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POWERING AFRICA'S SUSTAINABLE FUTURE

POLICY BRIEFS

Overcoming Infrastructure and Operational Challenges of Electric 2- and 3-Wheelers in Rural and Peri-Urban Africa

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The Problem

Despite the promising growth forecast for electric two-wheeler (E2W) and electric three-wheeler (E3W) in Africa, driven by their potential for lower operational costs and carbon emission reduction, several systemic challenges currently impede the realisation of these benefits and widespread adoption. The transition from traditional fossil-fuel to lightweight electric vehicle (LEV) faces complex infrastructural limitations, including the high upfront cost of installing charging facilities, unreliable electricity networks, lack of widespread private/public charging networks, and security issues, which can offset the anticipated operational savings. The high upfront costs of LEVs, coupled with limited financial mechanisms to support commercial users in transitioning from the traditional fossil fuel-powered models, further complicate the economic situation. The unique operational demands of the African two- and three-wheeler market in rural African communities, characterised by long daily distances, challenging terrain, and predominantly commercial usage for transporting farm produce, add another layer of complexity to achieving the projected benefits of LEVs. These challenges render the traditional private and public plug-in charging models used in developed countries and other urban African regions unrealistic, underscoring the need for innovative solutions like battery swapping to meet the unique demands of these rural regions. Battery swapping allows riders to exchange depleted batteries for fully charged ones at dedicated charging stations. Thus, battery swapping reduces downtime and addresses range anxiety, making it highly suitable for commercial applications.

The adoption of LEVs and battery swapping services faces several barriers, including high initial capital costs, standardisation issues, and regulatory hurdles. Additionally, the socio-economic context, characterised by informal economies and fragmented markets, further complicates the implementation of e-mobility solutions. Some of the most pressing concerns of the battery swapping service model are the compatibility of LEV chargers, battery management system (BMS), end-of-life management of batteries and ruggedness of existing E2Ws and E3Ws. The challenge of ruggedness is particularly acute in rural Africa, where E2Ws and E3Ws must withstand heavy loads and rough terrain. Current LEV models often lack the reinforced frames, heavy-duty suspensions, and load capacity that commercial users require for transporting farm produce, water, or goods. Without matching the durability and performance of conventional fossil-fuel vehicles, rural operators - who depend on these vehicles for their livelihoods - have little incentive to transition. The cost barrier is equally prohibitive. Many potential users already own functional fossil-fuel 2- and 3-wheelers and cannot justify the expense of purchasing new electric models outright. Compounding these challenges, a non-robust BMS will likely result in frequent premature battery damage before the manufacturer's recommended lifespan. This is especially problematic in battery swapping systems where multiple users share battery packs, as improper handling accelerates degradation. Without proper EV battery recycling systems, regions adopting LEV ecosystems risk creating new environmental hazards, as damaged or expired batteries could end up in landfills or oceans, releasing toxic chemicals and heavy metals into the environment. Furthermore, the current lack of standardised charging connectors and battery specifications across manufacturers creates confusion for consumers and limits the potential for universal swapping stations. This fragmentation discourages investment in charging infrastructure, slows market growth and transition initiatives.

These challenges highlight the urgent need for a comprehensive review of the rural Africa E2W and E3W ecosystem, with a focus on battery swapping services, rugged E2W and E3W design, and BMS, to identify gaps in the existing e-mobility ecosystem and propose actionable insights for researchers, policymakers, and industry stakeholders. This underscores the urgent need for integrated LEV ecosystem solutions that align with the principles of a circular economy while meeting the unique demands of rural African communities. The SUNRUN Phase II project was specifically designed as a pilot study to address these systemic barriers through its innovative solar-powered battery swapping model that combines affordability, gender inclusion, and environmental sustainability.

SUNRUN Phase II Project Findings

Project Process and Key Performance Indicators: The SUNRUN Phase II project achieved measurable success and impact against its core objectives of rural LEV deployment, solar-powered charging, and gender-inclusive adoption, as evidenced by its key performance indicators, which compared against the benchmark through series of regular monitoring and evaluation process throughout the lifespan of the project as depicted in Figure 1. The following findings detail how the project outcomes were realised through technical adaptations, community engagement, and policy alignment.

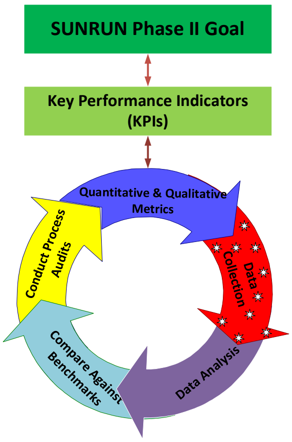

Figure 1: SUNRUN Phase II Monitoring Framework – An Iterative Cycle Linking Data Collection, Analysis, Benchmarking and Audits to Assess Performance Against Key Indicators and Ensure Alignment with Project Objectives

Gender Inclusion Strategies in the EV Adoption: The SUNRUN Phase II project revealed significant gender disparities in rural e-mobility adoption, with needs assessments showing fewer than 17% of women in pilot areas held driver's licenses due to cultural barriers and limited training opportunities. A striking 77.3% of surveyed women viewed LEV maintenance as technically complex, despite the relative simplicity of battery swap systems, highlighting deep-seated perception gaps. To bridge these divides, the project implemented a multifaceted approach: partnering with the Awuoth Widows and Orphans CBO to deploy women-operated E2W while training over 20 women in both riding skills and charging hub management. This was reinforced by collaborative efforts with Kisumu County to reduce driving test fees by 23%, directly addressing financial barriers to licensure. The SUNRUN project's female-dominated leadership and management team (66.67% women) served as powerful role models, challenging stereotypes through their technical work in charging hub operations, data analytics and delivery of training. Within 6 months, these coordinated interventions drove a fivefold increase in women's participation, from less than 20% to 45% of LEV riders in the pilot zones. This transformation demonstrates that systemic inclusion strategies - combining skills development, financial support, visible representation, and user-centered design - can effectively overcome the unique barriers women face in adopting emerging e-mobility technologies.

Critical Barriers to E-mobility Adoption in Peri-Urban and Rural Kenya: The challenge of ruggedness is particularly acute in rural Africa, where E2Ws and E3Ws must withstand heavy loads and rough terrain. Current E2Ws and E3Ws models often lack the reinforced frames, heavy-duty suspensions, and load capacity that commercial users require for transporting farm produce, water, and goods. Without matching the durability and performance of conventional fossil-fuel vehicles, field data shows that rural riders—who depend on these 2- and 3-wheelers for their livelihoods—have little incentive to transition to e-mobility. Compounding this, range anxiety—the fear of batteries depleting mid-route with no charging options—deters adoption, especially in areas where daily trips exceed 80 km and swapping stations are sparse. Furthermore, over 86% of potential riders in SUNRUN's pilot case study areas already own functional fossil-fuel 2- and 3-wheelers, which they depend on for daily income. These riders are reluctant to abandon their existing assets, which have lower upfront costs (typically KES 180,000 - 200,000 for fossil-fuel models versus KES 245,000 - 440,000 for equivalent LEV) and perceived reliability for long-distance travel, where fossil-fuel vehicles can be refuelled in minutes at ubiquitous petrol stations. SUNRUN's data highlights this dual challenge: while its battery swapping system reduced swapping time to 2 minutes (matching refuelling speeds), many potential adopters hesitated until swap station density reached one per 80 km^2—confirming that infrastructure gaps exacerbate both range anxiety and economic concerns. To address these barriers, Kiri EV retrofitted rugged fossil-fuel 2-wheelers with electric drivetrains, ensuring that the resulting E2W retained the durability rural riders were accustomed to. Critically, the conversion design was reversible, allowing users to switch back to fossil fuel if unsatisfied with the electric version, thus reducing perceived risk and building rider confidence in transitioning to e-mobility.

Policy and Regulatory Challenges: With regards to policy and regulation, the following challenges have been identified: there is no proper procedure for government licenses and permits, there are high levels of bureaucracy and there is no central agency to handle e-mobility. In addition to this there is a lack of incentives and subsidies from the government, with no budget for e-mobility. Furthermore, there is lack of awareness of the e-mobility tariff availability both in the government and from the public. In response to these challenges, SUNRUN contributed to policy dialogue by participating in multi-stakeholder engagements to support the development of streamlined regulatory pathways and to advocate for clearer licensing procedures and supportive tariffs for electric vehicles and battery swapping models. In addition, Kiri and eSafiri joined the Electric Mobility Association of Kenya (EMAK) and contributed to the Kenya Bureau of Standards (KEBS) technical committee, helping to shape national standards for battery technology, charging infrastructure, and other critical components of the e-mobility ecosystem.

Recommendations: Pathways to Accelerate E-Mobility Adoption in Rural Africa

Sustainable Battery Swapping and Charging Stations: Building on SUNRUN's proven success in Kisumu, policymakers and investors should prioritise adequate support to scale battery swapping and charging for rural e-mobility.

Promote Retrofitting as a cost-effective Transition Strategy: To address the dual challenges of high upfront costs and ruggedness requirements, policymakers and industry stakeholders should actively support local production of conversion kits like the novel kits developed by Kiri EV, which enable fossil-fuel lightweight vehicles to be retrofitted into electric models at lower cost than new LEVs. Financing mechanisms such as innovative low-interest loans and lease-to-own models designed by SUNRUN should be introduced to make these kits accessible to rural riders who depend on their existing vehicles for livelihoods. Concurrently, capacity building is critical—governments should partner with commercial actors like E-Safiri Africa and Kiri EV to train local mechanics, including women, in retrofit kit maintenance, ensuring the solution reaches underserved rural communities.

Durable and Serviceable EV Ecosystem: To create E2W and E3W capable of transforming rural mobility, governments should incentivise manufacturers through tax breaks and production-linked subsidies to develop heavy-duty models featuring reinforced frames with acceptable payload capacity, enhanced suspensions for rough terrain, and standardised components that simplify repairs, with these financial incentives being directly tied to compliance with internationally recognised durability benchmarks like UNECE L-category vehicle standards. Regional testing hubs can be established to validate vehicle performance under real rural operating conditions, including mud roads, steep slopes, and continuous heavy loading, with publicly available scorecards comparing different models across key metrics, including durability, repairability, and spare parts availability, to guide purchasing decisions. Given SUNRUN's findings about maintenance being a critical adoption barrier, regulations should require manufacturers to maintain stocks of essential spare parts within a few kilometers of sales locations while also providing comprehensive maintenance manuals and training programs for local mechanics, with particular emphasis on creating opportunities for women technicians through vocational partnerships. To further enhance sustainability, circular economy approaches should be promoted through subsidies for battery refurbishment workshops and the establishment of a 3D printing micro-factories capable of producing non-critical replacement parts on demand, ensuring rural operators are not sidelined by lengthy supply chains. County governments could pilot these solutions through spare parts cooperatives that leverage existing solar charging hubs like SUNRUN's as distribution nodes, creating an integrated ecosystem where rugged design, accessible maintenance, and renewable energy converge to support reliable electric mobility.

Smart Battery Monitoring for Reliable E-Mobility: To address the dual challenges of battery status monitoring, performance transparency, and charging efficiency, SUNRUN's model and research conducted by the research partner demonstrate that integrating an IoT-enabled BMS can revolutionise rural EV adoption by providing real-time monitoring of the rider's battery state of charge, charge cycles, voltage stability, and temperature thresholds at the charging station. These systems will have the capability of wirelessly alerting both riders and charging hub operators when batteries reach optimal swap thresholds to prolong lifespan, reducing range anxiety through predictive notifications sent to riders' mobile phones before critical depletion levels are reached. Simultaneously, charging hub attendants receive automated diagnostics on battery health, enabling proactive maintenance and preventing the circulation of degraded battery packs—a feature that reduced premature battery failures. By embedding this technology in Kenya's expanding battery swapping infrastructure, policymakers can ensure interoperability across different LEV and battery brands while creating data streams for regulators to enforce battery performance standards, turning isolated charging points into networked smart grids that balance energy demand with solar generation capacity. This approach not only addresses immediate user concerns about reliability but also builds long-term trust in LEVs as viable alternatives to fossil-fuel vehicles.

Gender Inclusion Strategies in the EV Adoption: Based on the findings from the SUNRUN Phase II project, a multi-pronged approach is necessary to address gender disparities and accelerate e-mobility adoption in rural Africa. To address key challenges such as cultural barriers, perception gaps, financial constraints and limited technical knowledge, EV industry leaders should expand gender-inclusive training through scaling up women-focused riding and LEV maintenance training programs in partnership with local organisations. Financing mechanisms such as low-interest loans through the Pay-as-you-go model and lease-to-own models designed by SUNRUN should be introduced to strengthen financial accessibility for women and youths to purchase or lease E2W and E3W.To further enhance women's participation in the LEV adoption, EV companies should ensure equal hiring opportunities, prioritising women in key roles such as technicians, mechanics and trainers and designing infrastructure with a user-centered approach incorporating safety, convenience and accessibility for women riders. Concurrently, policymakers should advocate for affirmative policies that require gender inclusion in the e-mobility projects. By implementing these strategies, e-mobility adoption can be significantly accelerated while ensuring women's active participation and leadership in transition.

Conclusion

The SUNRUN Phase II project achieved measurable success and impact against its core objectives of rural LEV deployment, solar-powered charging, and gender-inclusive adoption, as evidenced by its key performance indicators: daily battery swap rates reached three per vehicle, enabling about 200 km of commercial operation per rider, while solar energy constituted major part of the charging hub's power mix, reducing reliance on Kenya's electricity grid infrastructure. With a 67% female-led SUNRUN project management, implementation, and capacity building team, the project trained 20 women as hub operators and riders, significantly increasing female awareness and participation in the e-mobility transition drive. The SUNRUN hybrid battery charging model demonstrated great operational reliability despite rural infrastructure challenges in Africa. The performance metrics obtained validate the project's triple-bottom-line approach—environmental (total of 218 t/CO_2e of emissions avoided over the pilot study period), economic (fairly good operational cost savings for LEV riders), and social (inclusive job creation)—providing a replicable model for last-mile e-mobility transitions in emerging markets.

As a P4G-funded partnership between E-Safiri Charging Limited, Kiri EV Limited, Sustainable Transport Africa and Glasgow Caledonian University, SUNRUN has demonstrated how a solar-powered battery swapping and charging model can accelerate sustainable e-mobility in rural Africa. This work contributes to P4G's mission of scaling innovative solutions for SDG 7 (Affordable Clean Energy), SDG 9 (Industry Innovation), and SDG 13 (Climate Action). The lessons learned from SUNRUN will inform Kenya's national e-mobility strategy and future P4G green growth partnerships.

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