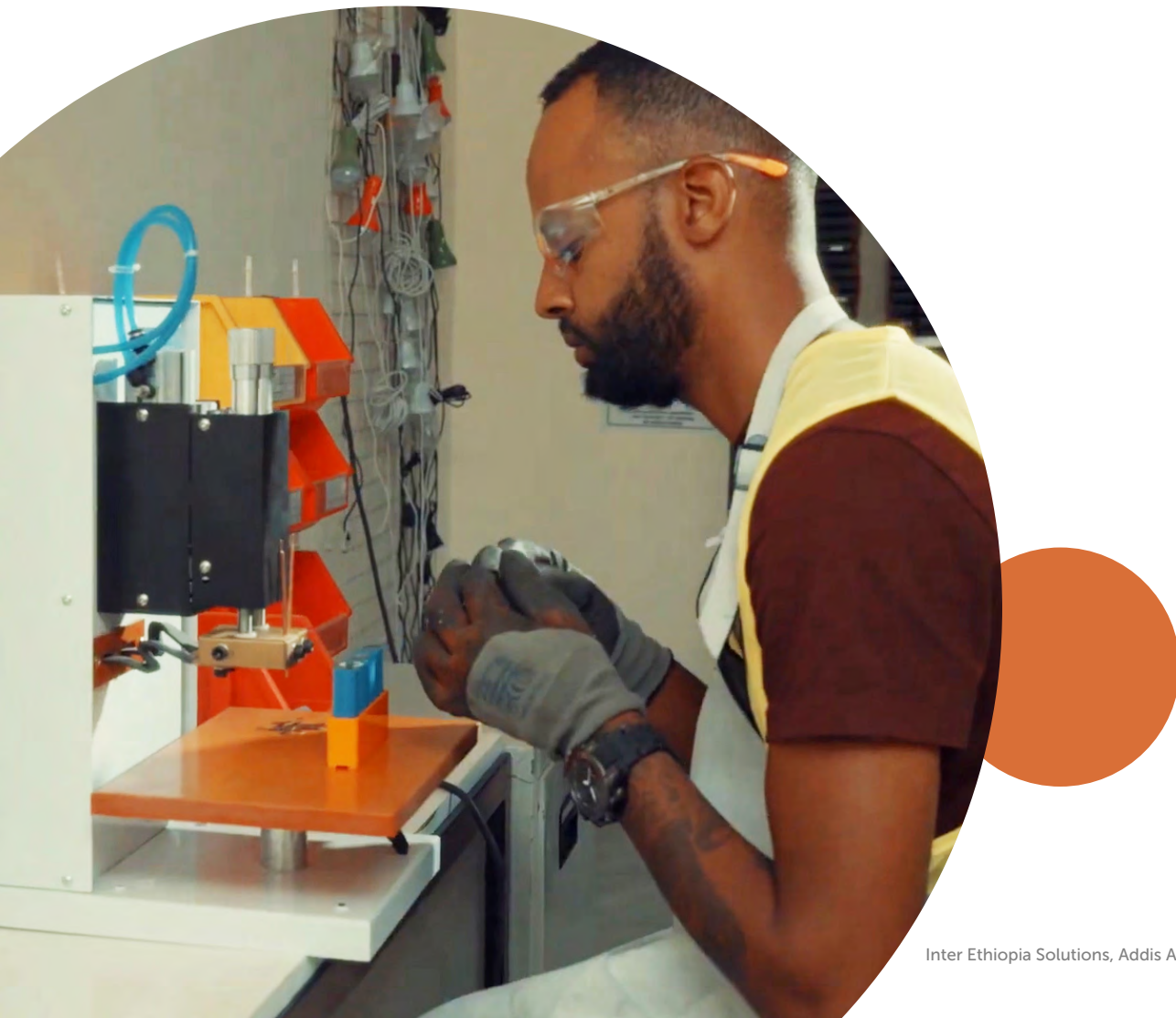


## 1.5 From system stress to infrastructure gap

Combined, these dynamics point to a structural shift in constraints facing PURE markets. The early barriers such as product-market fit, initial demand, and financing model validation are being progressively addressed in several segments. The emerging constraint is different. It lies in the system's ability to manage assets across their full lifecycle, particularly beyond first life.

Battery end-of-life is therefore not simply a downstream operational issue. It represents an infrastructure gap within the system that sits between deployment and long-term sustainability. Without mechanisms to retain value and manage second-life applications, the system can increasingly rely on linear replacement cycles. Over time, this can place upward pressure on costs, introduce operational inefficiencies, and affect the confidence of both users and financiers.

The implication is not that scale will stall immediately, but that the quality and efficiency of that scale becomes increasingly dependent on how this gap is addressed. It is within this context that second-life batteries must be understood as a functional layer required to sustain the next phase of PURE market development.



Inter Ethiopia Solutions, Addis Ababa, Ethiopia (2026)

# 02



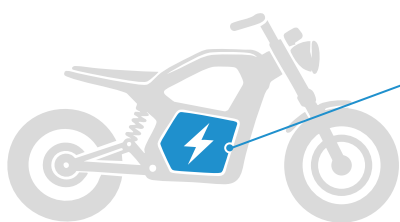
Inter Ethiopia Solutions, Addis Ababa, Ethiopia (2026)

## Retaining value to sustain scale

### 2.1 From system stress to value retention

Section 1 outlined that as PURE markets expand, battery end-of-life begins to emerge as a system-level stress. The natural extension of that argument is not for disposal, but value retention. In most current frameworks, batteries exiting first life are treated as waste streams. This framing is rooted in environmental risk aspects such as safety, disposal, and material recovery. While valid, it obscures a more immediate economic reality in PURE markets: batteries at end of first life are not exhausted assets, but partially utilised capital.

In applications such as electric mobility, batteries are typically retired when their state of health (SoH) falls to around 70–80% of original capacity<sup>5</sup>. At this point, they no longer meet the performance requirements of primary applications such as range, power output, and reliability. But the batteries continue to retain substantial functional capacity. For instance, consider a typical electric two-wheeler battery:



**Battery size**  
3–6 kWh

**Indicative cost**  
~US\$200  
per kWh

**Total battery value**  
US\$600–1,200  
per unit

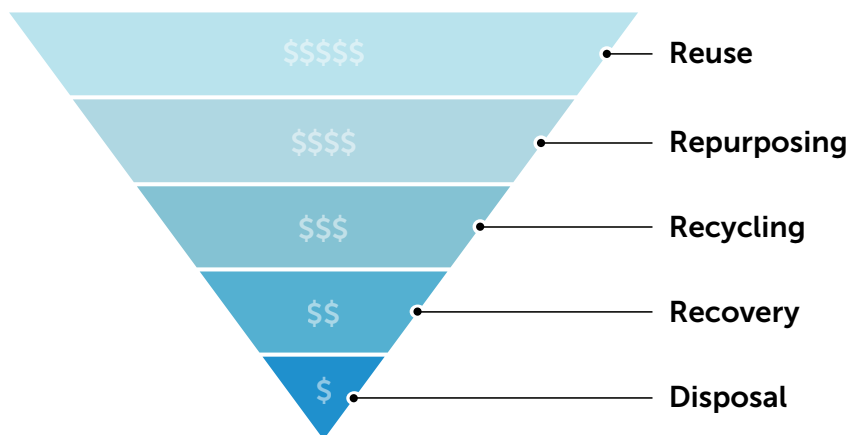


At 75% SoH, this battery still retains 2.25–4.5 kWh of usable capacity. In practical terms, this is sufficient to power a range of lower-demand applications such as small commercial refrigeration units (typically 0.3–0.6 kWh for 100–300 litre systems), SME backup systems, or low-load productive equipment. If the battery exits the system at this stage without reuse, most of this functional value is lost. The system effectively writes off most of the capital already deployed, despite the asset still being technically usable and with potential commercial value.

## 2.2 Battery lifecycle and the hierarchy of value

The economics of value retention can be understood through the full lifecycle of a battery, which reflects a progressive decline in both functional and economic value.

At the highest level, the lifecycle follows a clear hierarchy:



Each stage represents a step down in how much of the original value is preserved.

At the top of the hierarchy is reuse, where batteries are redeployed with minimal intervention, often in similar or slightly modified applications. This pathway preserves the maximum functional value, as both the energy storage capability and system integrity remain largely intact.

Closely following is repurposing, where batteries are adapted for alternative applications with lower performance requirements. This may involve reconfiguring battery packs, modifying battery management systems, or integrating them into new use cases such as stationary storage or SME energy systems. While some efficiency is lost in this transition, most of the functional value is retained.

Further down the hierarchy is recycling for material recovery. At this stage, the battery's functional value is fully lost, and the asset is dismantled to recover constituent materials such as lithium, nickel, cobalt, copper, and aluminium. Although these materials can be reintroduced into future manufacturing processes, recycling preserves only material value and discards much of the engineering, manufacturing, and system-level value embedded in the original battery.

At the lowest level is disposal, where batteries are landfilled, stockpiled, incinerated, or otherwise removed from productive use without recovering either functional or material value. This represents the greatest loss of economic value and, depending on the disposal pathway, may also introduce environmental and safety risks.



The distinction between these stages is not merely technical. It reflects a fundamental economic gradient. A battery embodies multiple layers of value:

- Embedded energy used in manufacturing;
- Engineering and manufacturing effort, including cell design and assembly; and
- Capital investment already incurred in producing and deploying the asset.

Reuse and repurposing preserve these layers by extending functional use. Recycling for material recovery, by contrast, recovers only material value, discarding most of the embedded economic value.

Evidence from lifecycle analyses, including that presented in a 2021 GIZ<sup>6</sup> report on end-of-life lithium-ion batteries, consistently points to this hierarchy: the earlier value is captured in the lifecycle, the greater the economic and system-level benefit.

### 2.3 Why value retention matters for PURE economics

The relevance of this hierarchy becomes particularly pronounced in PURE markets, where battery costs are not incidental but are central to system economics. In electric mobility, batteries account for approximately 30–40% of total vehicle cost for the electric two and three-wheelers that dominate these markets<sup>7</sup>, making them the single largest cost component. In solar-powered systems such as cooling and SME energy backup, batteries typically represent 25–40% of total system cost, depending on storage requirements and system design<sup>8</sup>.

This concentration of cost has direct implications. In the absence of value retention mechanisms, systems operate on a linear replacement cycle: batteries are deployed, degraded, and replaced with new units at prevailing market prices. Each cycle introduces new capital requirements, placing pressure on affordability, particularly in markets where:

- upfront costs are already a barrier to adoption;
- financing is limited or expensive; and/or
- asset performance is directly linked to income generation.

Value retention changes this equation. By extending the functional life of batteries through reuse and repurposing, systems are able to extract more utility from the same initial investment. This reduces the effective cost of storage, delays capital expenditure, and lowers the cost base for end users.

The impact is particularly tangible in productive use and SME contexts. Small businesses, such as retail shops, agro-processors, and cold storage operators, are increasingly reliant on battery-backed systems for income generation. Integrating second-life batteries into these applications can significantly reduce system costs, improving both accessibility and long-term viability.

This shift is central to sustaining scale. As deployment volumes increase, the ability to retain and redeploy value can become a determining factor in whether PURE markets continue to expand, without eroding the economic foundations on which that expansion depends.

# 03



Inter Ethiopia Solutions, Addis Ababa, Ethiopia (2026)

## The emerging infrastructure for value retention

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The preceding sections argued that as PURE markets scale, battery end-of-life emerges as a system-level stress, and that the most effective response lies in retaining functional value through reuse and repurposing rather than relying primarily on recycling and disposal. Without mechanisms to capture value at the top of the lifecycle hierarchy, the system increasingly relies on linear replacement cycles that place upward pressure on costs, reduce efficiency, and constrain further growth.

The case studies in this section examine how that plays out in practice. The seven profiled companies operate at different points in the second-life battery value chain, each responding to a common system bottleneck but through distinct business models. These companies are connected by a shared diagnosis: the infrastructure required to convert uncertain or underutilised battery assets into reliable, deployable storage does not yet exist at the scale the market needs. Each company is building a different piece of it.

These are early-stage models operating under constrained conditions. Most have received significant grant or concessional funding, and none have yet reached commercial scale. Processing volumes remain small relative to the waste streams they are designed to address. Supply chains are fragmented, feedstock quality is variable, and the financing structures needed to support asset-heavy models at scale are largely absent. The case studies should therefore be read not as evidence of proven, scalable solutions but as indicators of where infrastructure is beginning to form, and what systemic conditions would need to change for these models to grow. The patterns that emerge across them, the common bottlenecks and the recurring dependencies on trust, certification, and financing, are as instructive as the individual company trajectories.



The seven companies occupy distinct positions within the value chain:



**AceleAfrica** operates at the processing layer, where the core challenge is converting battery waste of unknown quality into graded, deployable cells through rigorous cell-level testing.



**Soleil Power** integrates second-life production into a first-life manufacturing operation, using shared infrastructure and engineering capability to produce lower-cost systems for price-sensitive segments where lead-acid still dominates.



**Hinckley Recycling** targets commercial energy cost displacement, applying unusually strict quality filtering to produce second-life systems that can compete with new lithium-ion on reliability as well as price.



**Inter Ethiopia Solutions** integrates second-life storage into complete productive use systems, linking battery recovery directly to income generation for farmers and small enterprises.



**SLS Energy** restructures ownership and risk, retaining battery assets on its own balance sheet and delivering storage to mini-grid and telecom operators as a managed subscription service.



**Vittoria Technology** addresses the financing and deployment layer, leasing storage to mini-grid operators through its Battery Bank Africa platform so that capacity can be added incrementally as demand grows rather than sized and purchased upfront.



**GreenBay** addresses the appliance layer rather than batteries directly, building the trust infrastructure of testing, warranty, and quality assurance that makes second-life productive use assets commercially viable for MSMEs.

Considered together, these case studies reveal where the value retention infrastructure described in Section 2 is beginning to materialise, and where the gaps remain.

The companies featured in this section have been supported by:





# CASE STUDY



Used Lithium-ion cell testing and grading machines at AceleAfrica’s workshop in Nairobi, Kenya (2026).

## AceleAfrica: Cell-level testing as processing infrastructure

AceleAfrica is a PREO-supported Nairobi-based battery technology company that assesses and repurposes used lithium-ion cells, converting battery waste from solar home systems and electric vehicles into affordable storage for off-grid productive use.

For a smallholder farmer using solar-powered irrigation, reliable battery storage is what allows water pumping to continue during cloudy periods, pre-dawn morning starts or fluctuating solar conditions. When batteries degrade, irrigation becomes unreliable even when solar panels remain functional, often disrupting crop production and income generation months earlier than expected. The same dependency applies across other productive use applications, from electric cooking to small enterprise energy systems, wherever reliable storage underpins daily income.

“ As an offtaker, we have found AceleAfrica’s batteries have seamlessly integrated into our electric cooking systems, delivering reliable performance even in high temperature environments. We see the serviceability and durability of the product drive real value through customer satisfaction and referrals.”

– Dr Emmy Wasirwa, CEO, Wana Energy Solutions, Uganda

### The model

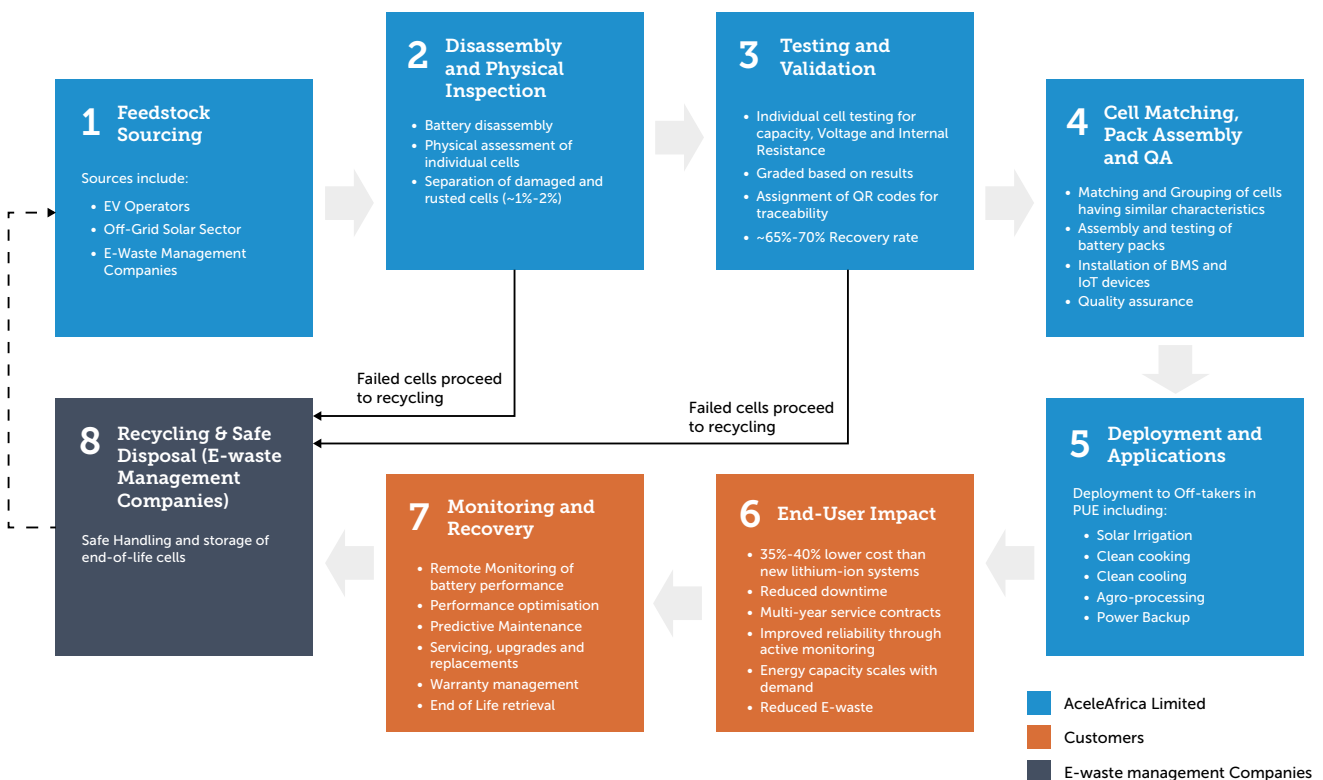
As distributed energy systems scale across East Africa, increasing volumes of lithium-ion batteries are reaching end of life. Yet end-of-life at pack level masks a more complex reality: individual cells degrade unevenly, and many retain significant usable capacity. Without the ability to evaluate and recombine cells individually, this residual value remains locked in. The default is disposal or bulk sale to informal handlers. Functional storage that could be retained and redeployed is lost, increasing replacement costs and reinforcing the assumption that batteries are consumables rather than assets with residual usable life.



AceleAfrica's second-life lithium-ion battery powering an electric pressure cooker in Nairobi, Kenya (2026).

Roughly 74% of the batteries entering AceleAfrica's facility come from solar home systems, with the rest from e-mobility and other sectors. Each pack is dismantled into its individual cells, and every cell is tested over cycles lasting several hours, assessing how much energy it can still hold, how stable its voltage is under load, and how efficiently it can charge and discharge. This cell-level testing is the core of the model. It is the step that converts battery waste of unknown quality into graded, deployable components, and it is what distinguishes repurposing from simple reuse. Cells that pass are then graded and grouped into matched sets with similar remaining capacity, because cells at different stages of degradation create performance imbalances when assembled. This grading and matching process makes testing labour-intensive and time-consuming, meaning throughput remains a major operational constraint.

Approximately 65-70% of cells are recovered for reuse following testing and grading and are repurposed into modular packs of around 1.3 kWh, each fitted with electronic controls that monitor performance, manage charging and protect against faults. The remainder enter formal recycling streams. Retained cells typically hold around 85% of their original capacity, enabling 3.5 to 5 years of additional deployment in PURE applications and distributed energy systems. The model therefore functions as a conversion layer, transforming disposal liability for upstream battery holders into affordable, validated storage for downstream users.



AceleAfrica second-life lithium-ion battery flow process



## Performance

To date the company has deployed 249 second-life battery systems, representing over 300 kWh of distributed storage and supporting an estimated 1,300 to 1,800 end users. Customers include irrigation operators, small enterprises, distributed energy providers, and clean cooking businesses, served through both direct deployments and integration into shared energy systems.

**~60% of recovered cells converted into deployable storage systems**

At the unit level, second-life systems sell at roughly 38% less than new lithium-ion equivalents and achieve margins of around 41%, though overall profitability remains constrained by ongoing investment in testing infrastructure and scale. Scaling the model now depends largely on increasing processing capacity and improving operational efficiency at the testing and assembly stage. In this context, the PREO-supported SAEBeW project, which targets the repurposing of 125,000 discarded lithium cells into second-life batteries with built-in remote monitoring, represents an important step toward the processing volumes required for commercial scale.

The variability of incoming supply remains the key operational constraint. Batteries arrive in widely differing conditions and compositions, and cell-level testing, while essential, is time-intensive, limiting throughput. Field deployment has nonetheless validated that second-life batteries can operate reliably in demanding conditions when matched carefully to the energy demands of the application, including high-temperature environments and heavy-load appliances such as electric cooking systems. As the deployed base grows, monitoring data from systems in the field is beginning to feed back into the testing and grading process, improving quality control and informing pricing over time. The systems are already being deployed in productive use applications across the region, including irrigation and clean cooking.

“ Each battery we repurpose from e-waste prevents environmental harm while delivering affordable energy. We serve customers who need dependable energy for real African conditions.”

– Kelvin Ndegwa, Lead Battery Engineer, AceleAfrica

## Implications

AceleAfrica's trajectory illustrates a pattern central to this report: in second-life battery markets, the binding constraint is not the availability of supply or demand but the absence of trusted processing infrastructure. Battery waste is abundant and demand for affordable storage is growing, but without credible systems for testing, grading and validation, value cannot move efficiently between the two. The cost advantage is significant, but large-scale adoption ultimately depends on trust, built through rigorous testing, consistent performance data, and reliable operation under real-world conditions. Without that processing layer, much of the remaining value within used batteries is lost before it can reach end users.



Soleil Power

## CASE STUDY



Soleil technician operating cell sorting equipment, Kirolo production facility (2025)

## Soleil Power: Integrating second-life production into first-life manufacturing

Soleil Power is an EEP Africa-supported battery manufacturer, founded in 2022, that produces both first-life lithium iron phosphate (LFP) systems and second-life battery packs within a single facility. First-life products serve applications where longer warranties, higher cycle life, and predictable performance are particularly important, including commercial and industrial energy storage, telecommunications backup systems, and selected e-mobility applications. Second-life products offer a lower-cost alternative for more price-sensitive market segments, with adjusted warranties and performance specifications.

Soleil's early assumption was that second-life cells could be assembled into packs with relatively limited additional processing. Cells arrived from a supplier that had already performed initial screening, and the expectation was that this would be sufficient for deployment. In practice, variability in cell capacity, charge-discharge behaviour, and degradation profiles led to inconsistencies in pack performance. Some systems underperformed, requiring rework and, in some cases, redesign. The experience reshaped the company's approach: while sourcing suitable second-life cells remains an important consideration, the principal operational challenge at current production volumes is the testing, grading, and quality-assurance processes required to convert variable-quality cells into reliable battery systems.

### The model

In price-sensitive energy markets across East Africa, lead-acid batteries remain dominant for solar and backup power despite clear performance limitations. For many customers, second-life batteries are not replacing premium lithium-ion systems but providing a lower-cost pathway away from lead-acid technology. New lithium-ion systems offer superior lifecycle economics but remain too expensive upfront for many retail and commercial buyers. The gap between what customers can afford and what modern storage technology can deliver leaves a large segment of the market reliant on short-lived, inefficient storage. Second-life lithium-ion batteries can occupy this gap, offering better performance than lead-acid at a price point closer to what the market can absorb.



Cylindrical and prismatic cell pack assembly lines, Kirolo production facility (2025)

Soleil’s solution is to produce both first-life and second-life batteries within a single manufacturing operation, using shared infrastructure, engineering capability, and quality systems. This is not two separate businesses, but a single manufacturing platform serving multiple market segments. The shared operating model allows testing equipment, engineering capability, and production infrastructure to be shared across both product lines, reducing duplication while accelerating operational learning. It also allows Soleil to reach customers who would otherwise remain priced out of lithium-ion storage, while maintaining a premium first-life offering for applications requiring longer warranties and higher performance specifications. First-life and second-life product categories are positioned differently within the market to serve distinct customer needs.

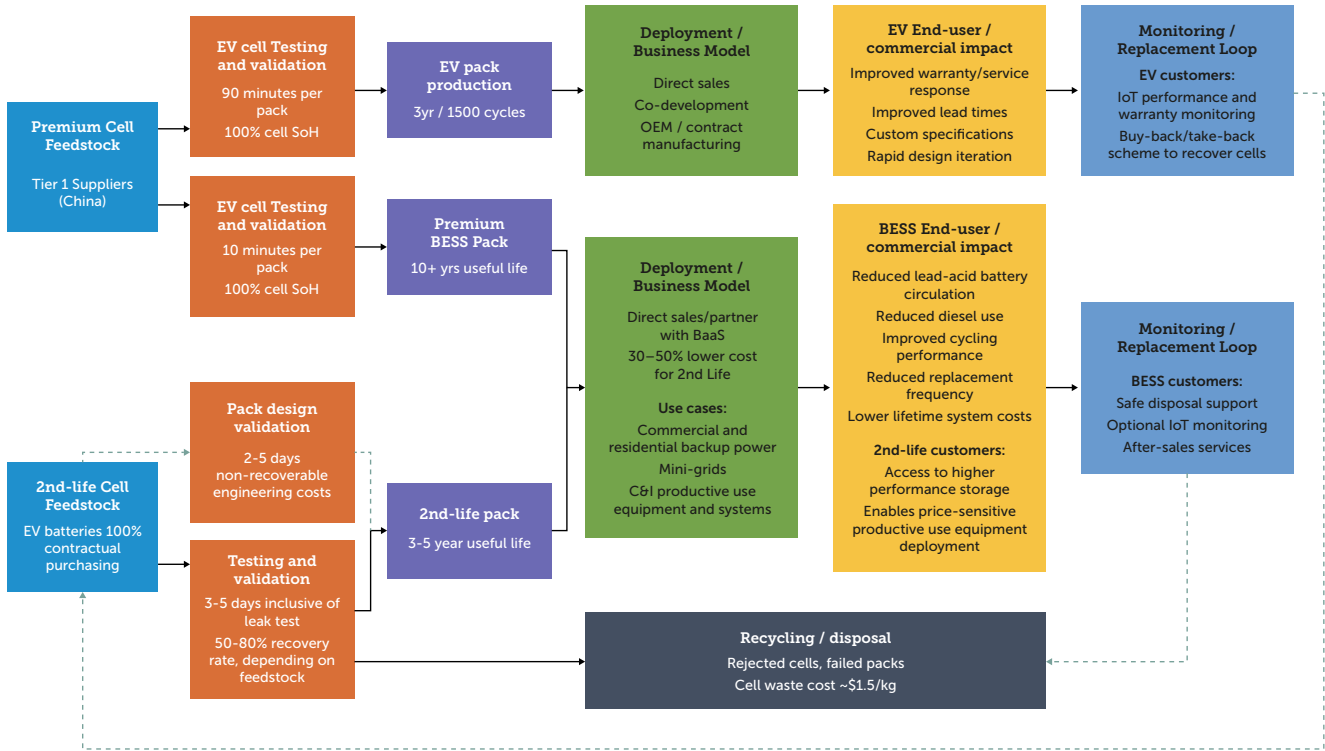
Its first-life lithium batteries are designed for customers requiring longer operating life, higher performance specifications, and extended warranties, such as commercial and premium energy users. The second-life batteries offer a lower-cost alternative for customers who cannot afford new lithium systems upfront, while still providing significantly better performance and lifespan than conventional lead-acid batteries. The pricing difference is substantial. Depending on system size and configuration, second-life battery packs are typically priced 35–50% below equivalent first-life lithium systems while still offering materially longer operating life than conventional lead-acid alternatives.

Second-life cells are sourced primarily from e-mobility operators and undergo multiple stages of inspection, testing, and grading before deployment. The process is designed to identify performance variability and remove unsuitable cells, with approximately 75–80% of received cells ultimately approved for reuse. This relatively high yield reflects feedstock that has already undergone initial supplier screening. Vittoria Technology (Section 3.6), which sources second-life batteries from Soleil Power for deployment across its mini-grid portfolio, sees this complementarity as central to the market’s development:

**Second-life battery packs are typically priced 35-50% below equivalent first-life lithium systems**

“ We see second-life battery packs as an important complement to first-life batteries rather than a direct substitute in every use case. Where the application is well matched and the product is well-priced, they can deliver meaningful cost savings and environmental benefits, provided the packs are properly tested, engineered, and supported after deployment.”

– Nathan Sermonis, CEO, Vittoria Technology



Soleil Power dual-line manufacturing and market segmentation process flow

## Performance

Soleil currently processes approximately 25,000 second-life cells annually, producing around 200 battery packs across a range of capacities and serving 10 second-life customers to date. Across both first-life and second-life product lines, the facility has an annual manufacturing capacity of approximately 50 MWh, of which about 10% is currently utilised.

The economics reveal a structural challenge in second-life battery production at early scale. Despite lower-cost feedstock, second-life battery packs currently cost more to produce than equivalent first-life batteries manufactured at the same facility. The difference is largely driven by the labour-intensive testing, grading, and quality-assurance processes required to convert variable-quality cells into reliable battery systems. As a result, second-life batteries remain commercially challenging to produce profitably at current volumes, even though they have the potential to offer customers a significantly lower purchase price than comparable new lithium-ion systems.

The customer value proposition remains strong. Depending on system size and configuration, second-life battery packs are typically sold at a 35–50% discount to equivalent first-life lithium systems, while still offering substantially better performance and lifespan than conventional lead-acid alternatives. This discount reflects both the lower guaranteed cycle life of second-life batteries relative to new systems and current production economics at relatively low manufacturing volumes. Soleil is confident that increased production volumes and operational efficiencies will enable profitable production while maintaining a significant customer price advantage over first-life alternatives. However, the business continues to face scaling challenges associated with low production volumes and a long working-capital cycle, where several months can pass between procurement, production, and revenue realisation.



“ We’re proud to be one of the innovators in the region’s circular battery value chain, and we believe that working now to address critical commercial and technical bottlenecks will position us as a key offtake partner to EV companies and a key supplier of high-quality second-life battery products to the market.”

– [Brendan Cronin, CEO, Soleil Power](#)

## Implications

Soleil’s experience challenges a common assumption about second-life batteries: that lower feedstock costs automatically translate into cheaper products. At current volumes, the labour-intensive testing, grading, and handling required to convert variable-quality cells into reliable packs more than offsets the savings on input materials. The cost advantage of second-life production is not inherent; it is scale-dependent, requiring processing volumes and efficiencies that do not yet exist. The dual-line model provides a structural hedge: first-life revenue and capability support second-life development, and learning transfers between the two. The case also suggests that until processing infrastructure reaches sufficient scale, the gap between what second-life batteries cost to produce and what the market can pay may need to be bridged by concessional finance, rather than by the economics of the product itself.

Soleil Power. Kirolo, Uganda, 2025.





# CASE STUDY



Hinckley conducting a training programme for women studying STEM subjects in local colleges and universities (2025)

## Hinckley Recycling: Second-life storage as commercial energy cost displacement

PREO-supported Hinckley Recycling converts discarded lithium-ion batteries into standardised storage systems for commercial and residential solar and backup power applications. The company applies a strict cell-level testing and grading process, prioritising reliability over the volume of cells reused. At many small cold-chain and commercial sites, the problem is not complete power failure but the rising cost and declining reliability of energy storage. When batteries degrade, operators fall back on grid electricity or diesel backup, both of which increase operating costs and reduce profitability.

“ The second-life battery solution deployed at our Ghana facility has delivered dependable performance while supporting our sustainability objectives. Working with Hinckley has allowed us to explore practical energy-resilient solutions that align with both operational efficiency and environmental responsibility.”

– Monic Esi, Project Transformation Manager, FanMilk Ghana

### The model

In commercial energy markets across sub-Saharan Africa, many businesses operate with grid connections or diesel generators but face high and unpredictable energy costs. Battery-backed solar systems can reduce these costs, but new lithium-ion storage remains expensive relative to the savings it generates. Simultaneously, growing volumes of lithium-ion batteries are being retired from solar installations, telecom infrastructure, UPS systems and commercial applications with usable capacity remaining. Without trusted systems to test, sort and certify used batteries for reuse, commercial users are often pushed toward expensive new lithium-ion systems or short-lived lead-acid alternatives that require frequent replacement. The lower-cost storage option that could make commercial energy displacement viable remains locked in waste streams.

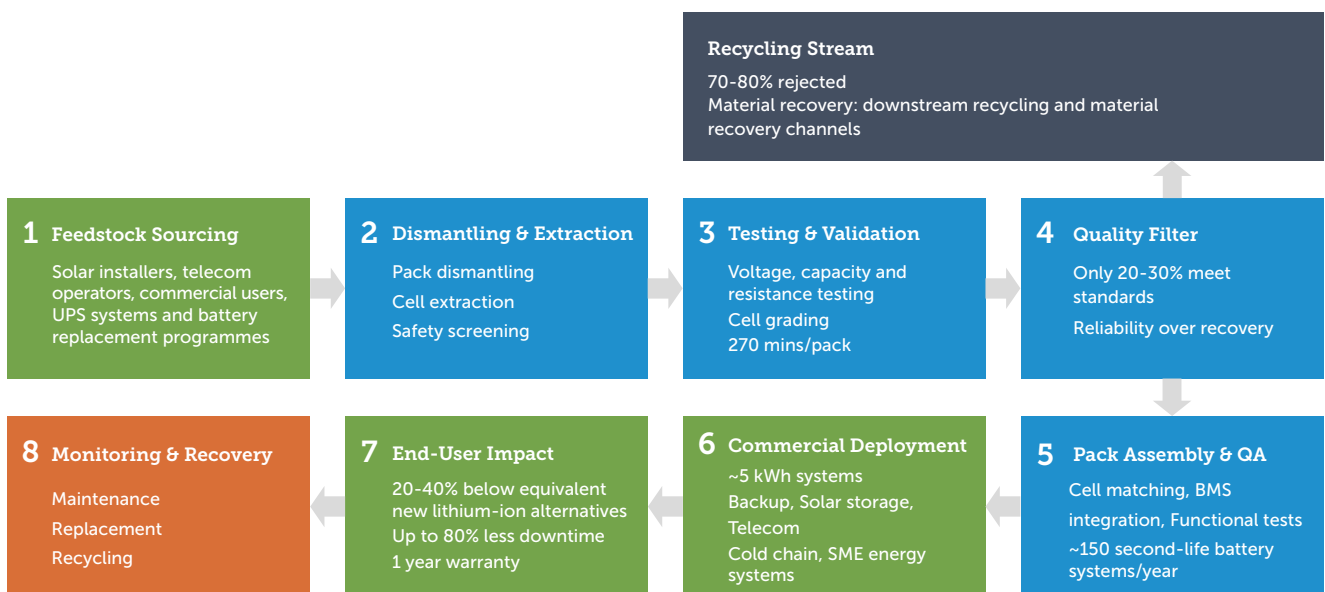


Hinckley technician commissioning a second-life battery energy storage system for a customer (2025)

Hinckley addresses this through a cell-level processing model with unusually strict quality filtering. Battery packs sourced from solar installers, telecom operators, commercial users, UPS providers and battery replacement programmes are dismantled, and individual cells undergo visual inspection and electrical testing for voltage, capacity and internal resistance. The process applies several layers of filtering, and only around 20 to 30% of recovered cells are ultimately deployed into second-life systems, reflecting a deliberate decision to prioritise long-term system reliability and customer confidence over maximising the number of cells reused.

The strict quality threshold emerged from early operational experience. Initial attempts to repurpose battery packs without detailed cell-level testing resulted in inconsistent performance and reduced system reliability, revealing significant variation in degradation between cells within the same pack. Hinckley subsequently shifted toward a more rigorous testing and grading process designed to prioritise deployed reliability over maximising reuse volumes. It demonstrates an understanding of how customer trust and system performance are more important than achieving the highest possible conversion rate.

Cells that pass testing are grouped into matched configurations and assembled into battery packs averaging approximately 5 kWh, integrated with electronic controls. In practice, a typical 5 kWh system can provide several hours of backup power for a small business, retail outlet, cold-room controller, telecommunications equipment, lighting circuits, computers and internet equipment. In solar applications, it can store excess daytime generation for evening use, reducing grid electricity purchases and diesel generator operation. Much of the feedstock is secured through long-term supply partnerships, which improve consistency relative to spot sourcing.



Hinckley Second-Life Battery Value Chain



## Performance

Hinckley currently produces approximately 150 second-life battery systems annually, with most deployments averaging around 5 kWh. Systems are delivered at 20 to 40% below the cost of equivalent new lithium-ion alternatives, depending on configuration and application. This cost reduction is sufficient to shift customer preference away from lead-acid and diesel-dependent systems toward lithium-based storage, where the total cost of ownership over the system's life is lower even before accounting for reduced maintenance and longer replacement cycles.

**80% reduction in downtime in commercial energy applications.**

Operational data indicates consistent reliability. Annual field failure rates are approximately 5%, and warranty returns are limited to around 2%. The strict screening process limits throughput, but it improves field reliability and system performance. For commercial users, second-life lithium-ion systems reduce diesel dependence, improve power stability, and require less frequent replacement than lead-acid alternatives. The result is lower long-term operating costs even where the upfront price advantage over new lithium-ion systems is moderate.

The model's commercial viability depends heavily on the quality of recovered batteries and the processing capacity required to filter them at Hinckley's quality threshold. Only a fraction of recovered cells meet deployment standards, but the company demonstrates that cost-competitive and reliable storage can be produced from battery waste when supported by rigorous testing and grading. Each second-life battery system also extends the productive life of lithium-ion cells that would otherwise enter waste streams prematurely, reducing demand for newly manufactured battery materials while creating local value from e-waste.

“ Our focus is on extending the usable life of energy storage systems through safe, tested, and commercially viable second-life battery deployment. Retired batteries can be repurposed into reliable backup and energy optimisation assets, helping businesses reduce waste, lower energy costs, and support circular economy goals across Africa.”

– [Adrian Clews, CEO and Founder, Hinckley Ewaste Recycling](#)

## Implications

Hinckley operates at the stage where second-life batteries move from technical pilots into commercial deployment, and the case exposes a tension that other models in this report face implicitly: the trade-off between conversion volume and deployed reliability. A stricter quality threshold reduces throughput but may accelerate commercial adoption by building the trust that institutional and commercial customers require before committing to second-life systems at scale.

The barriers that remain are increasingly commercial, regulatory and financing-related rather than purely technical. For commercial and institutional buyers, the constraint is not affordability alone but the absence of formal certification pathways that would allow second-life systems to be treated as standard procurement items, rather than exceptional purchases requiring individual risk assessment. Hinckley's recent ISO 14001 certification reflects a growing emphasis on formal environmental management systems and operational standards that can help strengthen customer confidence and support the wider commercialisation of second-life battery solutions. Until broader certification frameworks develop alongside the processing, quality assurance and financing capacity required for scale, commercial adoption may remain slower than the underlying economics would suggest.



IES battery technician collecting, sorting, and physically checking cells from a dismantled used battery in the IES warehouse, Addis Ababa, Ethiopia (2026)

## Inter Ethiopia Solutions: Second-life storage as productive use infrastructure

Inter Ethiopia Solutions (IES) is a PREO-supported Ethiopian energy company that repurposes discarded lithium-ion batteries into solar-powered productive use systems for MSMEs and smallholder farmers. Rather than selling second-life batteries as standalone storage, the company integrates them into complete systems designed for specific income-generating applications such as irrigation, tailoring, and welding.

For a smallholder farmer in Ethiopia, irrigation often depended either on seasonal rainfall or on diesel-powered water pumps. When diesel prices spike or supply is constricted, farmers cannot pump water reliably, limiting crop production and reducing incomes. Solar irrigation systems could solve this problem, but the cost of battery storage is often too high for many farmers. The challenge is often less about access to solar technology itself, but affordable storage that renders such irrigation systems reliable and usable. The same barrier is not confined to farming. Small enterprises that run on a diesel generator face the same bind: power that is unreliable and expensive, and storage they cannot afford to replace.

“ My garment shop used to rely on a diesel generator, which was expensive to operate due to rising fuel costs and frequent shortages in our area. Since installing the system, I have reliable and affordable electricity for my sewing machines, lighting, and other business activities. I can now continue serving customers during power outages, and my income has improved significantly.”

— Yewew Demelash, Garment Shop Owner, Finote Selam, Ethiopia



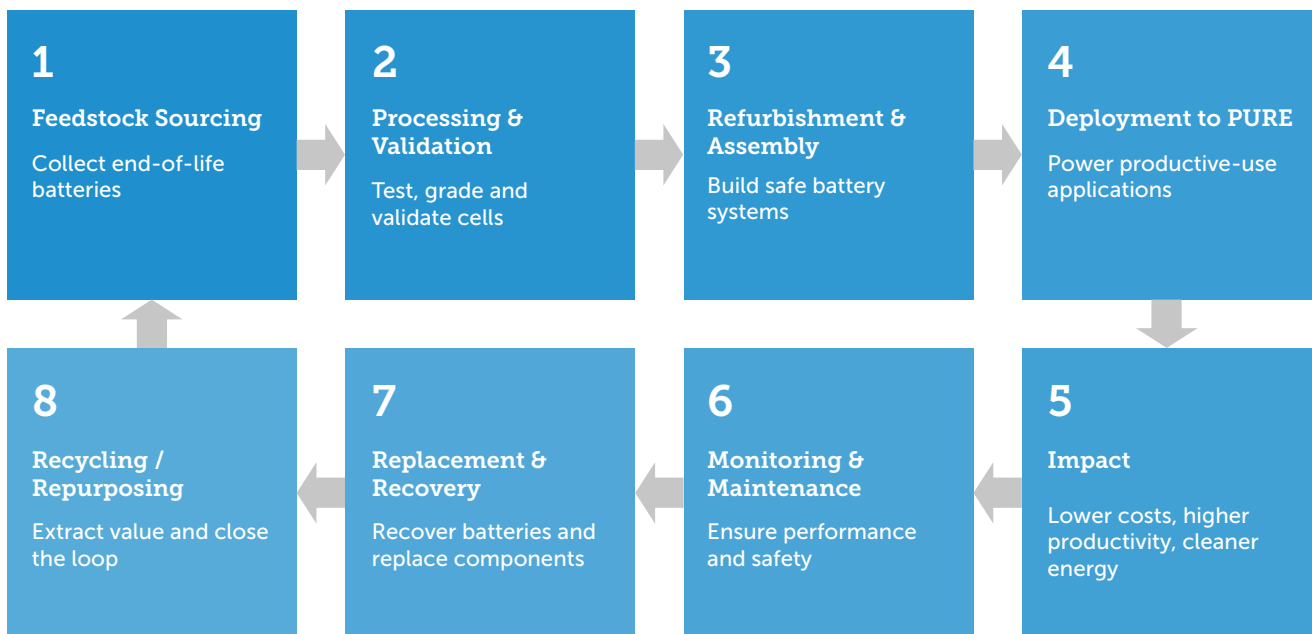
### The model

Productive use technologies are technically proven across multiple applications, but for many MSMEs and smallholder farmers the total system cost remains prohibitive, with storage representing a significant share of the overhead cost. New lithium-ion batteries are beyond the reach of these users. At the same time, increasing volumes of batteries from solar home systems, telecoms infrastructure, and other applications are being retired with usable capacity remaining. Without systems to link these recoverable batteries with productive use demand, usable storage capacity accumulates as waste, while the users who could most benefit from affordable energy systems remain underserved.

IES connects these parties through an integrated model that links battery recovery directly to productive use deployment. The company sources end-of-life batteries from solar distributors, telecom operators, MSMEs, and humanitarian programmes, with approximately 70% of supply originating from solar home systems. Collected batteries are dismantled and tested individually to assess safety, performance, and remaining usable capacity. Approximately 60 to 65% of collected batteries ultimately pass through testing, grading, matching, and assembly to reach deployment. The remainder are recycled or discarded.

The critical distinction is what happens next. Rather than selling the second-life batteries as standalone storage products, IES integrates them into complete solar-powered productive use systems designed around specific income-generating activities. A farmer receives an irrigation system, not a battery. A tailor receives a sewing system, not a power supply. This integration is supported by a distribution model using agents and local distributors for last-mile delivery, and by financing partnerships with banks and microfinance institutions that allow customers to repay over time. Revenue is generated not only through system sales but through distributor partnerships, repair services, and e-waste recovery, diversifying the income base beyond one-off transactions.

**Less than 1 year  
payback period for  
MSME users adopting  
second-life systems**



IES second-life battery process flow and productive use system integration



IES technicians install a second-life battery and solar-powered system to power a garment shop in Amhara (2026)

## Performance

IES currently processes approximately 46,000 cells annually, producing around 300 battery packs and serving over 100 MSME customers. Systems are deployed across applications including irrigation, tailoring, welding, and small enterprise operations. Systems are priced at approximately 30% below equivalent systems using new batteries, helping make productive use systems financially accessible to underserved users.

The integration of storage into income-generating systems shortens payback periods and strengthens the economic case for adoption. Survey data indicates that approximately 70% of users report cost savings, while 75% report

increased productivity. Income improvements vary widely, from 20 to 70%, reflecting the diversity of applications and baseline conditions: a farmer replacing diesel-powered irrigation captures different gains from a tailor gaining access to electricity for the first time. Many users report payback periods of under one year, a critical threshold for adoption in cash-constrained markets. For farmers previously dependent on diesel, the systems eliminate fuel expenses entirely and enable year-round irrigation, expanding both the range of crops and the number of growing seasons. Annual field failure rates are approximately 4%, with limited warranty returns.

Early assumptions that high feedstock volumes would automatically produce usable outputs proved incorrect, leading IES to strengthen its testing systems and sourcing relationships. The variability of incoming batteries remains a constraint on throughput, and the company's conversion rate of 60 to 65% reflects the cumulative filtering required across multiple processing stages to produce systems that can operate reliably in demanding field conditions.



At Inter Ethiopia Solutions, we see second-life batteries not as waste, but as valuable energy assets that can power rural businesses, reduce e-waste, and make productive use energy more affordable for communities that need it most.”

– Zelalem Nigatu, CEO, Inter Ethiopia Solutions

## Implications

IES demonstrates that second-life batteries create greater value when they are embedded within income-generating systems rather than sold as standalone storage products. By linking battery recovery directly to income generation, the model shortens the path between affordable storage and economic returns for end users, which in turn strengthens demand and improves repayment dynamics. In this sense, the model extends the logic of value retention beyond the battery itself to the full productive use asset in which it is deployed. However, the case also exposes the financial constraints that emerge at scale. Working capital requirements for inventory remain high, and end-user financing, while critical to the model's adoption rates, remains underdeveloped relative to the demand it needs to serve. Scaling will depend on whether the financing infrastructure can develop at the same pace as the processing and distribution capacity. The company's case suggests that the future of second-life storage in emerging markets may depend less on battery recovery alone and more on the ability to integrate storage into productive economic activity.



# CASE STUDY



SLS battery storage system for installation at a mini-grid in Chitandika, Zambia (2026).

## SLS Energy: Battery ownership as managed infrastructure

SLS Energy is a PREO-supported Kigali-based energy storage company, founded in 2021, that repurposes retired electric vehicle batteries into storage systems. Rather than selling batteries outright, the company provides storage through a Battery-as-a-Service (BaaS) model, retaining ownership of battery assets while customers pay for storage capacity and performance over time.

For many commercial energy users, battery storage represents one of the largest and most uncertain capital investments within an energy system. While second-life batteries can significantly reduce costs, concerns around battery degradation, maintenance requirements, and replacement risk often limit adoption. SLS addresses this challenge by assuming responsibility for battery performance throughout the asset lifecycle, allowing customers to access reliable storage without owning the asset itself.

**1 MWh of contracted storage deployed under a service model**

The company has deployed systems across telecommunications infrastructure, healthcare facilities, hospitality businesses, commercial and industrial sites, and distributed energy applications. More recently, SLS has expanded into mini-grid deployments in Zambia, demonstrating the applicability of second-life batteries in high-utilisation energy access environments.

“ With SLS Energy’s Battery-as-a-Service model, we can focus on delivering reliable electricity services while SLS manages battery performance, replacement, and lifecycle risks. The approach provides greater flexibility to scale storage as demand grows and improves long-term planning and cost predictability”

– Ignite Energy Access, Zambia



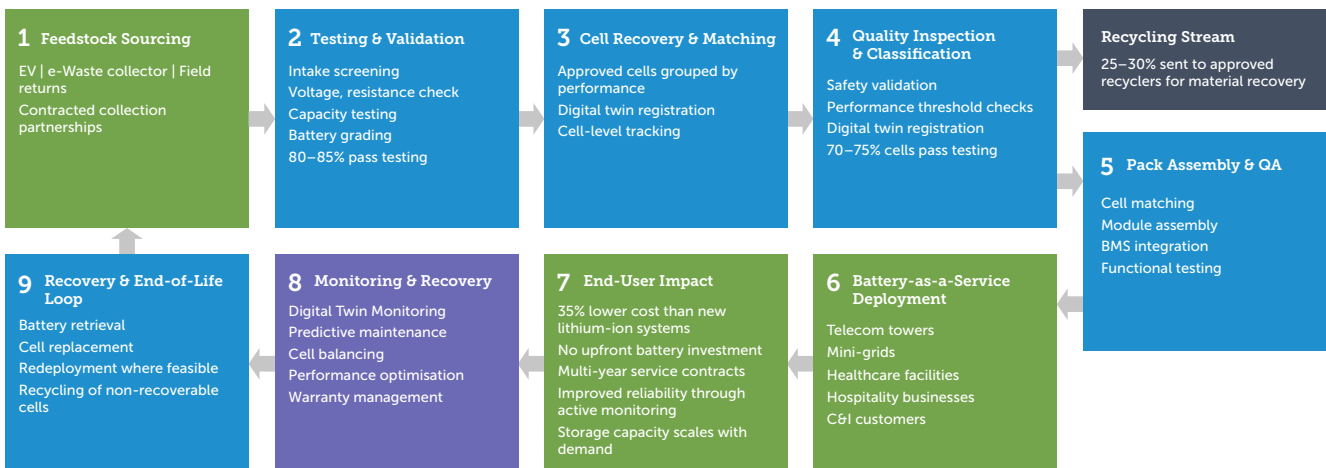
### The model

Most energy storage systems are purchased upfront and owned directly by operators, who bear the costs and risks associated with battery degradation, maintenance, and replacement. SLS has developed an alternative approach that separates battery ownership from battery use. Under its Battery-as-a-Service model, SLS retains ownership of battery systems and provides customers with storage capacity through multi-year service agreements. Customers pay for storage services while SLS assumes responsibility for deployment, monitoring, maintenance, replacement, and end-of-life management. This converts battery storage from a capital investment into a managed operating expense.

A key differentiator is the company’s battery digital twin platform, which combines sensing, modelling, and cell-level monitoring to track battery health and optimise performance over time. Continuous monitoring enables proactive maintenance, improves reliability, and extends the useful life of deployed assets. The company sources retired lithium-ion batteries primarily from electric mobility applications. Incoming batteries undergo inspection, testing, grading, and validation before being repurposed into second-life storage systems. Cells that do not meet deployment standards are directed to approved recycling pathways, while qualified batteries are integrated into modular storage systems for deployment.

SLS’s experience suggests that the economics of second-life batteries are driven less by the source application and more by asset utilisation and predictable cycling over time. This insight has informed the company’s expansion from backup-power applications into mini-grid systems, where batteries cycle daily and deliver greater value throughout their operational life. The company has also found that battery sizing represents a significant technical and financial challenge for many solar and mini-grid operators. Given expected demand growth of approximately 20–25% over a system’s lifetime, storage systems are often either oversized or undersized, reducing technical and financial performance. Under the Battery-as-a-Service model, storage capacity can be expanded as demand grows, enabling customers to better align system size with actual consumption.

The company is also developing innovative financing partnerships across the electric mobility ecosystem. Under these arrangements, battery suppliers can contribute financing for approximately 30–60% of Battery-as-a-Service deployment costs and participate in revenues generated from second-life deployments. This reduces capital requirements while creating a new value pathway for retired EV batteries beyond their first-life use.



SLS Energy business model process flow



Commercial & Industrial (C&I) Systems in Kigali, Rwanda (2026)

## Performance

SLS has deployed energy storage systems across more than twenty commercial customers, with average project sizes of approximately 30 kWh and total contracted storage capacity exceeding 1 MWh. Under service contracts extending up to five years, SLS assumes full lifecycle responsibility for battery performance, maintenance, replacement, and end-of-life management. Active monitoring and preventative maintenance contribute to low failure rates while providing customers with predictable storage performance throughout the contract period.

The company reports storage costs of approximately US\$111 per usable kilowatt-hour compared with around US\$170 per usable kilowatt-hour for equivalent new lithium-ion systems. According to SLS, these costs are influenced by current processing volumes and are expected to decline as deployment scales. The company projects costs could fall

below US\$80 per usable kilowatt-hour as throughput increases and operational capacity is more fully utilised. The expansion into mini-grid environments in Zambia demonstrates the potential for second-life batteries to move beyond backup-power applications and support core electricity service delivery. The company is also exploring innovative financing approaches to support future deployment growth and improve the economics of service-based storage models.

“ Our digital twin platform and Battery-as-a-Service model place asset risk where it is best understood and managed. By converting capital expenditure into operating expenditure, we make adoption easier while improving performance reliability and long-term economics.”

— Léandre Berwa, CEO, SLS Energy

## Implications

SLS demonstrates that scaling second-life batteries is not only a technological challenge but also a financing, ownership, utilisation, and system design challenge. The case illustrates how service-based models can reduce upfront investment requirements while providing the flexibility to adapt storage capacity as customer demand evolves over time. While repurposed batteries can reduce storage costs, customer adoption ultimately depends on confidence in long-term performance, maintenance arrangements, and risk allocation. By combining second-life batteries with a service-based delivery model and digital monitoring systems, SLS has created an approach that addresses many of the concerns traditionally associated with battery ownership. The case highlights how innovations in ownership structures, lifecycle management, and financing models can unlock value from second-life batteries while reducing risk for end users.

As new battery prices continue to decline, access to retired batteries alone is unlikely to be a sustainable competitive advantage. Instead, value creation may increasingly depend on ownership models, financing structures, performance management capabilities, and the ability to maximise utilisation throughout the asset lifecycle. SLS's experience suggests that business-model innovation may be as important as technological innovation in unlocking the full value of second-life energy storage.



Dairy cooperatives in Southwest Uganda utilise mini-grid power from FRES Solar, a battery leasing client of Vittoria Technology (2025)  
Photo credit: AVSI Foundation.

## Vittoria Technology: Battery leasing as deployment infrastructure

Vittoria Technology is an Energy Catalyst-supported energy company, based in Cape Town, that leases battery storage to mini-grid and distributed renewable energy operators through its Battery Bank Africa platform. After raising capital, Vittoria procures the battery bank equipment. It then manages performance and warranty over the 36-month term of the lease, after which ownership transfers to the customer.

Vittoria initially targeted new and expanding mini-grid sites with a modular proposition: operators could start with the storage they needed and scale capacity as demand grew. However, developers were cautious: many had previously been left with unsupported equipment after pilot phases ended or suppliers shifted direction, and few were willing to rely on a young company to deliver over a multi-year timeframe.

In response, Vittoria shifted its focus to existing sites where batteries were already failing and the need was immediate. In such cases, degraded storage was constraining service, reducing revenue and undermining user trust. While the core value proposition remained the same, Vittoria pivoted in how and where to apply it. The infrastructure developed by Vittoria does not depend on whether the battery is new or second-life. Its leasing model, monitoring platform, and modular approach to scaling capacity apply regardless of battery provenance. Vittoria has already deployed second-life batteries – sourced from partners such as Soleil Power (Section 3.2) and SLS Energy (Section 3.5) – across its 12 sites in East and Southern Africa. Five of these sites are equipped with second-life battery systems.

The lease-to-own structure may be particularly well suited to second-life systems, where uncertainty about lifespan and residual value can deter operators. By shifting performance and replacement risk away from the operator, this approach enables the uptake of second-life systems in contexts where they might otherwise be considered too uncertain.



“ Our storage-as-a-service model is built on a simple but important principle: right-size first, then grow. Rather than oversizing and risking over-financed, underutilised systems, we work with minigrid operators to closely match battery bank capacity to their realistic demand profile from day one. Our leasing structure and scalable technology mean that as demand grows, capacity can expand in step with it. This keeps costs to a minimum and fundamentally improves minigrid economics. The result is a system that is financially sustainable from the outset and structurally designed to scale.”

— Nathan Sermonis, CEO, Vittoria Technology

## The model

In mini-grid markets, storage is typically financed as a capital asset which is purchased upfront, sized against uncertain demand, and replaced when performance declines. This creates challenges as oversizing ties up capital before it is needed, while undersizing constrains service and revenue.

Although large investment packages can support new portfolios, smaller or more incremental upgrades at existing sites are harder to finance. As batteries degrade, they render energy systems, which would otherwise be operational, unreliable. This limits their performance and income stream.

In Vittoria’s model, operators lease storage through a flat monthly payment rather than buying it upfront. This does not replace outright purchase, which is still the cheapest option for operators who can afford it. Instead, it offers an alternative to slower, more complex financing routes such as waiting for funding rounds or assembling large multi-site investment packages. Its value lies in smaller upfront commitments, faster deployment and the ability to add capacity when the site needs it.

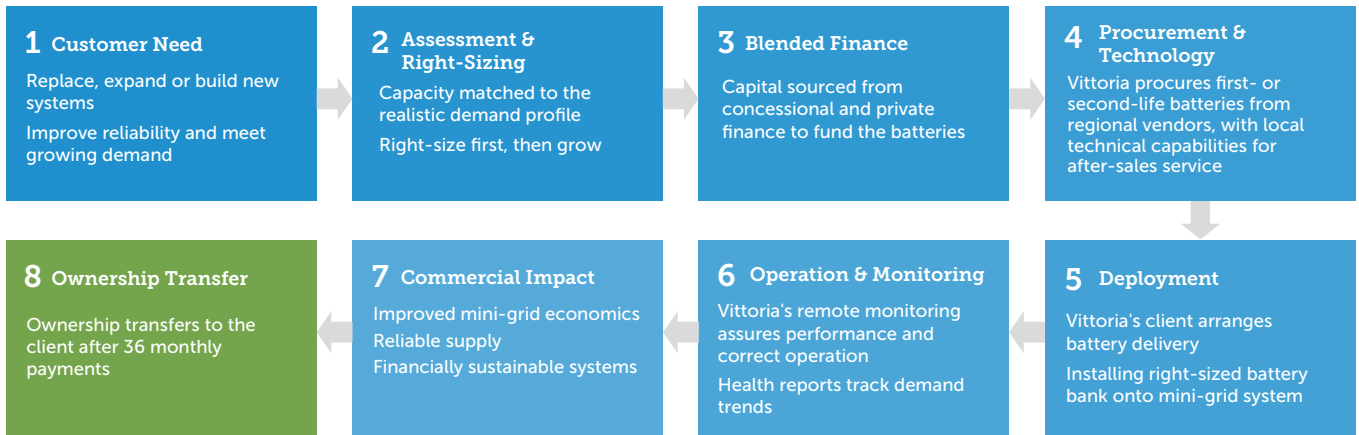


Dairy cooperatives in Southwest Uganda utilise mini-grid power from FRES Solar, a battery leasing client of Vittoria Technology (2025)  
Photo credit: AVSI Foundation.

Vittoria selects systems based on performance, warranty coverage, supplier reputation and regional availability. The company procures the battery while the operator manages shipping and installation, with remote support provided through manufacturer portals. Once live, the system is added to Battery Bank Africa’s monitoring platform. Data from batteries and inverters feeds into the platform, allowing Vittoria to track faults, monitor utilisation and flag capacity needs. Diagnostic capability is still being developed, with the aim of enabling a small team to manage a distributed portfolio through alerts and automated reporting rather than site-level intervention.

The platform also supports hybrid retrofits at sites with ageing lead-acid batteries. Where the original bank still has useful life, lithium-ion capacity can be layered in through shared control systems. The lithium component absorbs heavier loads, reducing strain on the lead-acid bank and extending its remaining life. The approach depends on the condition of the existing batteries and works best at larger system sizes.

**Over 950 kWh of storage deployed or contracted through Battery Bank Africa**



*Battery Bank Africa: Storage-as-a-service and Lease-to-own model process flow*

### Performance

To date, Battery Bank Africa has deployed or contracted over 950 kWh of storage across 12 sites and 6 operator customers in 6 countries, an early portfolio base rather than a single project proof point. As with any asset-heavy service model at early stage, the economics are scale-dependent: platform, monitoring and overhead costs require a growing portfolio base to amortise effectively.

Recent deployments in Uganda illustrate the site-level case. At mini-grid hubs anchored by dairy cooperatives, leased battery systems have replaced diesel generators that previously powered milk chilling equipment. With solar generation and leased storage, these anchor loads now pay around one third of their previous energy cost. Surplus capacity has allowed surrounding small businesses to connect. What began as a single productive use anchor has expanded into a wider rural energy platform serving 60 small businesses and productive use appliances.

The same logic applies to battery replacement. At several ageing mini-grid sites in Kenya, failing lead-acid batteries were causing outages and undermining revenue. Battery Bank Africa’s lease-to-own structure allowed the operator to spread the cost of replacement and additional capacity over 36 months, rather than funding it as upfront capital expenditure.

“ At our Busia sites, failing lead-acid batteries were causing regular outages, reducing revenue and trust. We addressed this by installing a lithium-ion BESS, which has stabilised performance.”

— Robert Oduor, Busia County Business Manager, Kudura Power East Africa

### Implications

Battery Bank Africa demonstrates that scaling mini-grid storage depends not only on cheaper batteries but on the structure through which storage is financed, deployed and maintained. By converting storage from an upfront purchase into a managed service, the model aligns investment more closely with demand as it materialises. The capital requirement does not disappear, but shifts to the intermediary. Grant and concessional finance have been essential to reaching this point, allowing Vittoria to test products, absorb risk and learn from failures that would have been unsustainable on commercial terms. Scaling further requires capital flexible enough to tolerate early-stage risk while behaving like commercial finance. Larger investors want a track record, but that track record cannot be built without smaller pools of patient capital sitting between site-level demand and institutional investment thresholds.



# CASE STUDY



Inventory and inspection activities at the GreenBay Kasarani outlet in Nairobi (2025), where second-life appliances and accessories are catalogued, inspected, tested, and graded under GreenBay's 47-point certification process. Image: GreenBay Market Kenya Ltd.

## GreenBay: Refurbishment as trust infrastructure

GreenBay is a PREO-supported Nairobi-based refurbishment and resale platform for productive use appliances, primarily refrigerators and freezers. It sources returned and overstocked units from distributors and Original Equipment Manufacturers (OEMs), and subjects them to a standardised inspection and repair process. It then sells them to Micro, Small, and Medium Enterprises (MSMEs) and households at 40 to 60% below new equivalents, backed by a tiered warranty of 3, 6 or 12 months, depending on product grade.

In Nairobi's informal appliance markets, buying a second-hand refrigerator is a gamble. Units are sold without testing, without warranty, and failures within weeks are common. For small businesses dependent on refrigeration to preserve stock and generate daily income, that uncertainty translates directly into financial loss.

“ I bought a second-hand fridge, but it broke after four months. When I bought from GreenBay, I was not sure it would be different, but it has been ten months now with no problems. The warranty is what convinced me.”

— Mary Wanjiku, provisions shop owner, Nairobi

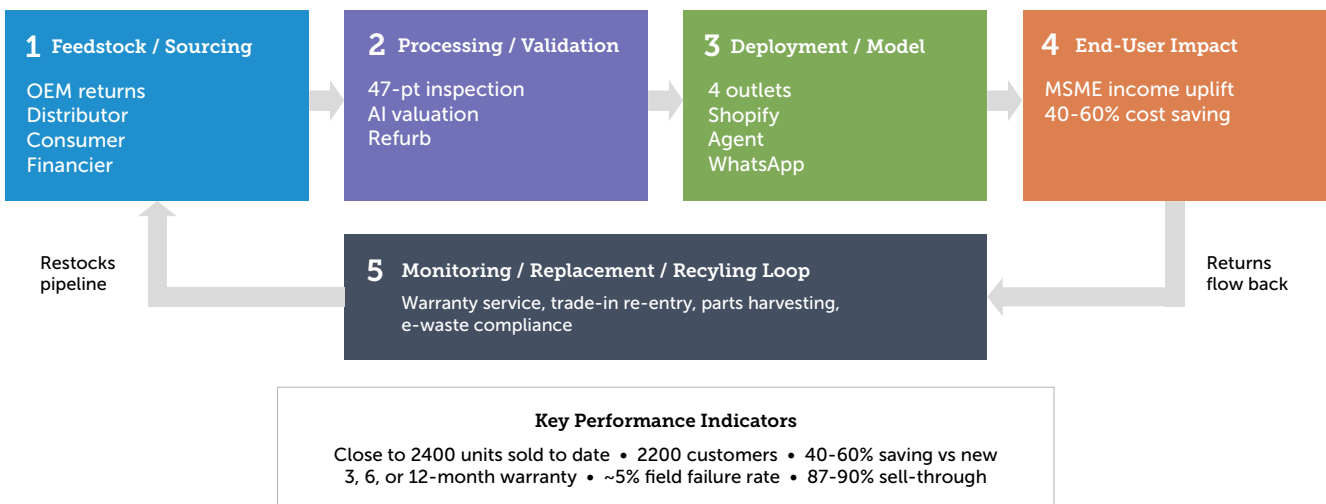
### The model

The cost barriers facing adoption of productive use appliances do not end at generation and storage. Appliances such as refrigerators, freezers, and cooking equipment are beyond the reach of many MSMEs and low-income households. Informal second-hand markets offer cheaper alternatives but provide no quality assurance, no warranty, and no after-sales support. At the same time, increasing volumes of returned, overstocked, and lightly used appliances accumulate within distributor and retailer networks without structured pathways back into the market. The result is a dual market failure: affordable appliances remain inaccessible to many users, while large volumes of usable assets remain underutilised or prematurely discarded within supply chains.



GreenBay formalises this fragmented market by creating a trusted refurbishment and resale infrastructure for productive use appliances. GreenBay sources appliances through four principal channels: OEM and distributor returns, retailer clearance stock, consumer trade-ins, and an emerging stream of repossessed assets recovered through financing partners. Distributor and OEM returns currently account for the majority of supply, complemented by consumer-sourced inventory and recovered assets that would otherwise remain underutilised or enter informal resale channels. All units undergo a structured 47-point inspection covering electrical safety, cooling performance, energy efficiency, mechanical condition, and overall functionality. Approximately 85 to 90% of appliances entering the system are ultimately refurbished and sold. Pricing is set using an AI-assisted valuation system that benchmarks against prevailing market conditions. Sales are executed through both physical retail outlets and digital channels, with most transactions completed via mobile money.

The company has evolved from a straightforward resale operation into a managed refurbishment and retail business. By owning inventory, standardising quality assurance, and offering equipment warranty, GreenBay assumes performance responsibility that the informal market does not provide. This shifts the transaction from one based on buyer risk to one based on seller accountability. In effect, the company is building the trust layer required for second-life appliance markets to scale commercially.



GreenBay business model process flow

### Performance

Since launch, GreenBay has sold close to 2,500 refurbished appliances to over 2,200 unique customers through a combination of four physical retail outlets, digital channels, and agent-led sales. While most customers make a single purchase, a growing cohort of repeat buyers, particularly MSMEs such as retailers, butcheries, and food vendors, purchase multiple units over time as their businesses expand. Refurbished appliances typically sell at approximately half the cost of new alternatives while still providing warranty-backed reliability. Recent performance indicates strengthening market demand and improving inventory availability. Between December 2025 and February 2026, monthly sales volumes roughly doubled, primarily due to improved access to second-life stock. Annual field failure rates are approximately 5%, and

**Refurbished appliances priced 40-60% below new alternatives**



warranty returns run at around 3%. In a market where second-hand purchases carry significant quality risk, those numbers matter: the tiered warranty of 3, 6 or 12 months converts what would otherwise be an uncertain transaction into one where the seller bears the performance risk. The company is exploring pay-as-you-go and rent-to-own arrangements for higher-value appliances, which would further reduce the upfront cost barrier for cash-constrained buyers.

The pattern of repeat purchasing provides further evidence of the model's commercial logic. Many MSME customers purchase multiple units over time, treating refurbished appliances as productive business assets rather than one-off consumer purchases. Sell-through rates for refurbished inventory consistently reach approximately 87 to 90%, indicating that the binding constraint at present is not demand but refurbishment throughput and the working capital required to finance inventory at scale.

“ The informal second-hand market has operated for decades with no testing, no warranty, and no recourse for buyers. GreenBay is building the trust infrastructure that this market has always lacked — an AI-assisted valuation engine, a 47-point certification process, and a tiered warranty that puts the performance risk on us, not on the customer. That is what makes second-life appliances commercially scalable”

— Dennis Nyunyuzi, Managing Director, GreenBay Market Kenya

### Implications

GreenBay highlights an infrastructure gap that is distinct from, but parallel to, the one this report identifies in battery markets. The MSMEs that GreenBay serves (small retail shops, butcheries, beverage vendors) are the same categories of end user that PURE systems with battery storage are designed to reach. For these customers, the trust gap does not exist at one layer alone. Even where second-life storage reduces the cost of energy, PURE adoption can remain constrained if the appliances that energy is intended to power are themselves unaffordable or unreliable. The intermediary functions required for second-life batteries, testing, grading, refurbishment, quality assurance and warranty, are equally necessary at the appliance layer. Such protections help insulate businesses with marginal turnover from unreliable products and unpredictable repair costs.

GreenBay demonstrates that the infrastructure required to scale circular productive use ecosystems extends beyond batteries alone. The same functions required in second-life battery markets – testing, grading, certification, warranties, performance monitoring, and customer trust – are equally necessary for productive use appliances, solar equipment, and emerging electric mobility assets.

The case suggests that circular economy infrastructure within the productive use ecosystem may need to extend beyond batteries to the full productive use asset base if the cost and reliability benefits of value retention are to reach end users.



Certified refurbished cookers, refrigerators, and freezers on display at a GreenBay Kasarani retail outlet in Nairobi (2025)

A photograph of a rural landscape with solar panels installed on a hillside. The panels are mounted on metal frames and are arranged in rows. In the background, there are some buildings and a fence. The sky is blue and overcast.

# Conclusion

The seven companies profiled in this report are building different layers of the same infrastructure at the same time: cell-level processing, product manufacturing, quality assurance, productive use integration, managed ownership, deployment financing, and appliance-level trust. Taken together, they reveal the early outline of a second-life battery value chain that did not exist across sub-Saharan Africa a few years ago. That value chain is beginning to form under the same market conditions that are generating the waste streams it is designed to absorb.

This simultaneity is significant. The deployment volumes driving battery end-of-life are growing on increasingly commercial terms: private capital is flowing, business models are maturing, and adoption in segments such as electric mobility is accelerating beyond pilot scale. The infrastructure required to manage what those volumes leave behind – the testing, grading, certification, financing, and redeployment systems documented in this report – is developing on different terms entirely. It remains dependent on grant and concessional funding, processing volumes are small relative to the waste streams they are designed to address, certification frameworks do not yet exist, and financing structures suited to assets whose residual value the market cannot yet systematically price are largely absent.

The risk this creates is specific and structural. If back-end lifecycle infrastructure cannot scale faster than the front-end deployment that feeds it, the hidden tax on productive energy systems does not diminish as markets grow, but compounds. Replacement costs remain higher than they need to be, usable storage capacity continues to exit the system as waste, and financing conditions reflect uncertainty rather than demonstrated asset performance. The incremental costs accumulate not because the technology has failed, but because the commercial systems around it have not yet caught up.

The case studies point consistently toward what those systems require. Processing infrastructure is the foundational layer: without credible, scalable testing and grading, value cannot move from waste stream to deployment. Processing alone is insufficient, however, if the products it generates cannot be certified for standardised procurement, financed on terms that match their risk profile, or integrated into ownership models that place performance responsibility where it can be managed.



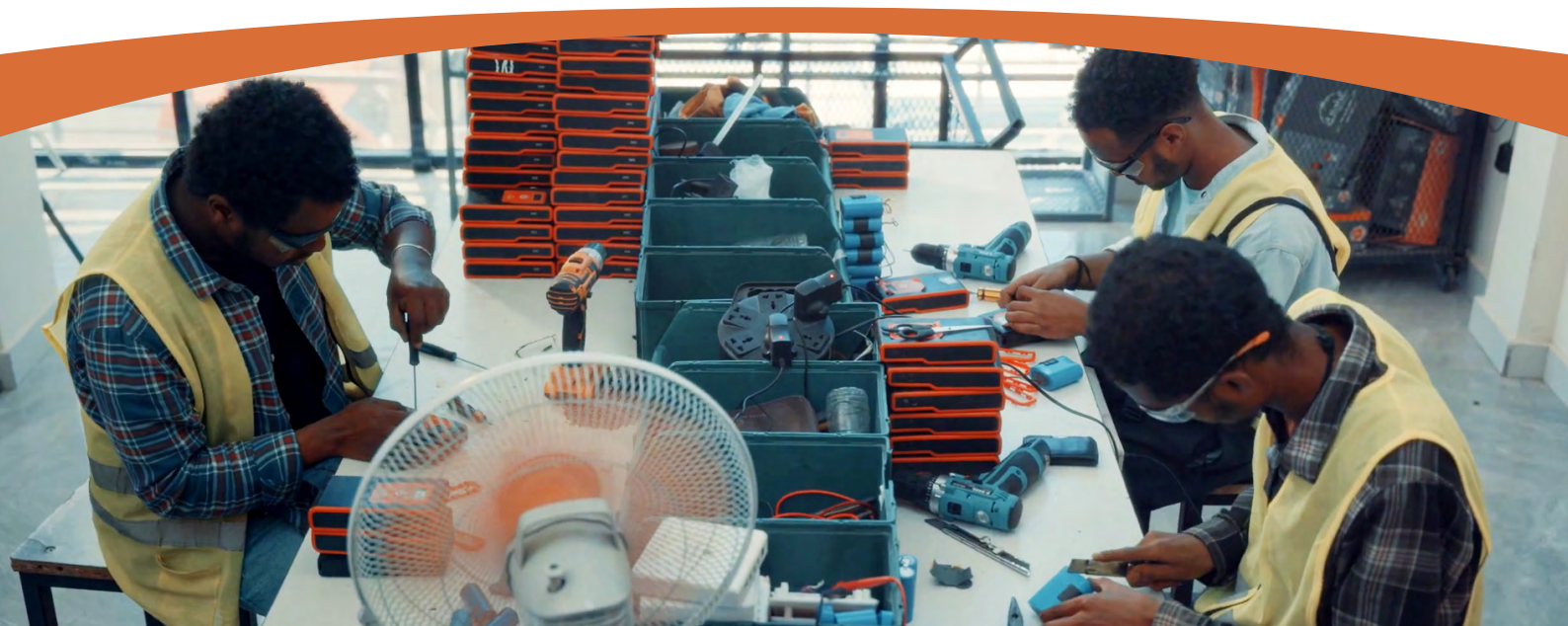
Several companies in this report have found that strict quality thresholds, even where they reduce throughput, may accelerate market acceptance more effectively than maximising conversion volume. Others have found that the shift from selling batteries to providing storage as a managed service addresses adoption barriers that lower prices alone cannot overcome. At least one has demonstrated that second-life batteries can create greater economic value when embedded within income-generating systems than when sold as standalone storage. These are not separate findings. They are interdependent elements of the same infrastructure gap, each reinforcing or constraining the others.

The case studies also suggest that this infrastructure extends beyond batteries. The intermediary functions required for second-life battery markets – testing, grading, certification, warranty, and quality assurance – are equally necessary at the appliance layer and across the broader productive use asset base. The circular economy within productive energy markets will need to be built as a connected system, not as a set of isolated interventions around a single asset class.

The companies in this report have demonstrated that second-life batteries can work. They can be tested, graded, assembled into reliable systems, deployed in demanding conditions, and integrated into business models that deliver measurable value to end users. The challenge now is not proving the concept, but creating the enabling conditions needed for these early successes to scale. Progress in standards, regulation, finance, and coordinated market development will determine whether second-life batteries can move from promising pilots to a core component of the infrastructure required to power productive energy markets.

Achieving that transition will require sustained and coordinated action. Policymakers must establish certification and regulatory frameworks that build confidence in second-life systems. Investors must provide capital that can accommodate early-stage risk while helping to create the track records needed to unlock commercial financing. Manufacturers have a critical role to play in improving battery traceability, data access, and design choices that affect reuse and repurposing potential. Development partners must continue to bridge the gap between current production costs and market affordability until economies of scale can take hold. The companies showcased in this report have demonstrated what is possible; the next phase of growth will depend on whether these actors can work together to turn early momentum into a mature, scalable market capable of meeting the energy needs of the future.

Inter Ethiopia Solutions, Addis Ababa, Ethiopia (2026)





## Endnotes

- 1 Ministry of Roads and Transport 2026: [Kenya Launches National Electric Mobility Policy](#); The Star 2026: [Kenya's uptake of electric vehicles](#)
- 2 TechCrunch 2025: [Spiro raises \\$100M, the largest-ever investment in Africa's e-mobility](#); CleanTechnica 2025: [Ampersand secures major investments to scale clean transport in East Africa](#); TechCabal 2026: [Dodai raises \\$13 million to expand battery-swapping EV network](#)
- 3 Ministry of Roads and Transport 2024: [Draft National e-Mobility Policy](#) (curtailed grid energy alone projected to power over 200,000 electric motorcycles)
- 4 arXiv 2023: [Challenges and Opportunities for Second-life Batteries: A Review of Key Technologies and Economy](#)
- 5 ScienceDirect 2026: [Beyond first life: progress and prospects in battery recycling and second-life utilisation](#)
- 6 GIZ 2021: [Dealing with the End-of-Life Problem](#); see also Frontiers 2024: [Lithium-ion battery second life: pathways, challenges and outlook](#)
- 7 P&S Market Research 2024: [EV Battery Swapping for Two- and Three-Wheeler Market](#)
- 8 ESMAP 2019: [Mini Grids for Half a Billion People](#) (capital-cost breakdown for solar-hybrid mini grids)



PREO promotes the productive use of renewable energy (PURE) in sub-Saharan Africa and the Pacific Island Countries to stimulate local economic development and support global progress towards the Sustainable Development Goals (SDG7, SDG8 & SDG13). By bolstering investment and engagement in the PURE sector, PREO strives to realise the potential of PURE as a key driver in a just and inclusive global clean energy transition. The PREO programme supports collaborative partnerships that are designed to meet the specific needs of local communities. For more information, please visit: [PREO Powering Renewable Energy Opportunities](#)

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