PREO
Powering Renewable
Energy Opportunities

Driving Interoperability: Insights from PREO's E-Mobility portfolio

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CARBON TRUST

Foreword

The Carbon Trust is committed to accelerating the transition to a Net Zero future that is inclusive, resilient, and economically sustainable. Nowhere is this mission more urgent–or more full of opportunity–than in Africa's rapidly evolving energy and mobility landscape.

Electric mobility, particularly of two- and three-wheelers, is emerging as a transformative force across the region. Through the Powering Renewable Energy Opportunities (PREO) programme, which is co-funded by the UK Government under the Transforming Energy Access platform and the IKEA Foundation, we have had the privilege of supporting some of the most innovative e-mobility companies on the continent. These pioneers are not only proving that electric motorcycles can thrive in African markets–they are also showing that clean transport can be a driver of job creation, income stability, and emissions reduction.

However, as this report makes clear, the next phase of growth will require more than innovation alone. It will require collaboration. The current model–where each company builds its own vehicles, batteries, and infrastructure–has delivered proof of concept. Yet it also risks locking the sector into high-cost, fragmented growth. Interoperability may offer a pragmatic alternative: shared systems that reduce duplication, improve asset utilisation, and unlock scale.

This report draws on five years of PREO's experience supporting e-mobility enterprises across East and West Africa. It offers grounded insights into where interoperability adds value, what it takes to make it work, and how shared platforms can accelerate the sector's transition from pilots to scale.

We hope this report will serve as a resource for policymakers, investors, and innovators alike. Achieving Net Zero will require more than technological advancement–it will depend on coordinated action across systems and sectors to deliver solutions that are scalable, inclusive, and resilient.

Richard Rugg
Deputy Chief Executive Officer
Carbon Trust

Executive Summary

The electric mobility, or e-mobility, sector in sub-Saharan Africa (SSA) has moved from proof-of-concept to early scale

The first generation of companies has demonstrated that electric motorcycles can succeed under local road and grid conditions: riders save on daily operating costs, businesses can be built, and emissions fall. Yet the sector now faces a structural constraint: most operators have taken a vertically integrated approach, building their own vehicles, batteries, and charging or swap networks. While this was necessary in the pilot phase, it has created siloes of proprietary systems. The result is duplication of infrastructure, fragmented supply chains, higher capital requirements, and under-used assets.

Interoperability offers a pragmatic way forward

It is not about forcing one universal standard, but about creating compatibility at critical technical interfaces, or building neutral platforms that any operator can plug into. The intended outcome is that companies build shared systems so that vertical integration is not needed anymore—at least for specific business functions.

In India, Interoperability-themed business strategies have emerged in the form of public charging targeted at personal users, and battery-as-a-service (BaaS) models targeted at commercial electric users.

In Taiwan, Gogoro's closed but market-dominant battery swapping network shows that scale can drive adoption, though at the cost of competition.

In SSA, operators are piloting a range of interoperable e-mobility solutions—including neutral swap stations allowing battery exchanges across different vehicle brands, modular battery systems designed for flexible integration, open-access charging points usable by any EV model, shared battery ownership schemes enabling collective use and management, and energy platforms that support cross-brand monitoring and billing. While these models are still in early development, they reflect a growing commitment to scalable, inclusive infrastructure.

Three insights stand out from PREO's portfolio and wider interviews

- **For riders, interoperability can reduce downtime (where drivers are unable to use their vehicles due to operational issues and charging), improve convenience, and increase daily earnings.** Commercial users–such as motorcycle taxi and delivery riders–are particularly affected by downtime, so access to compatible stations or batteries directly improves income stability.
- **For companies, shared systems lower breakeven points and improve asset utilisation.** A single operator can struggle to fill a station, but when multiple fleets use the same network, utilisation rates rise, supply chain volumes increase, and bargaining power with global suppliers improves.

- **For investors, interoperability reduces the capital intensity of growth.** Shared networks and neutral asset structures can shorten the path to breakeven, though this only works where governance, revenue sharing, and liability rules are clearly established.

Interoperability, however, is not a universal solution

For private two-wheeler users, home and workplace charging could remain the dominant mode for the foreseeable future. Closed systems may continue where infrastructure is less capital-intensive or where operators seek tight control over customer experience. Interoperability is most compelling in high-utilisation segments where infrastructure costs are high, riders are cost-sensitive, and demand aggregation can unlock scale.

PREO's role as one of the leading clean tech accelerators in SSA is to generate evidence on where interoperability adds value, under what conditions, and for whom

Since 2019, PREO has supported 15 e-mobility companies with early-stage, risk-tolerant funding and technical assistance, observing first-hand the critical challenges created by duplicated systems. We have backed business models with shared platforms across hardware, software, and financing layers. This report consolidates those insights—drawing on case evidence from companies like Mazi Mobility, AG Energies, CHAJI, STIMA, and Ecobodaa.

SSA's e-mobility future will likely be a mix of interoperable and closed systems, with different models suited to different user groups

Where the economics justify it, shared systems can accelerate scale, cut costs, and create investable business models. Where they do not, closed approaches will persist. We see our contribution as threefold: test these models early, demonstrate their viability, and build the evidence base needed to attract private investment, create jobs, and cut emissions.

Image: Rider battery swap. Ecobodaa. Kenya, 2023.

GLOSSARY - Key Acronyms

Acronym	Full form	Explanation / Relevance
API	Application Programming Interface	A set of digital rules that lets different software systems communicate. Used for open data and platform interoperability.
BMS	Battery Management System	Electronics that monitor and manage battery safety, charge, and performance.
CAN bus	Controller Area Network bus	A communication protocol widely used in vehicles for data exchange.
CCS	Combined Charging System	A global fast-charging standard used in Europe and North America.
CHAdeMO	"CHArge de MOve"	Japanese-developed fast-charging standard.
EV	Electric Vehicle	Any vehicle powered fully by electricity.
E-2W	Electric Two-Wheeler	Electric motorcycles and scooters.
E-3W	Electric Three-Wheeler	Electric tuk-tuks or tricycles.
GB/T	National standard recommended (in China)	The Chinese fast-charging standard.
ICE	Internal Combustion Engine	Traditional petrol or diesel-powered engines.
IoT	Internet of Things	Smart devices connected via the internet, e.g., charging units with sensors.
KPI	Key Performance Indicator	Metrics used to measure performance against objectives (e.g., uptime, utilisation).
kWh	Kilowatt-hour	Unit of energy, used to measure electricity consumption, measured as the average consumption of one kilowatt over one hour.
LFP	Lithium iron phosphate	A common battery chemistry, which has become cheaper and safer, though heavier, than NMC.
MWh	Megawatt-hour	Larger unit of energy (1,000 kWh).
NACS	North American Charging Standard	Tesla's proprietary fast-charging standard, now widely adopted in the US.
NMC	Nickel manganese cobalt	A common battery chemistry with high energy density (and therefore lighter and smaller) but a higher fire risk than LFP.
OEM	Original Equipment Manufacturer	Vehicle or battery producer (e.g., BYD, Tesla, Bajaj, TVS).
SaaS	Software as a Service	Subscription software model (e.g., billing or fleet management systems).
SLAs	Service Level Agreements	Contracts defining service quality standards.
SoC	State of Charge	Measure of how full a battery is (e.g., 20% full).
SPV	Special Purpose Vehicle	A separate legal entity to own and manage shared assets (e.g., batteries).

GLOSSARY - Key technical terms

Term	Simple explanation
Battery-as-a-Service (BaaS)	A model where riders rent batteries instead of buying them, lowering upfront costs.
Battery casing / shell	The outer structure of a battery pack that determines size, fit, and durability.
Battery cycle life	The number of charge-discharge cycles a battery can go through before its capacity significantly drops, typically to 80%.
CAPEX	Spending on infrastructure expected to deliver value over time, such as swap stations, charging points, vehicles, or battery inventory.
Charging protocol	The agreed digital rules that govern how a battery and charger communicate (e.g., safety checks, battery temperature, charging voltage).
Communication protocol	The system that allows devices (bike, battery, station) to share information safely and consistently—most commonly the CAN bus protocol.
Converter (voltage)	Equipment that allows a station to serve batteries of different voltages (e.g., 48V and 72V).
Data APIs	Software "bridges" that allow platforms to exchange information securely and automatically.
Dual-voltage system	Infrastructure that can handle both 48V and 72V batteries, improving interoperability.
Form factor	The physical size, casing, weight, and shape of a battery. A battery that is too large for a swap cabinet will require retrofitting.
Plug-and-play	Hardware/software that works immediately without special setup or custom integration.
Swap station	A facility where riders exchange empty batteries for charged ones.
Utilisation rate	How much a station or asset is actually used compared to its capacity. May be measured slightly differently by different companies.
Voltage architecture (48V vs 72V)	The "power system" of a battery. 48V is slightly safer (common in Asia), while 72V provides higher torque for uneven/ hilly terrain.
Vertically integrated	A vertically integrated model where one company controls everything: vehicles, batteries, stations, and software.

Contents

Image: Chaji, Kenya 2024
Image (front cover): Mazi rider sits next to his electric bike, capturing a moment of calm and connection with the future of sustainable transport. Mazi Mobility. Nairobi, Kenya, 2023.

Why this report, why now?

PREO's role as a market shaper in e-mobility in sub-Saharan Africa

Since 2019, PREO has backed some of the earliest e-mobility enterprises in sub-Saharan Africa (SSA) with catalytic capital and technical assistance. The objective was not only to pilot technology, but to validate business models. Could commercial riders earn more from electric motorcycles (e-motorcycles) than from internal combustion engine (ICE) vehicles? Would operators adopt batteries that could be charged or swapped reliably under local grid conditions? Could these business models be scaled into enterprises that attract private capital, create jobs, and reduce emissions?

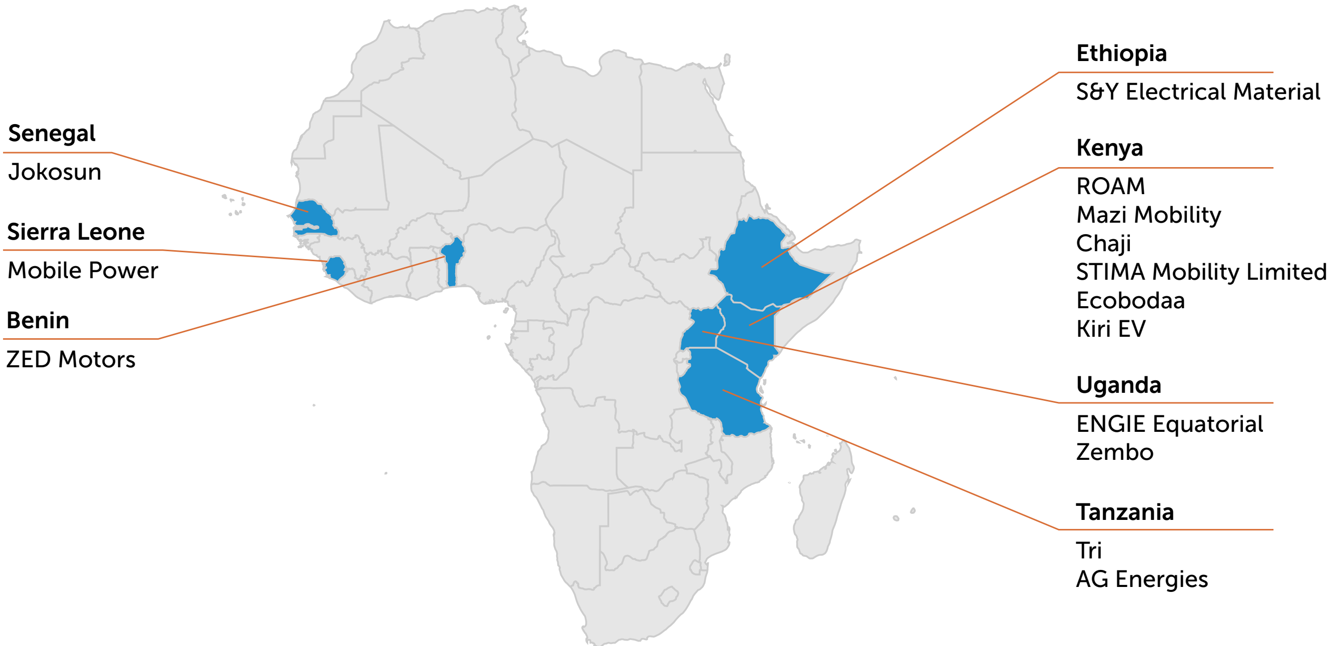


Figure 1 – Distribution of PREO E-mobility portfolio

Image (top): A Ugandan Boda rider gets exchanges for a fully charged battery with a franchise battery swap agent, Zembo. July 2025

The first wave of pilots gave clear signals. E-motorcycles performed well in local conditions, riders made the switch and, in some contexts, battery swapping proved scalable. These early results demonstrated the viability of investing in e-mobility as a private enterprise opportunity, not just as a technical experiment. They also showed that adaptations to local markets were critical: motorcycles had to be built for commercial use and rough road infrastructure, battery packs had to handle hot climates, fluctuating electricity supply and intensive usage, and business models had to reflect the economics of daily income earners.

From 2019 to 2022: Moving from concept validation to unboxing structural challenges

Between 2019 and 2022, PREO's portfolio companies progressed from proof-of-concept to early scaling. Roam in Kenya, MOPO in Sierra Leone, TRi in Tanzania and Zembo in Uganda each developed their own versions of the technology stack—covering mobility hardware, batteries, charging or swap capacity, and asset monitoring software. This approach was necessary at the pilot stage, but also revealed inefficiencies. Each operator sourced batteries independently. In one case, a company contacted over 100 suppliers, trialled samples, but still struggled to secure a reliable, high-quality partner. Without common specifications, prototyping timelines ranged from six months to two years, order volumes stayed low, and local operators lacked leverage with global suppliers.

A similar pattern emerged in infrastructure. Each company built swap or charging networks, but these were exclusive to their own users. The result was duplication of CAPEX, underutilised assets, and limited convenience for users. These experiences showed that while the concept of e-mobility had been proven, the path to scale risked being constrained by fragmented and siloed approaches.

Why interoperability? Why now?

PREO's approach to interoperability is driven by asking: where does it make sense, and under what conditions? Evidence from other markets provides useful context.

China

China's electric two-wheeler market, with a fleet of over 600 million vehicles, is shaped by government policy, commercial fleet demands, and technological standardisation.[1] Battery swapping has become the dominant model for commercial users like delivery and ride-hailing services, supported by companies such as Yadea, which has deployed thousands of swap stations nationwide. Government-led standardisation has enabled cross-OEM compatibility, fostering collaboration among manufacturers. However, personal-use vehicles—especially in smaller cities and rural areas—still rely on home or workplace charging, with proprietary systems remaining common due to a fragmented market and lack of universal standards. Overall, China's interoperability landscape is multi-layered, with commercial fleets benefiting from shared infrastructure while personal users face limited compatibility.

1 https://www.vynzresearch.com/automotive-transportation/china-electric-two-wheeler-market

India

In India, where personal-use motorcycles dominate, a majority (as much as 90%[2]) of electric two-wheelers are sold inclusive of batteries and home chargers. For personal users, over 70% [3] of all EV charging in India takes place at residences. Interoperability here is emerging instead in public charging networks (Bolt.Earth, Tata Power EZ Charge, Jio-bp Pulse, Ather Grid) that multiple OEMs can access. Sales to commercial users, such as delivery fleets, logistics operators, corporate fleet, among others, are dominated by the battery swapping model (or battery-as-a-service (BaaS)). These users require low CAPEX (30-40% cheaper without batteries), high utilisation (up to 200km/day) and cannot afford a long charging downtime. Interoperable models have significantly advanced in this segment with companies such as SUN Mobility and Yulu deploying BaaS at scale and partnering with multiple OEMs.

Taiwan

In Taiwan, Gogoro's battery swapping model is often cited as a success, but the conditions were unique: dense urban demand, government incentives, and alliances with major scooter OEMs. What appears to be interoperability was, in practice, closer to centralised standardisation under a dominant platform.

Sub-Saharan Africa

Across SSA, the commercial structure of the market in many countries makes interoperability particularly relevant in some areas, but not in others. Motorcycle taxis and delivery riders—the main users of e-motorcycles—are high-utilisation users who benefit from swapping models where batteries are owned by a third party. Charging interoperability, by contrast, is emerging gradually, but most private riders will still rely on home or workplace charging if and when individual consumer markets grow. It is also restrained by the costs of fast-charging infrastructure.

Our observation is that interoperability is not universal. It tends to take hold in places where commercial logic drives it—such as shared battery platforms, swap infrastructure, or open charging networks. Elsewhere, vertically integrated approaches may remain necessary until the ecosystem matures.

Scope and purpose of this report

This report builds on PREO's experience supporting e-mobility companies since 2019. Its purpose is not to prescribe a one-size-fits-all model, but to share grounded insights on:

- **Where interoperability has already emerged across PREO's portfolio;**
- **What business and technical conditions have enabled it; and**
- **How shared approaches can reduce duplication, improve capital efficiency, and support scale.**

2 Based on inference. As a proportion of total sales by companies that sell E-2W along with batteries and chargers.
3 Majority of E-2W users in India charge at home or private properties, with estimates up to 70%, based on industry commentary. Some references include Business Standard and EEPC India

Driving the need for shared systems: Lessons from full-stack pilots

Despite rapid progress, most of SSA's e-mobility companies still operate in isolation. Each has built its own stack of vehicles, batteries, charging or swapping stations, and billing systems. Between 2019 and 2022, this vertical integration was necessary to prove concepts: without it, there would have been no vehicles on the road. But as the sector moves beyond pilots, the cost of fragmentation is becoming more apparent—infrastructure is duplicated, supply chains remain inefficient, and riders face longer rides to infrastructure they can use.

Everyone built their own stack, now efficiencies are challenged

Early e-mobility companies had little choice but to control the full stack. The result today is a prevalence of proprietary systems. In cities such as Kampala, Nairobi, and Kigali, multiple operators run swapping stations, but each serves only its own riders. Our interviews suggest utilisation rates at some sites can fall as low as 20-30%, even as other operators invest in new stations—sometimes right next door. The same holds for batteries and monitoring platforms. Each company specifies its own form factor, connectors, and communication protocols. This ensures tight control but also locks out collaboration. Without the ability to share infrastructure, companies shoulder high CAPEX for assets that often remain underused.

A useful comparison comes from the traditional fuel market, where oil marketing companies frequently build petrol stations side by side on highways. Although this duplication is inefficient, it still allows open access—any vehicle can refuel at any pump. In contrast, duplication in e-mobility produces closed networks: a rider cannot use a neighbouring station unless it belongs to their operator. The inefficiency is compounded by the fact that the consumer gains no benefit from the parallel investment.

Image (top): Chaji charging station. Chaji. Kenya, 2025.

Swap station overlap and access in Kampala

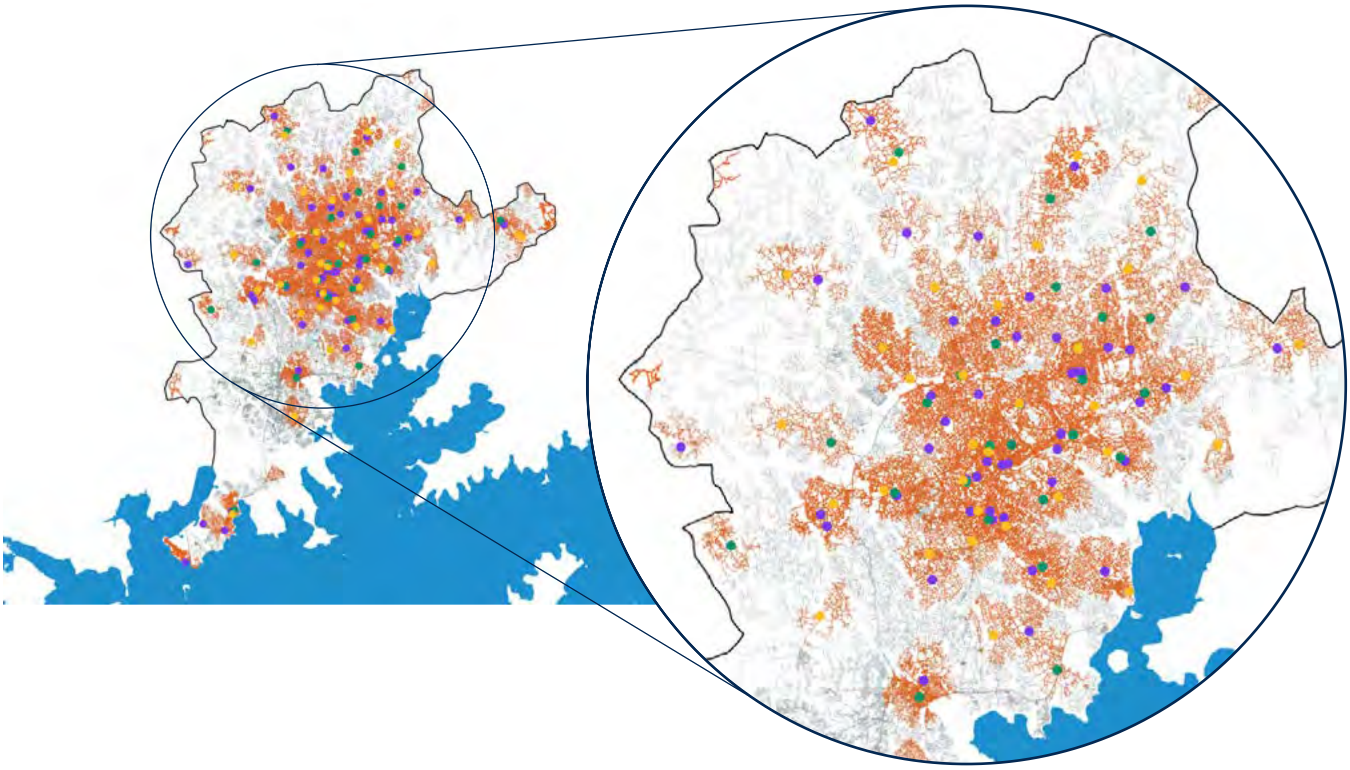


Figure 2 – Map showing locations within two kilometres of a swap station in Kampala, Uganda. Orange roads are within two kilometres of a swap station, gray roads are further than two kilometres. Different colour dots represent different swap networks. Large gaps remain, yet in many cases competing exclusive swap networks are within 500 meters of one another. Source: PREO analysis of public swap station maps of the three leading companies in Uganda.

Fragmented supply chains slow iteration and scale

Battery supply has proven to be a major bottleneck. SSA operators depend on Asian suppliers for battery packs and components, but because each company designs its own specification, order volumes typically remain too small to command attention. Several companies highlighted the difficulty of securing a consistent supply chain, with repeated trials failing to produce a reliable partner. Lead times for design changes routinely stretch from six to twelve months, and longer when including shipping. This fragmentation means the sector cannot benefit from collective bargaining or faster iteration. In some cases, companies may use identical voltage systems (48V or 72V) and even identical connectors (Chogori or Anderson, the plug types that link a battery to the bike or station). But small differences in battery casing (the outer shell size and shape) and communication protocols (the digital "language" batteries use to share information with bikes or stations) still prevent companies from pooling demand, even when the core technology is alike.

Duplication of capital, thin margins

Infrastructure investment is spread thinly across multiple proprietary networks. Each operator builds its own swap stations, backend software, and logistics, even within the same geography. With limited user bases, these assets struggle to reach breakeven. For investors, this duplication does more than slow growth—it raises the capital intensity of the entire sector, forcing each company to carry infrastructure costs that could otherwise be shared. The result is higher upfront capital requirements, longer payback periods, and weaker returns compared to shared models.

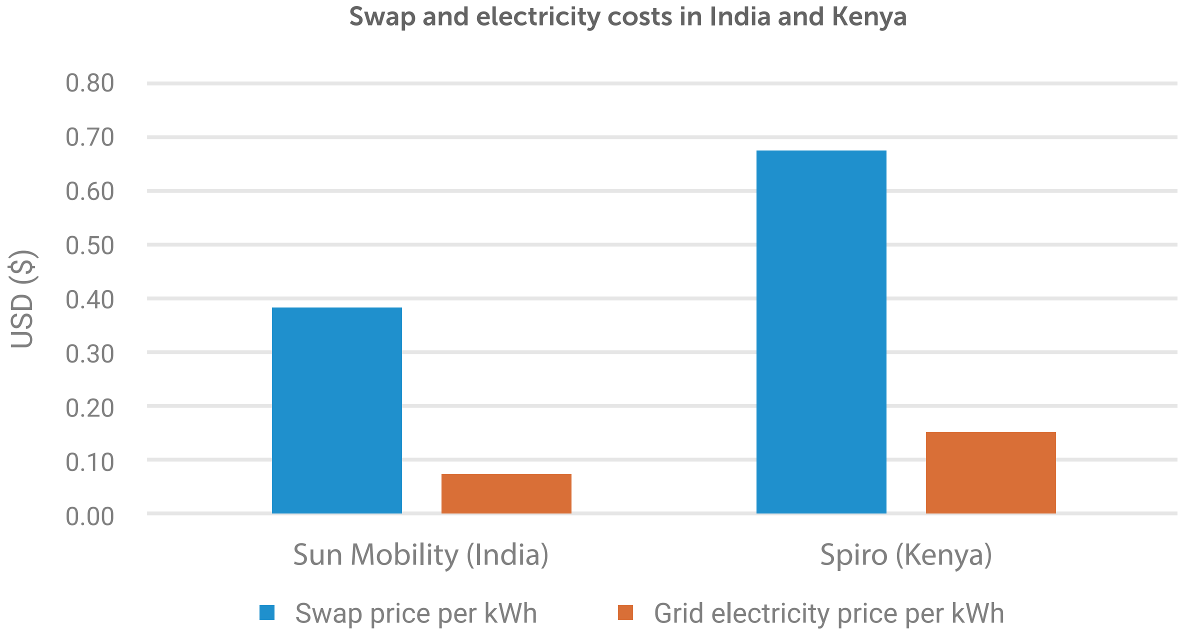


Figure 3 – Swap prices for Sun Mobility in India and Spiro in Kenya (without discounting for any factors such as cost of financing etc), per kWh. Source: PREO analysis and public documents.

The economic impacts spill over to riders. With fewer customers per station, companies must recover high capital costs from a narrow user base. This can translate into higher fees per swap or charge, which reduces the price advantage of switching from ICE motorcycles. For commercial riders—who are highly cost-sensitive—this is a material barrier to adoption.

User experience suffers

For riders, the lack of interoperability translates directly into reduced convenience. The most common complaint by ICE drivers considering switching to electric is the comparative lack of swap or charging stations; yet an e-motorcycle rider may pass several stations in the city in their search for a battery swap. Unfortunately, they can only use the one operated by their provider. When their own station is offline or lacks fully charged batteries, they have no alternative—even if another operator has capacity nearby. This is not just an inconvenience; for commercial riders whose earnings depend on time on the road, detours or waiting for stations to come back online can mean a tangible loss of income. Across Kigali, Kampala and Nairobi, the average e-motorcycle rider is between 3 to 5 km from a swap station that they can use—but are only 2.3 km from *any* swap station. This means riders could save 43% on the energy and time they use just to reach a swap station, if they were able to swap at any station and not just their own.

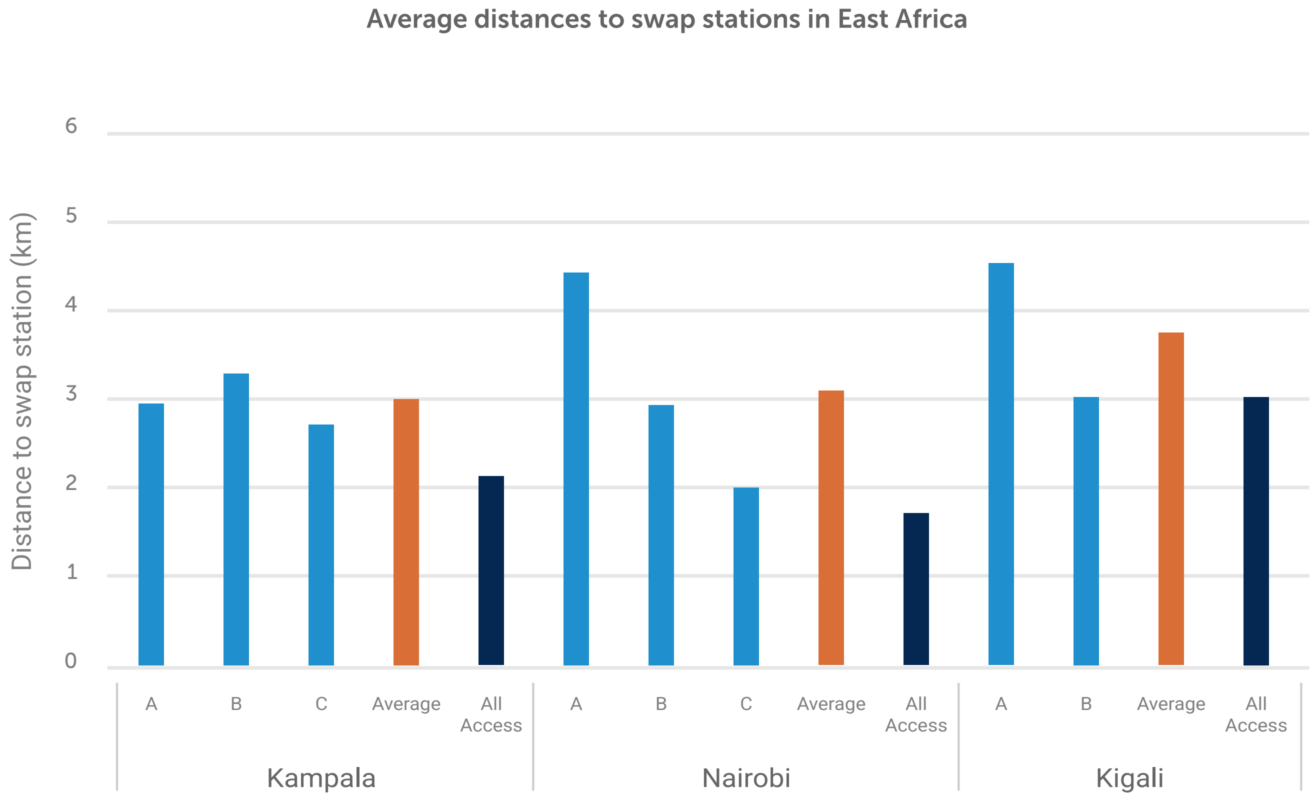
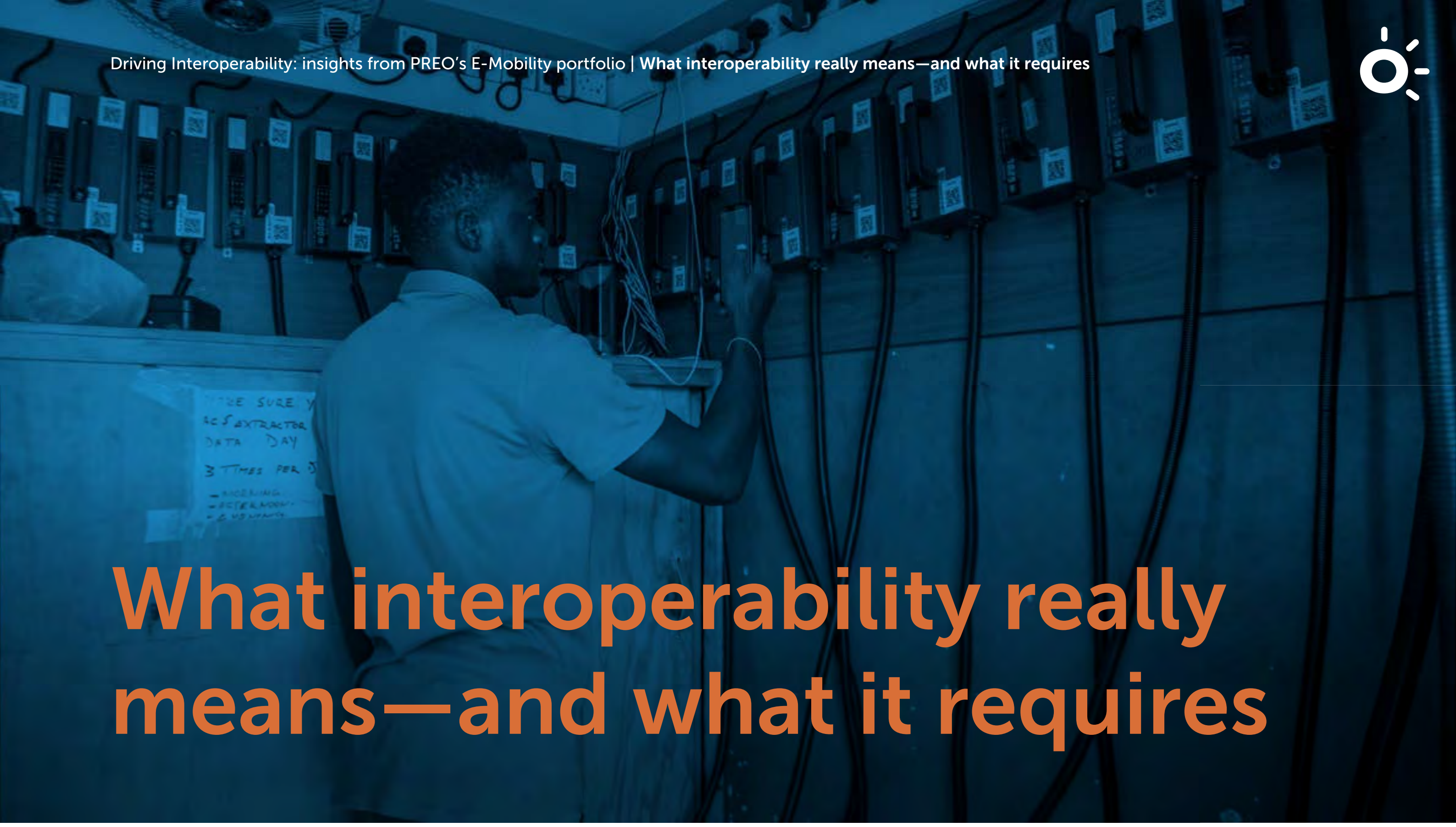


Figure 4 – Average distances to exclusive swap stations in Kampala, Kigali, and Nairobi for leading swap networks in each city, i.e. E2W drivers using a Company A motorcycle in Kampala are on average 3 km from the nearest Company A swap station. All access represents average distance to any swap station, i.e., in a standardised scenario where an E2W rider can use any swap station in Kampala, a rider would be on average 2.1 km from a station. Source: PREO analysis of top 3 swap networks serving over 1,000 motorcycles..

Payment systems add another layer of complexity. While most operators bill per kilowatt-hour (kWh), some new entrants and international players charge a flat rate per swap, or a subscription fee. Swap prices are often not publicly available, and changes in pricing can feel opaque. During our interviews, riders told us that these differences make it difficult to compare costs across providers, and that sudden changes in billing formats undermine trust. One interviewee described how even small differences in pricing units led to confusion about whether the service was saving them money compared to petrol.

Riders increasingly acknowledge that EVs are cheaper to run than petrol motorcycles. Yet they also note that the lack of flexibility in charging or swapping creates daily stress. In some cases, small-scale protests have occurred following sudden price increases. Riders cannot always plan their shifts with certainty. For an industry where trust, predictability, and convenience are critical to uptake, these frictions slow adoption.



What interoperability really means—and what it requires

The previous section described how full-stack pilots across SSA established viability for a business case but also created duplication of assets, supply chain inefficiencies, and user frictions. These observations raise an important question: If shared systems are to play a role, what would they actually require?

A spectrum of system compatibility

Fragmentation	Interoperability	Standardisation
• Proprietary system • No shared infrastructure • Company-by-company duplication	• Interface-level negotiated alignment • Shared plug types, voltage, protocols • Use case-driven agreements	• Full spec-converged • Use case-wide adoption
Eg. Early SSA E-2W players	Eg. Mazi Mobility, Chaji	Eg. STIMA, CHAdeMO

Figure 5 – Interoperability sits between two poles. In a fragmented ecosystem, each company builds fully proprietary systems: their own battery, vehicle, and infrastructure, with no cross-use possible. At the other, full standardisation ensures everyone adopts identical battery and interface specifications, enforced either by regulation or by monopolisation. Most real-world markets fall somewhere in between.

Photo (top): Ssenyondo station attendant. Zembo. Kampala, Uganda. 2025.

Examples from outside Africa illustrate this spectrum

In global four-wheeler markets, three fast-charging standards compete—CHAdeMO (Japan), CCS (Europe/US), and the NACS / Tesla standard (US). Instead of following one standard or the other, charge stations have, however, adapted to host multiple options. This can mean dual plugs (separate physical sockets) or multi-protocol software (software that communicates in more than one 'charging language'). This kind of coexistence represents a practical form of interoperability. It allows users to access charging more easily and helps infrastructure achieve higher utilisation, without requiring full convergence on a single standard.

In India, the Bharat Charging Alliance endorsed two standards: Type 6 for DC fast charging and Type 7 for combined AC + DC charging. This endorsement gives the industry a common reference point, but it does not ensure full compatibility. Interoperability still requires negotiation at the implementation level. Vehicle OEMs and charging providers have signed on one-by-one and, while India has moved towards Type 6 chargers, alternatives are still in use.

At the other end of the spectrum is Taiwan's Gogoro. Gogoro developed its own battery standard and swap cabinet early on, along with several two-wheelers compatible with its batteries. After gaining an early lead, Gogoro developed partnerships with multiple OEMs (e.g., Yamaha, Yadea, Aeon) which use the company's batteries and swap network, creating standardisation driven by a dominant platform. Gogoro sets the specifications and others align around it.

By contrast, India's Sun Mobility built a similar battery-and-cabinet system but positioned itself from the outset as a neutral infrastructure provider. It does not compete in vehicle manufacturing. Instead, it partners with multiple OEMs, offering BaaS that reduces upfront cost for riders and allows diverse vehicle brands to plug into the same shared backbone. This is platform-level interoperability: one system deliberately designed to aggregate demand across many OEMs, not to enforce a single winner.

The lesson for SSA is clear.

Standardisation is top-down

Everyone is required—or compelled by dominance—to adopt one identical design. It can accelerate uniformity but risks freezing innovation too early.

Interoperability is bottom-up

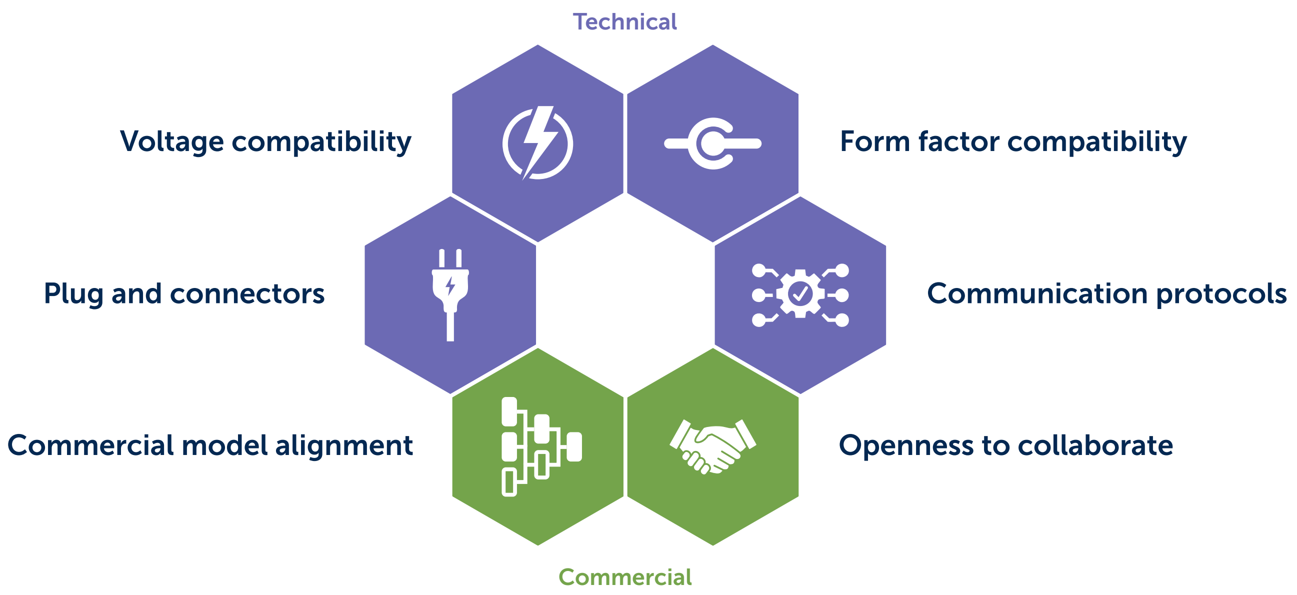
Systems remain different but are designed to work together. This can happen at the interface level (e.g., multi-plug charging stations) or at the platform level (e.g., Sun Mobility's shared battery system).

Why does this distinction matter?

This is important because, if market players wait for full standardisation, expecting regulators to intervene or a single winner to emerge, progress could be delayed or stalled. Interoperability offers a more flexible pathway: companies can continue innovating in vehicles, batteries, and business models, while collaborating at the points where shared systems cut costs, improve rider convenience, and make investment more attractive.

The six building blocks of interoperability

Interoperability depends on alignment at key interfaces. These are the foundations that allow different systems to work together without requiring full standardisation. PREO's experience highlights six essential building blocks—four technical and two commercial—that support shared use.



1

TECHNICAL

Voltage compatibility

Most e-motorcycles in SSA today use either 48V or 72V systems. Voltage compatibility is a fundamental building block: networks that can bridge 48V and 72V through converters or dual-voltage systems help lower costs for station operators and give battery suppliers greater confidence to scale production.

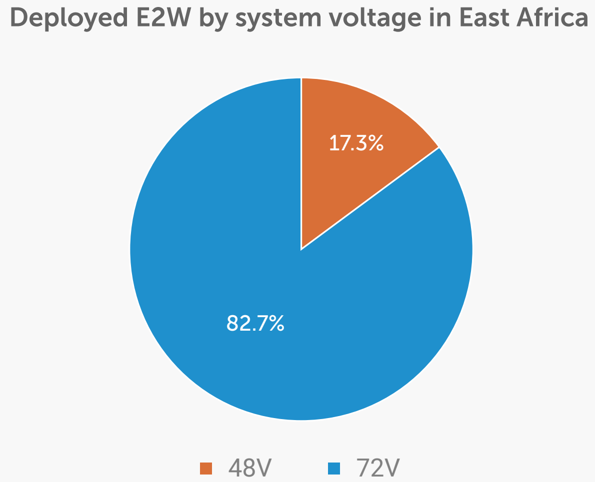


Figure 6 – The share of e-motorcycles using 48V and 72V infrastructure from the six largest providers in East Africa. Source: PREO analysis.

2

TECHNICAL

Plugs and connectors

Different motorcycle manufacturers (OEMs) use different power connectors (the plugs that link a battery to the bike or charging station). In SSA, the most common are Chogori and Anderson. Some companies, such as MOPO and Zeno, have introduced plugless designs and have deployed several stations in Kenya since January 2025. Plug and connector design is therefore a key building block: interoperability can be achieved through dual ports, physical adapters, or swappable plugs at the station. While making batteries directly compatible with motorcycles is harder—since there is limited space to add extra connectors—stations that support multiple plug types can expand access and utilisation across brands.

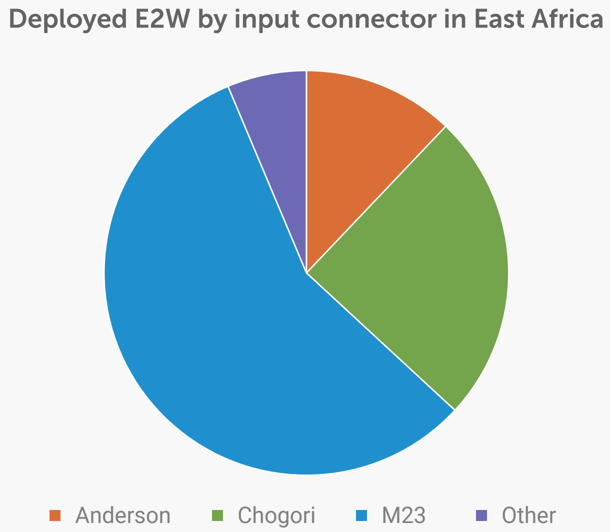


Figure 7 – The share of e-motorcycles using various input connector types from the six largest providers in East Africa. Note at least one brand uses different connectors for charging and motorcycle usage. Source: PREO analysis.

3

TECHNICAL

Communication protocols

Batteries share key information with vehicles and stations—such as state of charge (SoC, how full the battery is), temperature, and safety warnings—through communication protocols. Most African e-motorcycle companies use CAN bus (a standard digital "language" for vehicles) to exchange this data. But each manufacturer codes the data differently, so the system has to be decoded before it can be used. For this reason, any partnership between a motorcycle maker and a battery provider requires access to the CAN bus protocol. Because the protocol gives access to a wide range of control functions and sensitive data, these arrangements are usually negotiated one by one—or set through closed consortium agreements—rather than through open, universal standards.

4

TECHNICAL

Form factor compatibility

The physical dimensions of batteries—casing size, weight, handle orientation, and mounting points—are a core building block for interoperability. When dimensions align, batteries can be shared across bikes and stations with minimal modification. One operator noted that even a few centimetres' difference forced them to redesign a swap cabinet three times, highlighting the importance of early convergence on form factors. Establishing practical common dimensions, or designing modular stations that can accommodate variation, reduces hidden costs and makes shared systems far easier to scale.

5

COMMERCIAL

Commercial model alignment

Interoperability is only sustainable when business models can work together. Agreeing on how to share revenues requires transparency around battery cycle life, product quality, financing costs, and utilisation data. Allocating scarce chargers or station space also depends on shared information about rider density and demand patterns. Clear rules on liability—such as in the case of battery fires—are another foundation. Interviews showed that partnerships are most viable when operators can reconcile revenue splits and space allocation upfront. Establishing practical, trusted mechanisms for cost and risk sharing is therefore a critical building block for interoperability.

6

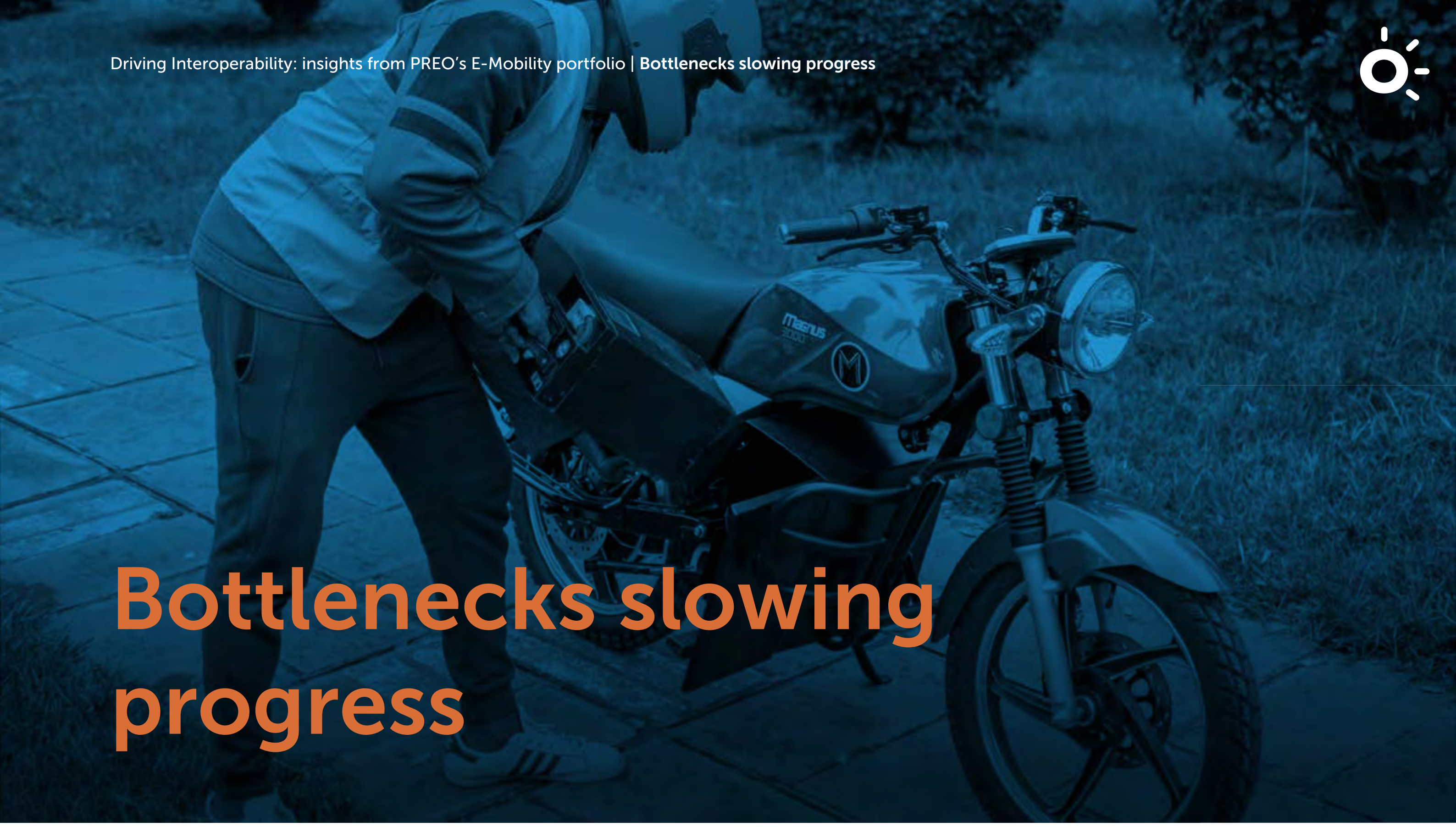
COMMERCIAL

Openness to collaborate

A final building block is the willingness of companies to open their systems. Collaboration is only possible when operators are prepared to share specifications, publish APIs, or participate in neutral governance structures. Trust is central: without it, technical compatibility alone will not lead to shared use. Interviews underscored that operators often want their format to dominate, but also recognise that neutral third-party platforms can provide the safeguards needed to make collaboration viable. Building this openness is therefore essential to unlocking interoperability.

Reflection

These six building blocks show that interoperability is not just a matter of technical design; it is equally about commercial alignment and willingness to cooperate. The experience of India, Taiwan, and global EV markets illustrates that interoperability can take many forms: coexistence of standards, platform-led dominance, or negotiated arrangement. Interviews conducted by PREO confirm that alignment will not happen automatically but also suggest that precisely where gaps exist - between voltage bands, or in willingness to share - there is an opportunity for new approaches. Building even partial compatibility around these foundations can reduce duplication, improve utilisation, and create conditions for scale.



Bottlenecks slowing progress

Despite clear technical feasibility and early traction, six systemic bottlenecks continue to inhibit interoperability at scale, linked to the building blocks described above.

The "Gogoro Syndrome" and limited collaboration

SSA's e-mobility ecosystem suffers from what could be called the "Gogoro Syndrome"—where many startups aspire to become the dominant battery-swapping network. However, this creates fragmentation, as multiple companies attempt to build mutually exclusive networks, despite most lacking the capital to achieve Gogoro-like dominance.

Beyond platform ambitions, operators worry about diluting their brand if they share space with competitors, fearing loss of customer relationships they view as critical for future value creation. Shared infrastructure requires coordination on operational standards and service quality-areas where companies currently differentiate themselves.

The challenge is compounded by tensions over battery data access. Battery-station interoperability requires station operators to have significant battery data access to mitigate fire risk, yet battery data can also reveal the battery owner's or manager's proprietary battery management techniques.

The result is a sector where companies are simultaneously too small to scale meaningfully on their own, and too afraid of losing competitive advantage to collaborate effectively.

Dual-voltage fragmentation (48V vs 72V)

SSA's e-mobility sector is divided between two competing voltage architectures, creating technical and economic barriers to interoperability. Around 85% of E-2Ws in East Africa operate on 72V systems, which provide better torque for the region's challenging terrain—particularly the steep hills of cities like Kigali and Kampala.[4] However, this puts most African networks at odds with Asian standards, where dominant players like Gogoro and Sun Mobility (which has recently expanded to Kenya) use 48V systems.

4 PREO in-house analysis, based on ten biggest E2W fleets in East Africa.

Image: Mazi rider swaps a depleted battery for a fully charged one. Mazi Mobility. Nairobi, Kenya, 2023

This fragmentation adds significant complexity to interoperability efforts. Supporting dual voltage requires either expensive converters at the charger level or separate charging infrastructure, potentially doubling CAPEX requirements.

Over investment in swap networks can lead to underutilised infrastructure

Drivers' demands for high swap station density and reach pushes companies to invest heavily in infrastructure buildout. However, this infrastructure-first approach results in underutilised stations that strain finances. One major operator described its utilisation following an exponential curve—a few high-traffic urban stations carry most volume while many peripheral stations operate well below capacity.

Infrastructure choices shape this challenge. While automated cabinets offer better security, they create operational inflexibility, as the CAPEX needed for charging slots is higher. Furthermore, once the existing battery slots are all used an additional cabinet is needed, which can cost around US$3,000-$4,000 without batteries. Without shared utilisation, each operator bears full infrastructure cost while serving only their own captive fleet.

This utilisation problem is exacerbated by scale mismatches. Large motorcycle OEMs find insufficient value in partnerships with small networks.

Scale disparity manifests in different operational priorities and timelines. Large networks optimise utilisation across established routes and can build ahead of demand, trading short-term inefficiency for longer-term dominance. In contrast, smaller operators must achieve profitability quickly. Even when companies express collaboration interest, their growth trajectories can prove incompatible.

Commercial model misalignment

Revenue sharing requires a high level of openness about the costs of battery swapping and partners' margins. One operator detailed the economic challenge, estimating that if they were to charge other companies' batteries using their battery swap network, they would need to charge up to 90% of the revenue generated to cover the costs to cover the costs including people, security, rent, electricity, and transfers. However, one currently operating partnership has a more even revenue share of around 60%/40% for network and battery owner, indicating room for flexible arrangements.[5]

This economic reality reflects deeper structural issues in the sector. Companies charge around US$0.65 per kWh but struggle with high operational costs[6]. If parties are still operating at a loss, there is simply insufficient economic surplus to share. Trust becomes particularly challenging, because transparent cost-sharing requires revealing sensitive information to potential competitors; it must also address issues like battery degradation, maintenance responsibilities, peak/off-peak pricing, and demand risk allocation.

Revenue-sharing also becomes very difficult when operators use subscription models or flat rate swaps, which don't evenly account for energy usage or battery degradation.

5 Interviews with multiple operators in East Africa.
6 PREO in-house analysis based on ten largest E2W networks in East Africa

Baked in form factors

Physical battery compatibility represents one of the most intractable barriers to interoperability because form factor decisions are physically built into both vehicles and charging infrastructure. Slot-style cabinets—such as those offered by companies like Zeno or Sun Mobility—leave almost no room for accepting different battery sizes and shapes. Plug-in cabinets, such as those in use by Mazi, Spiro, and Arc Ride, provide more space for different form factors but still have hard limits. Shelving solutions offer more flexibility along form factor lines but have higher OPEX costs due to labour and rental expenses.

Motorcycle-battery compatibility is equally challenging. As one operator noted, fixing the battery mount compatibility between their own V1 and V2 battery generations required about 2 hours of metalwork for each motorcycle. It doesn't cut equally each way: if the motorcycle battery mount is larger than the battery, it's easier to adjust other companies' battery mounts. If the battery is too big for the motorcycle battery mount, it can raise more challenging design issues. Solving this requires a complex technical negotiation that must be resolved before any hardware is retrofitted or deployed.

> "At Roam, we strongly believe in open charging infrastructure. That means finding the right charging protocol and charging formats for all the players."
>
> **- Romain Petiteau, Director of Energy & Charging Systems, Roam**

Image: Roam, e-bike warehouse, Kenya, 2023.

Charging for all—if it's fast enough

While most e-motorcycles in East Africa have been deployed on battery-swapping platforms, charging-focused players such as Roam and CHAJI focus on e-motorcycles with rider-owned batteries that can be charged from any socket.

Socket-based charging in East Africa is typically limited to around 1 kW charging speed, meaning a battery will take 2-3 hours to charge fully, a major inconvenience for working users. One potential solution is fast charging for motorcycles, enabled by the Type 6 charger. While a 6 kW Type 6 charger—which would allow for charging most batteries within 30 minutes—can be around US$1,000 pre-tax from retailers, the price can drop to US$800 when sourced from OEMs. However, it requires BMS and cooling systems that can handle higher charging speeds. So, while public charging may appear to offer "truer" interoperability than locked-in swap networks, it still faces the same challenge: fast recharging comes at a cost.

PREO's strategic drive: Building interoperability in e-mobility

As PREO's early portfolio companies scaled, recurring patterns began to emerge. Operators were duplicating infrastructure in the same cities, each with its own batteries, stations, and software. Supply chains were strained by small, bespoke orders to Asian suppliers. Riders benefited from lower running costs but faced limited coverage and incompatible systems. These were not individual company problems—they were structural signs that the sector was locked into high-cost growth.

PREO's response was to add complementarity to its investment thesis. In addition to focusing only on exclusive network operators, PREO began to back business models that could enable shared use and cross-brand compatibility. This involved supporting companies like **Mazi Mobility**, whose swap stations are designed for multiple OEMs; **AG Energies**, which is developing one battery format usable in both 2- and 3-wheelers; **CHAJI**, building open-access charging points; **STIMA**, which is piloting neutral battery ownership through a Special Purpose Vehicle (SPV)—that is, a separate legal entity to own and manage shared assets (e.g., batteries); and **Ecobodaa**, which offers SaaS billing systems that work across brands.

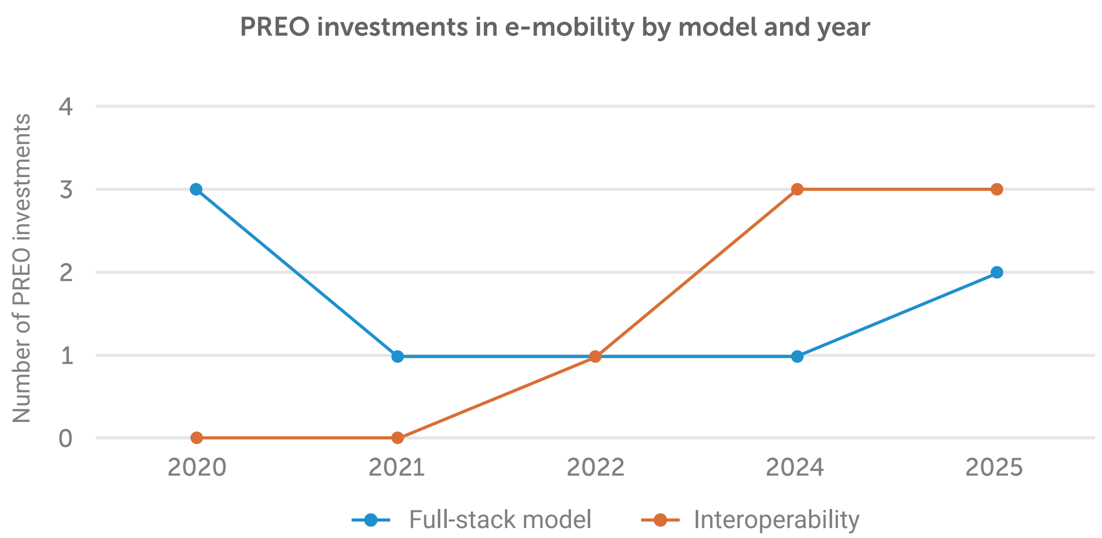


Figure 8 – Breakup of PREO e-mobility investments: Full-stack vs Interoperability. Source: PREO analysis.

Image (top): Battery swap. Ecobodaa, Kenya, 2023, PREO

These were early tests of whether shared platforms could reduce duplication and improve utilisation. PREO was not looking for universal standards, but for context-specific opportunities that could make business models more efficient. Today, PREO applies a practical lens when assessing new opportunities:

- **Does shared use improve capital efficiency and utilisation?**
- **Can billing models and commercial arrangements be aligned?**
- **Who owns and governs shared assets in a way that builds trust?**
- **Will the model unlock private investment, job creation, and emissions reductions?**

In some contexts, closed systems will continue to dominate. But where the commercial case is strong, where utilisation is high, and where capital costs can be pooled, PREO sees interoperability as an important enabler of scale.

Image: A local technician performs repairs on an electric motorcycle, Zembo. July 2025.

Interoperability in action

Case studies from the PREO portfolio

This section profiles five companies from the PREO portfolio, each demonstrating a unique approach to interoperability in East Africa's e-mobility sector.

Mazi Mobility	Interoperable ***infrastructure***: One station for many
AG Energies	Interoperable ***batteries***: One battery across vehicle formats
CHAJI	Interoperable ***charging***: One plug for many
STIMA Mobility	Interoperable ***battery ownership***: One asset base for many OEMs
Ecobodaa	Interoperable ***software***: One energy sales platform for many

Image: Ecobodaa, Kitengela Swap Station, Kenya, 2023.

CASE STUDY

Mazi Mobility

Kenya

Interoperable infrastructure: One station for many

Mazi Mobility began as a traditional vertically-integrated battery swapping company in 2021, developing its own proprietary batteries, vehicles, and charging infrastructure. However, by early 2024, Mazi recognised that the exclusive model was capital-intensive and limited scale potential. With only a handful of stations serving its own small fleet, Mazi faced the same challenge plaguing the broader Kenyan e-mobility sector: underutilised infrastructure and slow network growth. Rather than continue building for a single brand, Mazi made the strategic decision to pivot into a platform play—opening its stations to serve multiple E-2W operators and positioning the company as neutral infrastructure rather than a competing OEM.

Tackling underutilised infrastructure and unlocking scale through a shared battery swap network for e-motorcycles

Rather than building proprietary infrastructure tied to a single manufacturer, Mazi operates as an infrastructure platform that aggregates demand across multiple OEMs including eWaka, Ecobodaa (via Transboda and Kiri), Waya, Roam, and Tankvolt (Transsion).

Image (top): Mazi rider sits next to his electric bike, capturing a moment of calm and connection with the future of sustainable transport. Mazi Mobility. Nairobi, Kenya, 2023. Image (below): a Mazi Mobility e-bike. Nairobi, Kenya, 2023.

This platform approach enables significantly higher station utilisation rates, faster network expansion, and lower per-unit infrastructure costs compared to the capital-intensive, single-brand models that have struggled to achieve viable scale. Critically, Mazi also enables international OEMs such as Transsion which is not interested in operating swapping infrastructure itself but has the financial clout and technical expertise to rapidly scale quality products. By serving as the shared backbone for multiple e-motorcycle operators, Mazi transforms swap stations from brand-specific assets into multi-use infrastructure that can support the entire ecosystem's growth.

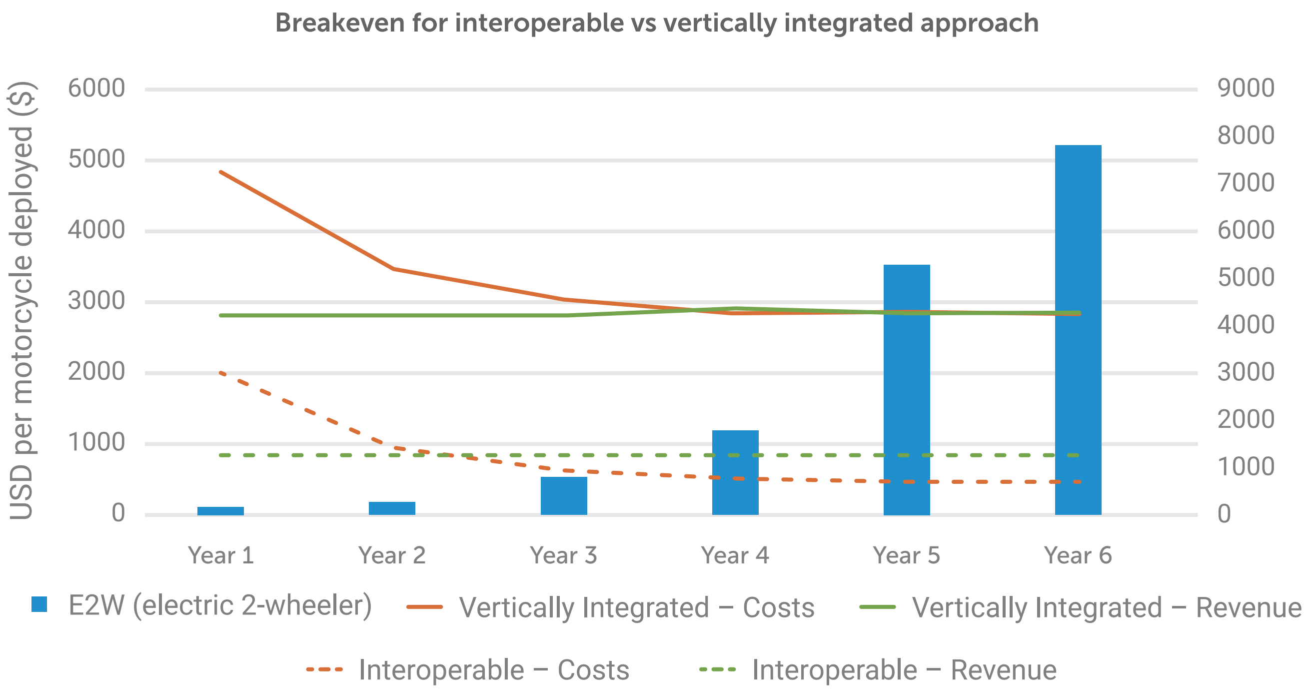


Figure 9 – With significantly lower capital costs per motorcycle, Mazi's interoperable model can breakeven in around 30 months, where a vertically-integrated model would take roughly 42 months. Source: PREO & Mazi Mobility analysis.

Mazi's interoperability approach is built around three key technical adaptations

First, physical compatibility through modular charging slots that accommodate different battery form factors and mounting systems—from eWaka's compact designs to Waya's larger connector systems. Second, voltage flexibility via cloud-controlled chargers that can serve demand from different voltage requirements (48V, 72V, and higher) depending on the battery detected. Third, protocol integration using its proprietary Mazi charging protocol that can interface with various battery management systems (BMS) to ensure safe charging cycles across brands.

Mazi has evolved from focusing solely on automated cabinet-based stations (costing around US$4,000 per unit) to adding more quick-to-deploy and lower CAPEX manual stations using standardised shelving with IoT-enabled distribution boards. This pivot allows faster expansion with ready-to-go partners while maintaining cross-brand compatibility through adaptable connector systems and real-time monitoring, drastically bringing down the scale needed to break even, from a projected network of nearly 6,000 e-motorcycles to just over 400. Put another way, with the same capital that would enable a fleet of 100 e-motorcycles on a vertically integrated network, Mazi is able to serve 765 e-motorcycles.

Image: Mazi rider fixes the battery connector during a swap, ensuring a secure connection for smooth and reliable electric mobility. Mazi Mobility. Nairobi, Kenya, 2023.

A business model that demonstrates both the promise and complexity of interoperable infrastructure

Allocating battery swap revenue requires clear and transparent discussions with partners, in order to ensure that all individual costs—battery amortisation, station operation, maintenance, and more—are covered. In addition, distribution challenges can arise when riders from one network concentrate at specific stations at certain times of day, requiring live coordination with network partners and an honest assessment of the battery stock required to serve the relevant fleet.

The technical integration process requires bilateral coordination with each OEM. For instance, while Mazi's chargers can charge multiple battery types, some manufacturers prefer having their batteries only charged on proprietary chargers—a software restriction rather than a technical limitation.

Key insights

Swap stations represent the most retrofit-friendly layer for interoperability, but success requires more than technical compatibility. Mazi's experience reveals that operational alignment is equally critical—from revenue-sharing agreements to battery distribution protocols and partner willingness to open their systems.

The company's evolution from exclusively automated stations to a hybrid manual/automated model shows how interoperability demands can drive innovation in deployment strategies. By the end of 2025, Mazi expects to operate over 30 stations serving 1,000+ bikes across multiple brands—demonstrating that shared infrastructure can achieve the scale that individual companies struggle to reach alone.

Most significantly, Mazi's partnerships highlight the 'interface-level' nature of practical interoperability: rather than requiring complete standardisation, it creates compatibility through adaptable connectors, flexible protocols, and negotiated commercial arrangements that benefit all parties.

CASE STUDY

AG Energies

Tanzania

Interoperable batteries: One battery across vehicle formats

AG Energies is a Tanzanian renewable energy company founded in 2015, specialising in solar solutions and clean technology implementation across East Africa. Based in Dar es Salaam, the company has established itself as a leading provider of solar installations for commercial and residential clients, with projects spanning Tanzania, Uganda, Kenya, Rwanda, Zambia and Burundi. In 2024, AG Energies expanded into electric mobility as part of its broader clean energy portfolio, positioning itself to address Tanzania's growing urban transportation challenges while leveraging its existing expertise in battery technology and energy systems.

Figure 9 – AG Energies e-motorcycle by an AG Energies swap cabinet. Source: AG Energies.

Building a smart, standardised battery swap network along key routes in Dar es Salaam

A unified battery swapping ecosystem featuring standardised 72V/44Ah LFP batteries is being developed to serve both two-wheeler and three-wheeler platforms, supported by strategically located swap stations along four key transport routes radiating from Dar es Salaam's city centre. The system leverages partnerships with TotalEnergies to co-locate swap infrastructure at existing fuel stations, using 12-slot charging cabinets and incorporating GPS tracking, QR code identification, and CAN bus communication protocols. AG Energies has also established an assembly line for both vehicle types to qualify for Tanzania's CKD import duty exemptions, while developing specialised protocols to ensure proper battery pairing for three-wheelers, where batteries must operate in parallel to maintain accurate charge readings.

Image (top): AG Energies Swap Station, Uhuru, Kenya, 2025. PREO

AG Energies' interoperability strategy is centred on cross-vehicle segment compatibility rather than cross-brand standardisation

The company developed a unified 72V voltage architecture that supports both motorcycle and tricycle applications through form factor design and operational protocols. Initially considering separate battery specifications—a 72V/44Ah unit for two-wheelers and a 72V/88Ah system for three-wheelers—AG Energies recognised that dual inventory would create operational inefficiencies and limit station utilisation.

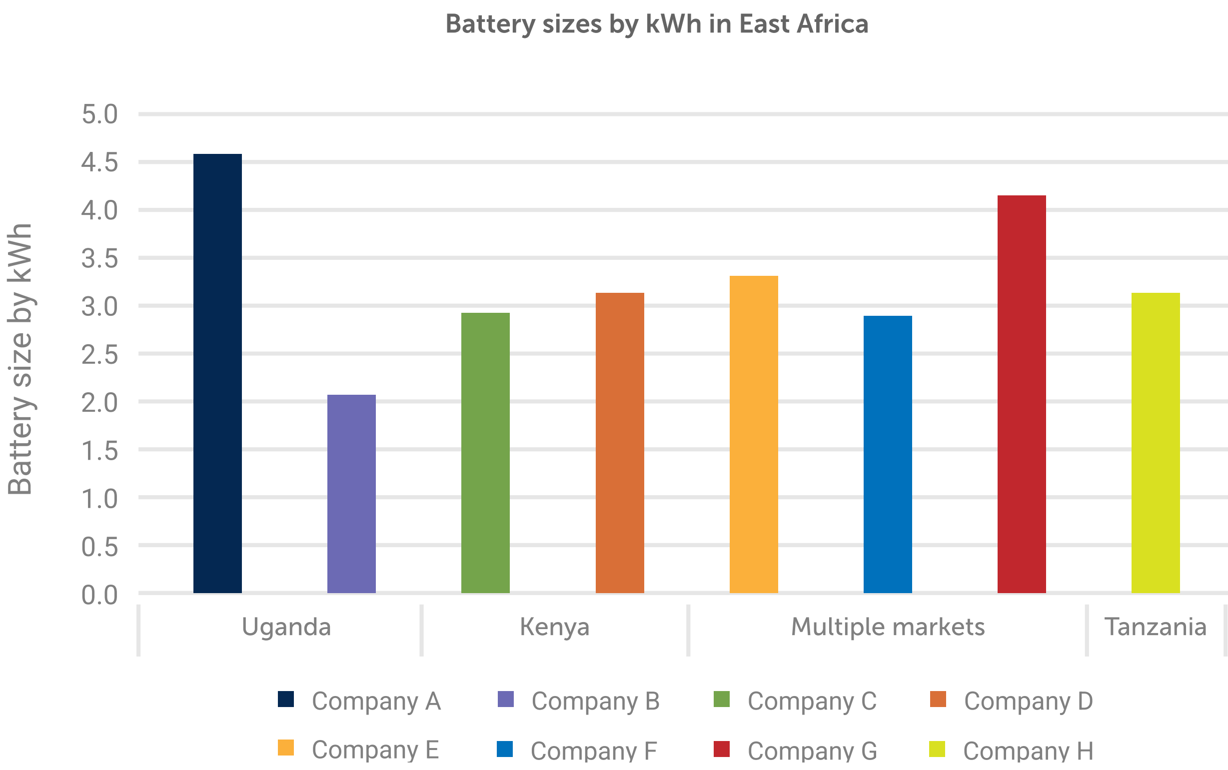


Figure 10 – AG Energies battery, which services both E2W and E3W, strikes a balance between larger batteries which are either heavier or use the less safe NMC chemistry, and smaller batteries which provide insufficient range. Source: PREO analysis of seven leading companies and AG Energies.

The company's solution maintains voltage consistency while addressing the different power requirements through battery pairing protocols. For three-wheelers with higher power demand, the system deploys batteries in parallel configurations, ensuring that paired batteries maintain consistent state-of-health readings and accurate state-of-charge calculations. This approach creates a one-way interoperability pathway where batteries can migrate from two-wheeler to three-wheeler service but cannot return to motorcycle applications once they have been used in tricycles. The technical architecture incorporates modular casing designs that accommodate different vehicle mounting points and connection interfaces. Each battery integrates comprehensive battery management system communication, enabling seamless data exchange across both vehicle categories. The standardised form factor ensures that charging cabinets can accommodate mixed inventory while maintaining operational simplicity.

AG Energies predicts two-wheelers to comprise 90% of swap demand, with three-wheelers more prevalent in the downtown ferry corridor

This distribution reflects both the larger addressable market for motorcycle taxis and the competitive pressure from CNG-powered three-wheelers in passenger transport.

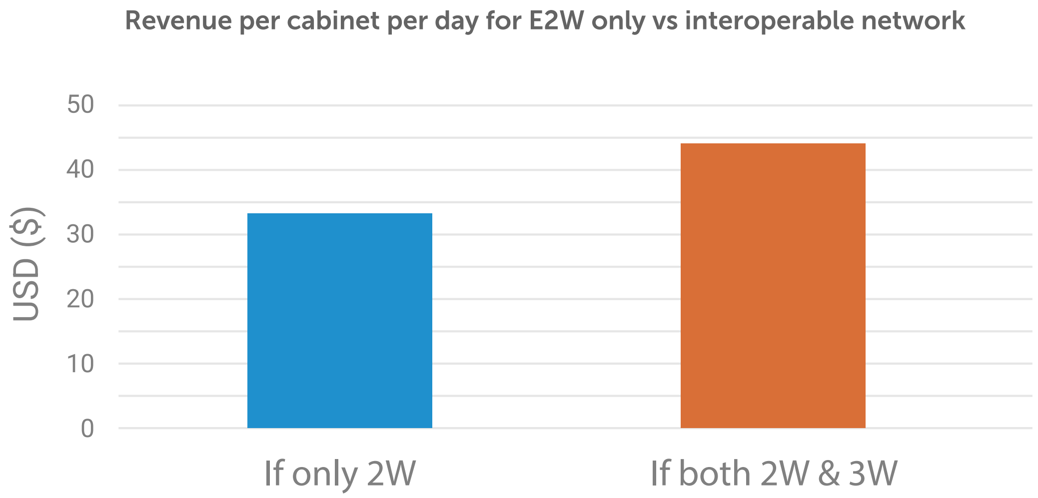


Figure 11 – By providing battery swapping to three-wheelers in addition to two-wheelers, AG Energies can increase the cabinet utilisation by 36%. Source: PREO & AG Energies analysis.

The company's battery swapping stations are being deployed along four strategic axes radiating from Dar es Salaam's city centre, in partnership with TotalEnergies. This approach leverages existing fuel station infrastructure while ensuring coverage of the city's primary transportation corridors. Each charging cabinet holds 11 batteries and is designed to accommodate the mixed-use requirements of both vehicle categories.

Key insights

Batteries that can serve both 2W and 3W offer a path to volume aggregation and improved station utilisation but require careful form factor alignment and operational protocols at the outset. AG Energies' experience shows that interoperability is most viable when designed into the system architecture from the beginning, rather than retrofitted across existing proprietary platforms.

The company's mixed-use battery approach addresses a fundamental challenge in SSA: achieving sufficient transaction volume to justify charging infrastructure investments. By serving both motorcycle and tricycle segments through a unified battery platform, AG Energies can capture a broader customer base while maintaining operational simplicity and cost efficiency.

CASE STUDY

CHAJI Kenya

Interoperable charging: One plug for many

CHAJI is a Kenyan energy and charging solutions company that has pioneered accessible electric vehicle charging solutions across East Africa. The company began by addressing the fundamental challenge of energy access for electric mobility through simple, user-friendly charging stations that could serve any electric vehicle with a standard wall socket. CHAJI's approach has since evolved from basic IoT wall socket charging units to advanced fast-charging infrastructure designed for cross-brand compatibility. Today, CHAJI operates across Kenya and Uganda with significant traction, having facilitated over 25,000 charging sessions and delivered more than 29 MWh of clean energy through its interoperable network.

Figure 12 – CHAJI provides the only public charging available for e-tuktuks in Mombasa, Kenya. Source: CHAJI.

A plug-in charging network powering vehicles, devices and livelihoods

CHAJI operates a plug-in charging network designed to serve multiple E-2W and E-3W brands, evolving from universal socket charging through its Energy ATM product, to standardised fast-charging protocols using Type 6 connectors. Its value proposition is simple: instead of each motorcycle brand building its own expensive charging network, riders can charge anywhere in CHAJI's system regardless of which bike they own. This approach eliminates the need for proprietary charging infrastructure by creating shared charging points that any compatible electric two- or three-wheeler can access. This model extends beyond mobility to serve consumer electronics and productive use equipment, such as phones or a rechargeable hair cutter. This creates a comprehensive

Image (top): E-mobility charging hardware. Chaji, Kenya, 2025.

energy access platform for micro-entrepreneurs offering charging services. The system has already served 4-6 distinct electric vehicle brands and models across its network, proving the viability of the company's interoperable approach

Interoperability on two levels: Plug-in simplicity and protocol integration

The first is plug-level interoperability, achieved through universal three-pin sockets that work with any device's existing charger. This requires no technical coordination between manufacturers and allows instant compatibility across electric vehicles and devices. Users simply plug in with their own mobile charger, while socket owners generate income.

However, commercial users needed faster daytime charging, prompting CHAJI to advance to protocol-level interoperability. This involves Type 6 fast chargers that require integration of battery communication protocols and advanced BMS. This technical shift demands working directly with motorcycle manufacturers, with each new OEM integration requiring 2-4 weeks of custom firmware development and testing. CHAJI retains control over its firmware and enables over-the-air updates, allowing it to build a library of manufacturer-specific protocols while maintaining standardised hardware.

By focusing on Type 6 connectors, already adopted by Zeno in Kenya and several Indian manufacturers, CHAJI is positioning itself as the de facto standard for fast-charging standard in African markets, while enabling true cross-brand compatibility for rapid charging.

CHAJI's business model centres on equipment leasing with impressive utilisation metrics that vary significantly across markets

CHAJI's network demonstrates the economic viability of interoperable charging through strong regional performance: Kampala leads with over 14,700 charging sessions and 13.4 MWh delivered, while coastal Kenya (Mombasa and Ukunda combined) delivered 13.0 MWh across 6,180 charging events. These markets show distinct charging patterns. Urban areas like Nairobi and Kampala achieve utilisation rates of 20-35%, driven by frequent motorcycle charging. In comparison, coastal markets dominated by electric tuk-tuks show 15-25% utilisation, with longer but less frequent charging sessions.

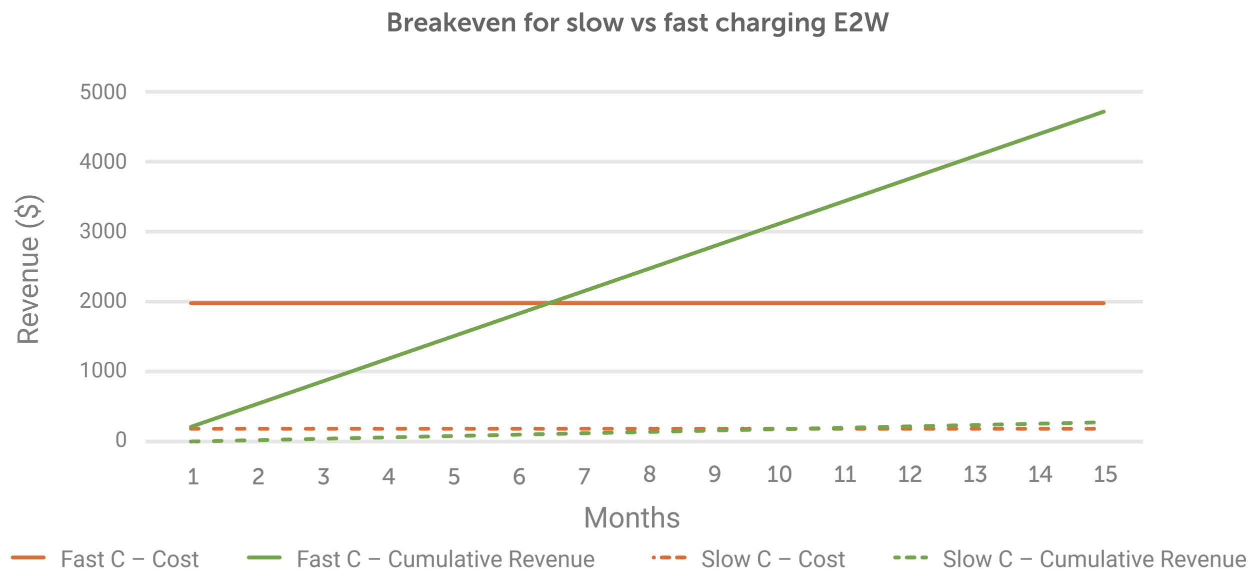


Figure 13 – Revenues for a fast charging station would be significantly higher and allow CHAJI to reach breakeven on each station by the middle of month seven, while it takes around twice that long to reach breakeven with slow charging stations. Source: PREO and CHAJI analysis.

The financial model is straightforward but effective: shop owners lease Energy ATM units for around US$4.50 (600 KSh) per month against deployment costs of approximately US$50 (6,400 KSh), paying off the device in 10 months before transitioning to pure revenue. Shop owners can generate US$21-$31 (2,800-4,000 KSh) monthly through diverse charging services, creating sustainable income streams while expanding network coverage. CHAJI is scaling through strategic partnerships to deploy 10 sites with 30 total plug points and expects to reach 90 total charging points by Q4 2025.

Transitioning to Type-6 fast chargers will reduce time to breakeven viability by reducing charge times from 2-3 hours to under 30 minutes (as long as the BMS allows it) and significantly increasing customer uptake. Although integration requires 2-4 weeks of OEM firmware work per brand, the payoff is higher energy consumption per station. This halves breakeven time from 13 months (from pure EV charging revenue) to 6.5 months for CHAJI.

However, setup challenges emerge as CHAJI advances towards fast charging. The transition from universal socket compatibility to Type 6 fast charging requires custom firmware integration and bilateral testing protocols with each OEM partner. Market dynamics also create obstacles, particularly where the higher costs of available electric three-wheelers have limited fleet scaling. Improved financing terms and dropping vehicle and battery costs are expected to address this barrier.

Key insights

CHAJI's experience reveals that charging infrastructure offers the most accessible path to interoperability in electric mobility, but the technical requirements and business dynamics vary dramatically by charging speed and market context. Universal socket charging achieves instant interoperability with zero coordination needed between manufacturers, enabling immediate market entry and broad compatibility. However, the real competitive advantage emerges through fast charging capabilities that can compete with battery swapping while maintaining cross-brand compatibility.

The data demonstrates clear market segmentation patterns suggesting that successful interoperability platforms must be designed as flexible systems, capable of serving diverse vehicle types and usage patterns, rather than optimising for a single market segment.

Unlike battery swapping, which requires exact physical compatibility and substantial investment in battery inventory, charging networks can achieve interoperability through standardised connectors and open communication protocols, making them inherently more scalable and capital-efficient. Installing Type 6 chargers and integrating Type 6-capable BMS can unlock significantly more value by making daytime charging much more viable.

CASE STUDY

STIMA Mobility SPV

Kenya

Interoperable battery ownership: One asset base for many OEMs

STIMA Mobility Limited was founded in 2020 in Kenya as an e-mobility company focused on EV battery management in SSA. While other e-mobility startups developed vertically integrated business models requiring significant capital injections for vehicles and batteries, STIMA focuses on its SaaS platform that views the battery as the key value driver for e-mobility in SSA. STIMA has partnered with battery asset owners like GreenWheels and eFTD, using its platform to optimise battery performance, extend lifespan, improve safety, and boost unit economics for battery-swapping systems. However, STIMA's founders noticed that every electric motorcycle company was building everything themselves, making the industry expensive and limiting where riders could charge. Meanwhile, large Asian e-motorcycle OEMs—many of which have recently developed models tailored for African motorcycle taxi use—are struggling to enter the market. This is because the existing battery swap infrastructure is controlled by vertically integrated start-ups, each building closed networks compatible with only their own motorcycles.

In response, STIMA is launching **Okoa**, its new subsidiary dedicated to creating an interoperable battery swap network. Okoa focuses on creating an interoperable battery design that works across multiple motorcycle brands from the start, to rapidly scale by having pooled resources and multiple motorcycle OEM partners.

Okoa wants to solve a big problem: every motorcycle company is stuck buying expensive batteries and building their own charging networks

This makes e-motorcycles costly and limits where riders can charge. Okoa's solution is to create an SPV—a separate company that owns standardised batteries and leases them to Okoa, which manages and optimises the battery swap network. As the battery is around 40% of the cost of the vehicle, and accounting for additional battery stock for the battery swap network means each e-motorcycle requires around US$1,000 in battery stock, the SPV greatly reduces capital costs for OEM partners.

Image: Stima battery swap station for electric boda-bodas. STIMA. Nairobi, Kenya, 2023.

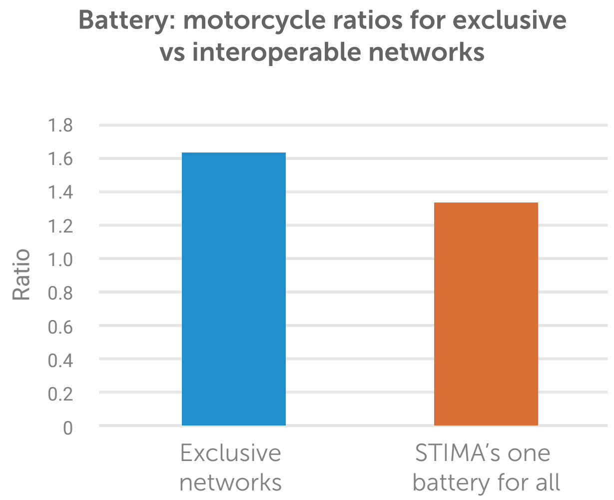


Figure 14 –STIMA's interoperable network will allow for a lower battery: motorcycle ratio, reducing overall costs. Source: PREO and STIMA analysis.

The value is clear: motorcycle companies can focus on making good bikes without worrying about operating expensive battery swap networks, riders get access to more charging spots, and everyone benefits from shared costs. Critically, STIMA estimates that it can lower battery/bike ratios from the 1.6 required for a typical exclusive network (with a similar battery) to 1.3 batteries per bike through having one battery for all. This means a 19% reduction in capital needed for battery swap assets.

The SPV will be funded by investors—a mix of DFIs, funds, and private capital—providing equity and debt. This capital is then used to buy standardised batteries in bulk from suppliers, driving better pricing and more consistent quality. Operators, including local franchisees, host swap stations under revenue-sharing agreements. Finally, STIMA will provide the SaaS platform and battery maintenance expertise to manage the batteries, swap cycles, payments, and performance analytics.

Driving interoperability through battery standardisation

STIMA is creating batteries that work across different motorcycle brands by standardising six key factors: voltage (power level), form factor (dimensions), power delivery, connector type, communication protocol, and battery capacity. The company has been meeting with major battery makers in China and motorcycle OEMs in both China and India to make sure everyone agrees on these standards.

The value of the innovation lies in STIMA's battery management expertise, while allowing other companies to manufacture the actual batteries. This means multiple suppliers can produce compatible batteries, driving down costs through competition.

> "Interoperable batteries create scale: instead of many small, isolated networks, riders benefit from a wider swapping network, and operators save costs by reducing the number of spare batteries."
>
> - Emile Fulcheri, Co-founder, STIMA

STIMA's three-part business model: Design, Finance, Operate

First, STIMA designs the battery specifications and works with leading battery suppliers to produce them. Second, it uses an SPV to buy and own the batteries—this SPV can attract funding from investors who want to support the e-mobility revolution without being tied to a single, motorbike-exclusive network. Third, it works with local franchisees (like petrol stations or motorcycle repair shops) to operate the swapping stations, sharing revenue with these partners.

STIMA SPV operational dynamics

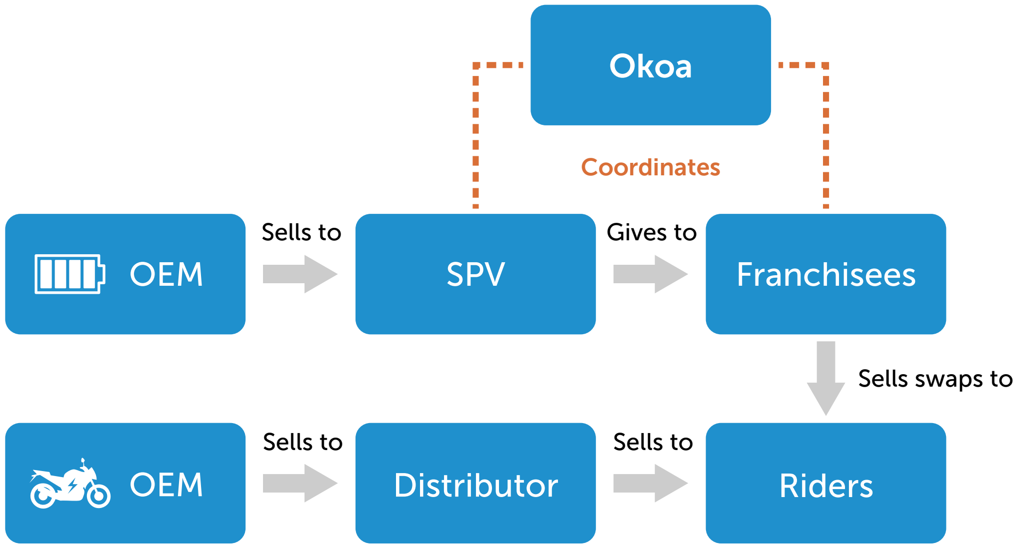


Figure 15 – The STIMA SPV will work within the African e-mobility ecosystem and provide opportunities for local franchisees. Source: PREO and STIMA analysis.

The company has already tested this with partners like Rubis petrol stations, Mogo, and local repair shops in Nairobi. The revenue-sharing is straightforward, dividing revenue between the station operator, the SPV investors, and Okoa's management costs. The SPV also allows for equitable risk distribution.

The main challenge is timing and trust. Okoa needs to raise significant capital for the SPV, coordinate with multiple motorcycle companies to launch simultaneously and convince all partners that sharing is better than owning.

Key insights

Technical compatibility is just the starting point—the real challenge is building trust between companies and agreeing on fair revenue sharing. STIMA's SPV model is smart because it creates a neutral entity that owns the batteries, preventing any single motorcycle company from controlling the system. However, this requires significant upfront capital and careful coordination.

The model works best when there's enough scale to ensure profitability among all parties. The battery rental model offers much higher returns, but only if STIMA can convince multiple motorcycle companies to join and encourage riders to adopt the system. Success depends on moving from competition to collaboration—something that's easier said than done in an emerging sector where every vertically integrated company needs market penetration to break even.

CASE STUDY

Ecobodaa

Kenya

Interoperable software: One energy sales platform for many

Established in 2020, Ecobodaa began as a direct e-mobility operator but has since identified a more pressing market need: the need to enable micro-payments for energy and allow riders to tackle arrears manageably. Along the way, it found fragmented systems blocking its ability to solve these problems for e-mobility companies and its customers. While OEMs built proprietary systems, financiers struggled to utilise their available data and manage risk across multiple platforms, while riders faced inconsistent payment experiences across brands. Ecobodaa pivoted to address this interoperability gap with its **Safiri** platform—a comprehensive software solution that bridges technical, financial, and operational silos.

Safiri: A universal platform for electric vehicle financing

Ecobodaa's Safiri platform provides a single system compatible with any electric vehicle brand, simplifying financing and standardising payment processes. It includes a small IoT kit, costing US$86 (11,000 KSh) that can be installed on any electric motorcycle and battery, along with cloud-based software that connects to the BMS. Safiri enables remote control of energy access real-time pricing adjustment—powerful capabilities that support a range of innovative applications.

For financiers, Safiri offers a new way to manage credit risk that protects both the rider's livelihood and their own portfolios. Instead of immediately resorting to repossession when a rider falls behind on loan payments, Safiri allows financiers to redirect incremental vehicle repayments into energy micro-purchases until the arrears are cleared. In a pilot with 45 motorcycles, this approach increased loan repayment rates from 70% to over 97% in just four weeks and has maintained an average of 93% over four months, considerably higher than the market average of 65-70%.

Image (top): Ecobodaa, Kitengela Charging and Swap Station, Kenya, 2023, For riders, Safiri enables small payments under US$0.80 (100 KSh), helping them avoid high mobile money fees on larger transactions. Riders who begin the day with only US$0.40-$0.60 (50-80 KSh) in hand—less than the cost of a full battery swap—can still access enough energy to complete their first few trips, earn income, and top up gradually throughout the day. gradually throughout the day.

For vehicle manufacturers, Safiri offers flexibility. Customers can be switched instantly between different payment models without any hardware changes.

Safiri e-mobility platform

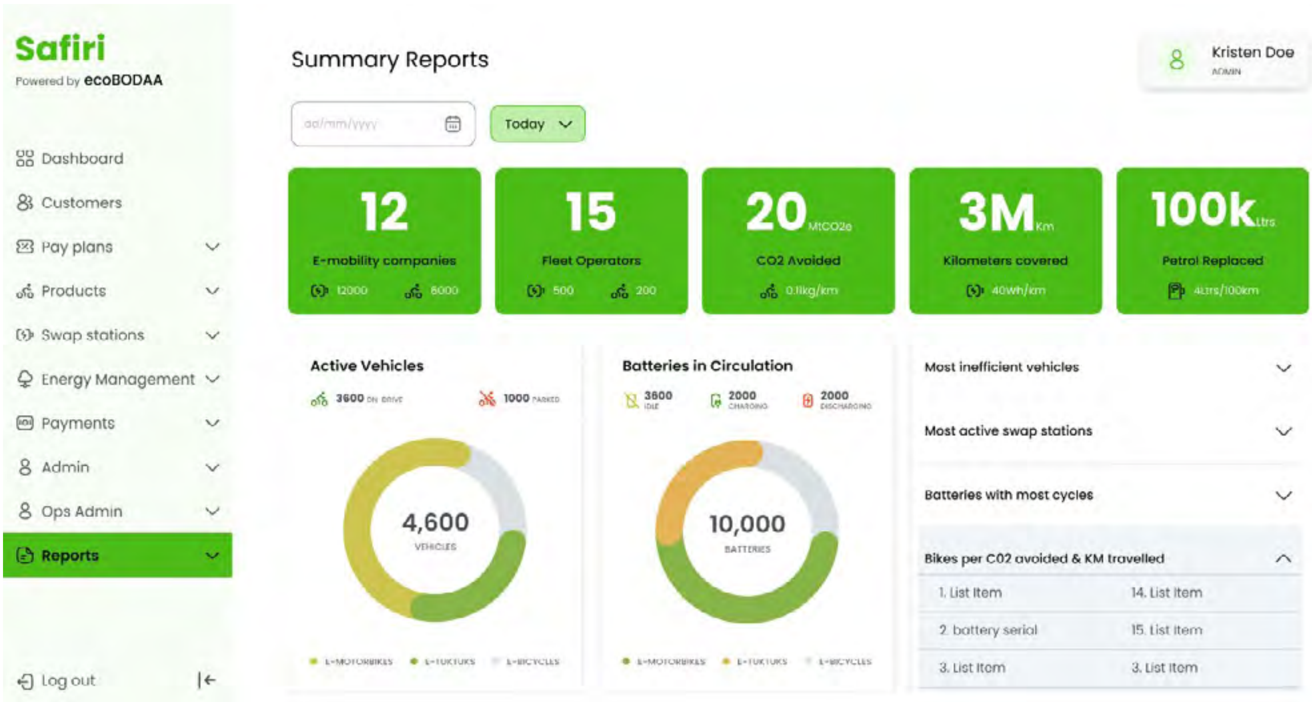


Figure 16 – Safiri's platform has a wide range of capabilities, including battery and revenue management. Source: Ecobodaa.

Safiri works by speaking the language of different battery systems

Each battery brand uses different communication protocols (mainly CAN bus and RS485), which are like different languages for sending instructions. Ecobodaa writes custom software so that Safiri can understand each one.

Currently, Safiri is compatible with SuperPack batteries, all JBD BMS systems, and Meishun BMS. Ecobodaa is in process of integrating with two other common BMS systems to achieve a plug-and-play approach with major SSA OEMs and battery/BMS suppliers by the start of 2026.

The technical challenge is significant. Each integration can require a 50-page manual, collaboration with battery and/or BMS suppliers, extensive testing, and sometimes hardware modifications. For example, some batteries don't have the right power outlet to power the Safiri device, so Ecobodaa must install a voltage converter, a one-hour installation which costs under US$10.

The company has deployed across multiple brands in Kenya and Nigeria including Kiri, Transboda, WeTu, EcoWaka, and Orbit Motorcycles.

Ecobodaa's dual revenue streams: manufacturers and financiers

Ecobodaa generates revenue in two ways. First, it earns from battery manufacturers, charging US$86 (11,000 KSh) per IoT kit (including e-motorcycle and battery IoT and GPS modules and a display) plus US$3.75/month (480 KSh) per battery for data access and payments processing. Second, it earns from financiers, charging US$3.75/month per vehicle, plus a 10-15% commission on recovered late payments.

Financiers control over 80% of electric vehicle sales in Kenya, giving them significant leverage.[7] When major financiers like Mogo require their partner manufacturers to use Safiri for loan approvals, manufacturers must comply to maintain access to financing.

A key challenge for financiers is the cost and complexity of managing multiple platforms. Currently, they must access different data portals for each brand's battery and GPS information. Some financiers told Ecobodaa they have considered developing their own unified platform but lack the technical expertise to do so.

As more vehicle brands integrate with Safiri, the platform becomes increasingly valuable to financiers, offering a complete view of their entire portfolio. More data means better risk prediction and default avoidance, creating network effects that benefit all stakeholders.

Key insights

Software integration looks easy but is technically complex. Even though Safiri doesn't require standardising physical batteries or charging stations, each brand integration still demands custom engineering, hardware modifications, and extensive testing. There is no simple plug-and-play solution.

Financiers are a key entry point to the market and can be leveraged for market share through improving their unit economics. Since financiers fund most EV purchases, getting them on board first is more important than convincing manufacturers. When financiers make Safiri a requirement for loan approval, manufacturers have little choice but to adopt it.

Data without enforcement is useless. While many platforms collect vehicle data, Safiri's unique value is enabling action—adjusting energy prices, controlling access, and managing payments remotely. This level of control is only possible with electric vehicles where energy access is digital, unlike traditional petrol motorcycles.

Ecobodaa shows us that software can create interoperability without forcing everyone to use identical hardware, but it still requires sophisticated engineering and the right market positioning to succeed.

7 Interview with Ecobodaa

Four-part roadmap to unlock shared growth

PREO's shift toward interoperability isn't ideological—it's pragmatic.

Fragmented systems can prove concepts, but they are costly to scale. Interoperability, when grounded in commercial logic and technical compromise, enables specialisation, reduces duplication, and builds systems that both investors and users can trust.

Image: Zembo rider. Zembo. Kampala, Uganda. 2025

Four-part roadmap to unlock shared growth

To overcome current barriers and accelerate capital-efficient scaling, PREO recommends a coordinated push around four key areas:

1

Build the technical rails

- Invest in modular plug designs, dual-voltage support, and interoperable battery form factors, slots and mounts.
- Encourage convergence on practical casing specs, voltage bands, and BMS protocols.

2

Enable shared infrastructure platforms

- Support interoperable swap and charge stations.
- Co-finance high-CAPEX infrastructure with guarantees for multi-brand access.
- Prioritise platform-level value creation over vertically siloed control.

3

Align commercial models

- Provide technical assistance for revenue-sharing agreements and asset governance.
- Develop standardised contracts between OEMs and interoperable infrastructure operators.
- Make commercial viability—not tech idealism—the benchmark for interoperability.

4

Create soft regulatory guardrails

Governments can:

- Signal preferred specs (e.g., plug types, comms protocols).
- Require data openness via open charging protocols.
- Use licensing, procurement, or tax policy to reward openness without mandating full standardisation.

Three emerging trends shaping e-mobility across SSA

The evolution of PREO's portfolio reveals where the sector is naturally converging—and where it isn't. After five years of investing across the e-mobility sector, three clear trends have emerged that point toward the future architecture of African e-mobility.

Battery network-led standardisation is gaining momentum

The most significant shift happening today is toward one battery serving multiple vehicle brands. Following the successful models of Sun Mobility and Gogoro, African companies are increasingly pursuing this approach, including both STIMA and Ampersand.

This convergence reflects both market maturity and practical necessity. As the sector moves beyond proof-of-concept to commercial scale, the inefficiencies of proprietary battery systems become prohibitive. Battery standardisation allows companies to specialise, rather than requiring every player to master the entire stack.

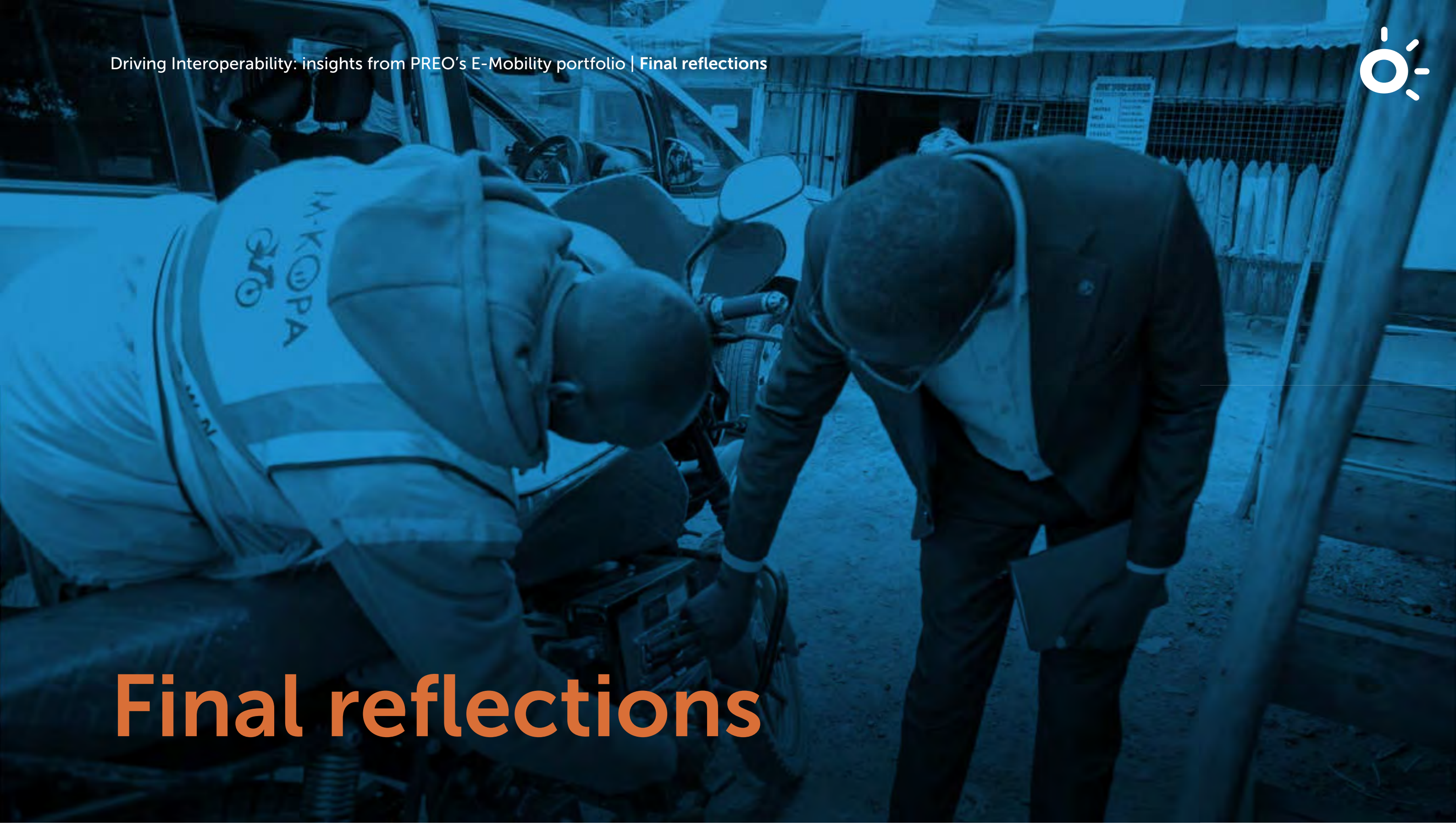
Software interoperability offers the lightest path forward

Interoperable software that can serve multiple brands represents the most technically feasible form of cross-brand compatibility. Companies like Ecobodaa have demonstrated that payment systems, fleet management, and usage analytics can operate across different hardware configurations.

However, software interoperability remains dependent on hardware cooperation and advanced BMS functionality. Software interoperability therefore works best when it doesn't require significant hardware changes.

International OEMs represent an untapped partnership opportunity

One of the most promising developments is the growing interest from large Asian OEMs in African markets—coupled with their reluctance to operate local infrastructure. This creates a natural partnership structure: international OEMs can focus on what they do best—manufacturing vehicles at scale—while local companies handle infrastructure deployment, customer relationships, and regulatory navigation. The appeal is mutual: OEMs gain market access without operational complexity, while local operators gain access to proven vehicle designs and supply chain efficiencies they couldn't achieve independently.



Final reflections

Interoperability can provide sector-wide benefits

By allowing companies to focus their time and resources on their respective expertise, be it battery manufacturing, battery management, swapping operations, or motorcycle manufacturing, interoperability can accelerate sector development. Interoperability can also free users from exclusive networks, both giving them access to more swap stations or motorcycle brands and allowing for more competition between swap station and charging providers. Fundamentally, interoperability can drive sector growth, customer choice, and company competition.

Building rails, not walls

The future of African e-mobility isn't about building walls—it's about building rails. Successful mobility infrastructure requires standardised interfaces that allow different operators to use shared systems while maintaining competitive differentiation in service or product quality, pricing, and customer experience.

This doesn't mean that a single standard will emerge overnight. The sector will likely support multiple competing standards over the coming years, as the global EV passenger car charging market does. PREO's experience suggests that interoperability emerges naturally when the commercial incentives align—when the benefits of collaboration exceed any gains from going it alone. The sector is approaching that inflexion point. Companies that position themselves at the intersection of these trends—standardised batteries, flexible software, and international partnerships—are likely to capture disproportionate value as the market consolidates around shared infrastructure.

The question is therefore not whether interoperability will emerge in African e-mobility—it is already evolving along several electrifying routes—but who will shape its development.

Image: Inspecting the battery swap technology on a Chaji motorcycle. Chaji. Kenya, 2024.

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Energy Opportunities

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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