



E-MOBILITY

Solar Appliance Technology Brief

JULY 2021

EFFICIENCY FOR ACCESS COALITION

Photo Credit: EEP Africa

This e-mobility technology brief is one in a series of insight briefs developed to synthesise the latest market intelligence and chart the pathway to commercialisation for some of the off-and weak-grid appropriate technologies most relevant to catalysing energy access and achieving the Sustainable Development Goals.

The first iteration of the LEIA Technology Summaries was published in 2017 to help the newly established Efficiency for Access Coalition navigate a nascent market. At the time, e-mobility was not identified in the business case of the LEIA programme, as there were other appliance technologies that were more applicable to resource-constrained settings. Since then, there has been a growing interest in the e-mobility sector, from donors and funding programmes, as well as the emergence of companies active in the sector. This technology brief brings together the latest insights on the e-mobility market across emerging economies. You can access briefs on all technologies that are a part of this series [here](#).

This brief was developed by CLASP and Energy Saving Trust as part of the Low Energy Inclusive Appliances programme, a flagship programme of the Efficiency for Access Coalition. It is a catalyst for change, accelerating the growth of off-grid appliance markets to boost incomes, reduce carbon emissions, improve quality of life and support sustainable development.

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IKEA Foundation

Introduction

Electric mobility (e-mobility) encompasses transport modes that are battery-powered, eliminating the need for an internal combustion engine (ICE), that releases toxic particulate matter and carbon dioxide. Road vehicles, including buses, trucks, cars, 2-wheelers (2w) and 3-wheelers (3w) account for almost 18% of transport CO₂ emissions globally. However, only 1% of all road vehicles are currently electric, highlighting the need for a rapid transition to e-mobility.¹ The use of renewable energy for powering e-mobility solutions is critical to ensuring that the transition to electrified transport is clean and low- to zero-carbon.

Micro-mobility, consisting of, but not limited to, 2w and 3w, is the fastest growing form of transport in emerging markets due to its small size and relative affordability.² In fact, the 2w vehicle segment is set to be the second largest to be electrified globally.³ However, the electrification of micro-mobility is still nascent in many urban and rural areas of emerging economies, due to affordability barriers, a lack of infrastructure and unreliable energy systems.⁴ Data is limited across much of Sub-Saharan Africa and South Asia, but some data on the progressive Indian market is more readily available and therefore has been presented in this brief.

Battery-powered e-mobility (comprised of a battery and electric motor-powered system) competes with hybrid and ICE vehicles. Batteries convert stored chemical energy into electrical energy through the flow of electrons. The electrical energy powers the motor, which is often connected to a gearbox that turns the wheels of the vehicle. The system offers energy savings of almost 83% compared to an ICE. The amount of energy stored per unit of battery volume, known as energy density, is crucial to ensuring that the performance of the vehicle can match that of an ICE vehicle. Advances in material chemistry have enabled batteries to be



E-MOBILITY

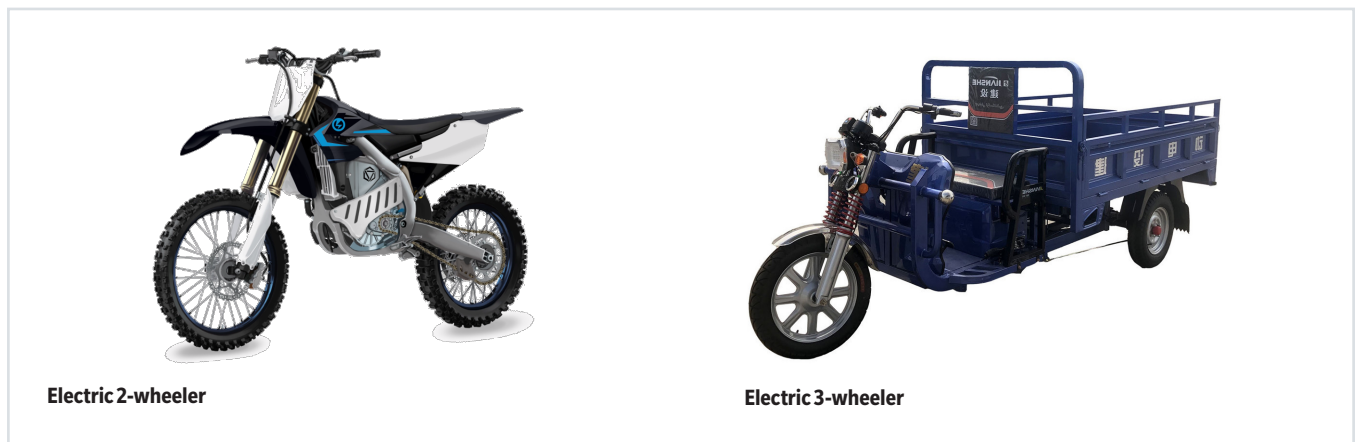
- SDG 1:** No Poverty
- SDG 2:** Zero Hunger
- SDG 3:** Good Health & Wellbeing
- SDG 5:** Gender Equality
- SDG 7:** Clean Energy
- SDG 9:** Industry Innovation & Infrastructure
- SDG 10:** Reduced Inequalities
- SDG 11:** Sustainable Cities & Communities
- SDG 13:** Climate Action

E-mobility eliminates tail pipe emissions, addressing good health by reducing pollution, and contributes to building sustainable cities. Rural communities can safely transport their produce, typically food, increasing their productive efficiency. Improved food systems transportation can nourish populations better and provide fair incomes to producers through access to new markets, allowing them to exit the cycle of poverty and contribute more to economic growth.

more energy dense, but production is costly. Smart batteries allow for advanced functioning of e-mobility solutions. They balance battery cell voltages and track temperature and charging rates to avoid stresses to the battery pack.⁶ The integration of this monitoring software can be used to harness data, not only on vehicle and battery usage, but also on charging, leasing and billing, which can reduce operational costs and increase productivity in the long term for all companies.

Permanent magnet (PM) motors are common in micro-e-mobility applications. They offer greater energy efficiency, performance and reliability than other electric motors. An electric motor requires a combination of around 20 parts

Figure 1. Electric two- and three-wheelers commonly available



1. IEA, Transport: Improving the sustainability of passenger and freight transport. (2021), <https://www.iea.org/topics/transport>
2. UNEP, Electric two and three wheelers. (2021), <https://www.unep.org/explore-topics/transport/what-we-do/electric-mobility/electric-two-and-three-wheelers>
3. Bloomberg NEF, Electric Vehicle Outlook 2021. (2021), <https://about.bnef.com/electric-vehicle-outlook/>
4. KPMG, Mobility 2030 ICE in Africa. (2020), <https://assets.kpmg/content/dam/kpmg/za/pdf/pdf2020/mobility-2030-ice-in%20africa.pdf>
5. Efficiency for Access, The Benefits of Permanent Magnet Motors, Volume 1. (2021), pg.28, <https://storage.googleapis.com/e4a-website-assets/The-Benefits-of-Permanent-Magnet-Motors-Efficiency-for-Access.pdf>
6. E-mobility Engineering, Battery Management Systems. (n.d.), <https://www.emobility-engineering.com/post/tech-focus-battery-management-systems>

compared to more than 200 parts for a petrol engine,⁷ reducing maintenance costs. More information on this technology can be found in the PM Motors Technology Brief.

State of Play

The cost and performance of e-mobility technology is affected by the battery market. Vehicle specifications for emerging technologies in Sub-Saharan Africa are sparse. However, specifications from the Indian micro e-mobility market are more readily available (Table 1).

The battery pack currently comprises almost 40% of the cost of an electric vehicle, as advancements in battery technology have not yet reached market maturity.⁸ Low-cost lithium-ion (Li-ion) batteries are projected to dominate micro e-mobility applications in markets such as India by 2023 due to their lighter weight and higher energy densities.⁹ The most common Li-ion battery chemistry is the nickel manganese cobalt oxide (NMC) cathode, developments within which are expected to present energy densities of up to 325 Wh/kg on a cell-level.¹⁰ Existing Li-ion battery technology is adequate to meet the range and speed expectations for micro mobility currently, but other evolving battery innovations, such as solid-state batteries, are expected to meet the needs of heavier duty ICE vehicles around 2030. In India, electric 2w (e-2w), electric 3w (e-3w) and cars will have lower capital costs than their ICE equivalents by 2027 due to a projected decline in Li-ion battery prices.¹¹

Li-ion batteries used for e-mobility can be re-purposed for rural

stationary storage applications, such as solar home systems, increasing affordability, access to energy and the uptake of appliances in off-grid settings.¹² This also helps to ensure the sustainability of lithium usage for battery production, as battery up-cycling and urban mining can reduce waste. The [Global LEAP Solar E-Waste Challenge](#) is one example of initiatives encouraging companies in the off-grid solar sector to implement end-of-life systems for batteries.¹³

Rural Sub-Saharan Africa presents a strong potential market for micro e-mobility solutions, as the climate is warm and people typically travel less than 80km daily with average vehicle speeds of 60 km/h. Several early-stage start-ups have infiltrated regions like East Africa. Companies are piloting and adopting various manufacturing approaches, including importing off-the-shelf e-2w and e-3w from China and India, importing components from China for local assembly and retrofitting existing ICE vehicles, as Africa is home to 40% of global exports of used ICE vehicles.¹⁴

India is a large exporter to Africa. Bajaj Auto, the country's largest manufacturer of 2w and 3w, exports to 35 African countries.¹⁵ Average specifications of e-2w and e-3w from the Indian market are displayed in Table 1 to give an approximate representation of micro e-mobility solutions. The total cost of ownership (TCO) considers the capital and maintenance costs of owning a vehicle. E-2w and e-3w in India are reaching cost parity with ICE equivalents already (see Table 1), due to their smaller size and lighter weight compared with heavier ICE vehicles.¹⁶ Although the upfront cost of e-mobility is high, the payback period for consumers in emerging economies is

Table 1. Typical specifications for e-2W and e-3W available in the Indian market.^{17,18}

VEHICLE	CLASSIFICATION	BATTERY CAPACITY (LI-ION)	MAX SPEED AND/OR MOTOR POWER (ELECTRIC)	TCO PARITY ACHIEVED WITH ICE WHEN TRAVELED
e-2w	Low/medium speed	Most are 1.2 to 2.2 kWh	25 km/h, 0.25 kW	Less than 10 km daily
	High speed	Most are 1.2 to 2.2 kWh	45 km/h, 0.5 kW	More than 40 km daily
e-3w	E-rickshaw	2.8 to 6.6 kWh	4 kW	More than 120 km daily (parity with lead-acid)
	E-auto	3.8 to 7.4 kWh	>25 km/h, >0.25 kW	-
	E-cargo	4.8 to 7 kWh	-	-

7. ESMAP, Electric Mobility & Development. (2018), pg.31. .

8. Amit Raja Naik, Electric Vehicles This Week: Amended Motor Vehicle Rules To Boost EV & More. (Inc42, 2020), <https://inc42.com/infocus/electric-vehicles-this-week/amended-motor-vehicle-rules-to-boost-ev-more/>

9. Charlie Bloch et al., Breakthrough Batteries: Powering the Era of Clean Electrification, (Rocky Mountain Institute, 2020), pg.8, https://rmi.org/wp-content/uploads/2019/10/rmi_breakthrough_batteries.pdf

10. EPO, IEA, Innovation in batteries and electricity storage. (2020), pg.29, [http://documents.epo.org/projects/babylon/eponet.nsf/0/969395F58EB07213C12585E7002C7046/\\$FILE/battery_study_en.pdf](http://documents.epo.org/projects/babylon/eponet.nsf/0/969395F58EB07213C12585E7002C7046/$FILE/battery_study_en.pdf)

11. Id.

12. Climate Smart Mining Initiative and ESMAP, Reuse and Recycling: Environmental Sustainability of Lithium-Ion Battery Energy Storage Systems. (2020),

13. Global Leap Awards, Solar E-Waste Challenge: A program to support innovations in off-grid solar e-waste management. (2020)

14. Jonathan Gaventa, Africa's bumpy road to an electric vehicle future. (E3G, 2021), <https://www.e3g.org/news/africa-s-bumpy-road-to-an-electric-vehicle-future/>

15. Richa Goyal, Six Key Trends Driving Affordable, Low-Carbon Growth in the Rural E-Mobility Sector. (next billion, 2020), <https://nextbillion.net/key-trends-affordable-low-carbon-rural-e-mobility/>

16. Science for Environmental Policy, Towards the battery of the future. (European Commission, 2018), https://ec.europa.eu/environment/integration/research/newsalert/pdf/towards_the_battery_of_the_future_FB20_en.pdf

17. Shyamasis Das et al., Charging India's Two- and Three-Wheeler Transport. (AEE, 2020)

18. Avendus, Electric Vehicles: Charging towards a bright future. (2020)

estimated to be between two and three years. Inclusive business models that prioritise affordability can make e-mobility more accessible to consumers.¹⁹

Market Insights

Direct comparisons between emerging markets have been difficult to make due to regional differences in government support, use cases and demographics. Other Asian countries (excluding China) have demonstrated uptake of e-2w and e-3w, but have faced barriers in performance, where the units deployed have been low quality, using lead-acid batteries and low-powered motors.²⁰ The most activity is seen in East-African urban markets, with more ride-hailing companies offering electric fleets.²¹ Rural Sub-Saharan Africa is still far behind. To successfully address core barriers, reliable energy access and longer travel distances, a deeper understanding of rural use cases is needed. Falling battery prices combined with more government support and private investment can help bring Li-ion based mobility solutions to the market. A focus on consumer needs can avoid reliance on and relapse into ICE-powered mobility for convenience.²²

The Southeast Asia market is largely untapped where over 80% of households in Thailand, Malaysia, Vietnam and Indonesia own ICE 2w.²³ Although there is limited information available on rural areas and use-cases, the TCO for e-2w is 27% lower than ICE scooters for these countries,²⁴ presenting a strong case for business models that reduce the up-front cost for consumers. Consumers across the region in dense, traffic-heavy urban areas have communicated a high willingness to pay for mobility. 60% of people would pay to reduce their commuting time.²⁵ The Philippines has seen growth in the demand for e-tricycles and e-jeepneys,²⁶ where e-3w postal fleets launched during COVID-19 accelerated the delivery of food packs for quarantined people.²⁷ Safa Tempos, e-3w mini-buses in Kathmandu, Nepal have gained traction again, despite existing for over 20 years. The fleet of around 1,000 vehicles provides rides for 90,200

passengers. These passengers are predominantly women as other public buses are heavily congested.²⁸ They have recently increased in circulation due to wider access to finance for women.²⁹

India is one of the largest manufacturers of micro-mobility and has adopted supportive policies, such as the Faster Adoption and Manufacturing of Hybrid and EV (FAME) scheme in 2015, to accelerate the electrification of its vehicle fleets. Although market penetration of all e-mobility in India is less than 1%, FAME has doubled the sales of e-2w, from 54,800 to 126,000 recorded in March 2019 (Figure 2).³⁰ The policy demonstrates the important role of subsidy schemes in growing a nascent e-mobility market. India is also positioning itself to be a hub for the manufacturing of e-mobility components, such as motors and temperature management systems.³¹

Figure 2 (page 6) shows increasing domestic sales of e-2w and e-3w in India, though COVID-19 impacted the sales in 2021. The demand for last-mile mobility is expected to see continued growth due to rising activity in e-commerce and food delivery, which saw increased uptake of e-mobility solutions pre-COVID-19.^{32,33} Sales are projected to reach between 8 and 9 million units by 2030 for e-2w. Expected sales of e-3w in 2030 may reach almost 600,000 units.³⁴

Activity and innovation are growing in East Africa, particularly in Uganda and Kenya. Kenya had only 350 electric vehicles registered in 2019, while 2w and 3w accounted for the majority of its 3.2 million vehicles/ Kenya is working to electrify fleets and cut transport emissions as part of its nationally determined contributions (NDCs).^{35,36} As of May 2021, 18 companies are working in the e-mobility sector, 16 of which are focused on e-2w or e-3w.³⁷

Uganda is one of the largest ICE motorcycle importers in East Africa,³⁸ presenting huge potential to switch its fleets to electric. Companies, such as Bodawerk in Uganda and Opibus in Kenya, have had early success with displacing ICE motorbikes.³⁹ This

19. IEA, Africa Energy Outlook. (2019), https://iea.blob.core.windows.net/assets/2f7b6170-d616-4dd7-a7ca-a65a3a332fc1/Africa_Energy_Outlook_2019.pdf

20. Jurg M. Grutter and Ki-Joon Kim, E-mobility Options for ADB Developing Member Countries. (ADB, 2019), pg.75, <https://www.adb.org/sites/default/files/publication/494566/sdwp-060-e-mobility-options-adb-dmcs.pdf>

21. Gaventa, Africa's bumpy road to an electric vehicle future

22. Grutter and Kim, E-mobility Options for ADB Developing Member Countries, pg.75

23. UNEP, Paving the way for electric mobility in South-East Asia.

24. Deloitte, Full speed ahead: Supercharging electric mobility in Southeast Asia. (2021), <https://www2.deloitte.com/id/en/pages/strategy-operations/articles/full-speed-ahead.html>

25. Shell, Cities on the Move: Driving Asia's Mobility Revolution. (2020), pg.10, <https://www.shell.com/energy-and-innovation/the-energy-future/future-transport/future-transportation-asia.html>.

26. Shell, Cities on the Move, pg.13

27. UNEP, Paving the way for electric mobility in South-East Asia

28. Anup Ojha, Tempo drivers are driven to despair as not many are using these three-wheelers over Covid-19 fears. (The Kathmandu Post, 2020), <https://kathmandupost.com/valley/2020/08/01/tempo-drivers-are-driven-to-despair-as-not-many-are-using-these-three-wheelers-over-covid-19-fears>

29. Anne Cassidy, How women are driving change in Kathmandu. (Winrock International, n.d.), <https://winrock.org/how-women-are-driving-change-in-kathmandu/>

30. EED Advisory and Siemens Stiftung, Environmental Impact of E-mobility in the Lake Victoria Regions, Western Kenya. (2020), pg.13, <https://www.siemens-stiftung.org/wp-content/uploads/medien/publikationen/studie-environmentalimpactofemobilityfinalreport-siemensstiftung.pdf>

31. Uma Gupta, Electric vehicle adoption in India will be led by three-wheelers. (pv magazine, 2020), <https://www.pv-magazine-india.com/2020/11/05/electric-vehicle-adoption-in-india-will-be-led-by-three-wheelers>

32. Malyaban Ghosh, India poised to be top EV manufacturing hub. (mint, 2021), <https://www.livemint.com/industry/manufacturing/india-will-become-largest-hub-for-manufacturing-of-evs-in-coming-years-gadkari-11618760404015.html>

33. McKinsey Center for Future Mobility, The unexpected trip: The future of mobility in India beyond COVID-19. (2020), <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-unexpected-trip-the-future-of-mobility-in-india-beyond-covid-19>.

34. Id pg.4

35. Siemens Stiftung, E-Mobility Solutions for Rural Sub-Saharan Africa: Leveraging Economic, Social and Environmental Change. (2020), <https://www.siemens-stiftung.org/en/media/news/e-mobility-solutions-for-sub-saharan-africa-siemens-stiftung-publishes-its-first-booklet/>

36. Association for Electric Mobility and Development in Africa (AEMDA), EV Market Barriers in Kenya: Market Survey 2021. (2021), pg.2, <https://aemda.org/knowledge-hub/>

37. Id., pg.4

38. Linda Calabrese, How manufacturing motorcycles can boost Uganda's Economy. (ODI, 2017), <https://odi.org/en/insights/how-manufacturing-motorcycles-can-boost-ugandas-economy/>.

involves replacing an ICE with an electric system and allows for a resource-efficient way to electrify second-hand petrol-powered fleets.^{40, 41}

In contrast, companies such as Powerhive in Kenya and Mobility for Africa in Zimbabwe, first tested off-the-shelf micro e-mobility solutions to identify how the vehicles can be adapted to suit their rural customers better.

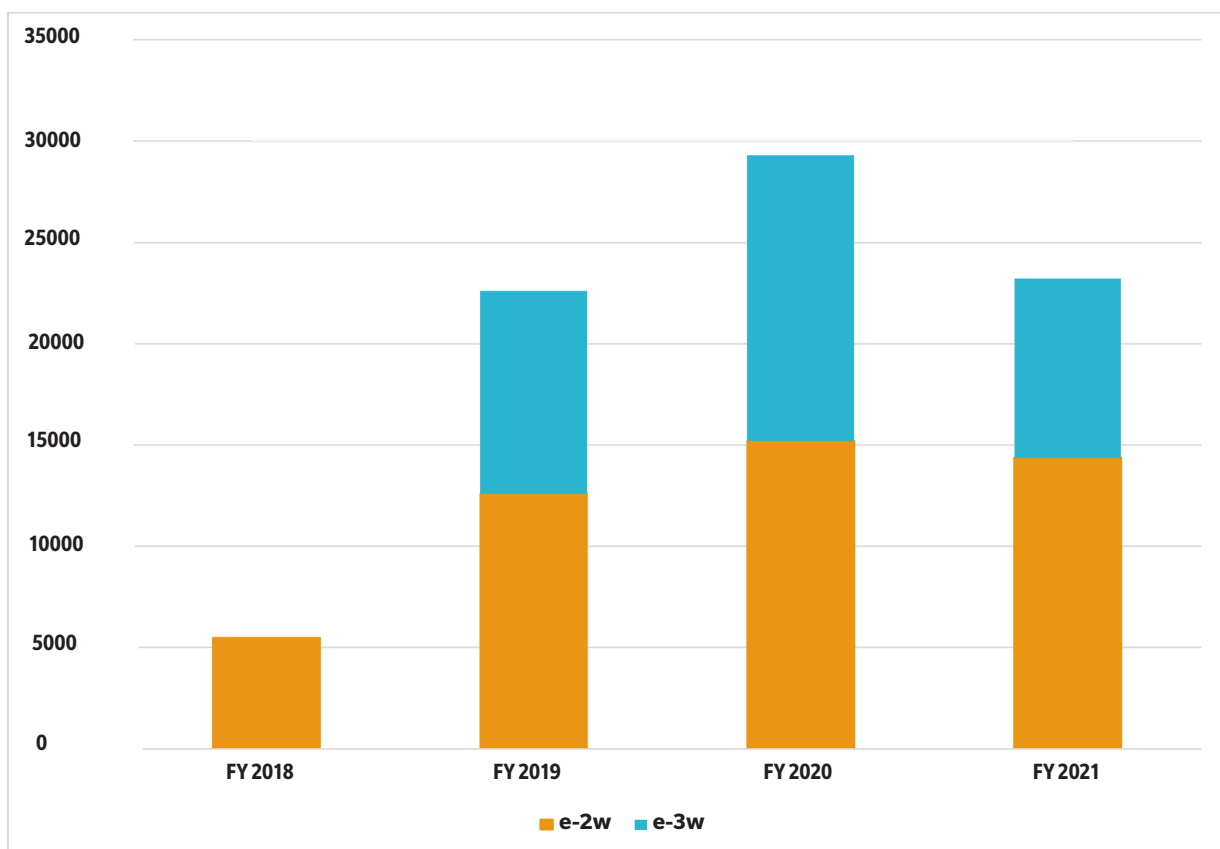
Powerhive then ordered more customised vehicles based on feedback from their riders and Mobility for Africa imported parts and assembled locally to create employment opportunities for women. To accelerate the uptake of e-mobility solutions, specific business models that are more established in India, and emerging in Africa, are addressing affordability challenges.

These include mobility-as-a-service (MaaS), charging-as-a-service (see Box 1) and lease-to-own. The former two involve the service provider retaining ownership of the batteries and

vehicles. Drivers can rent vehicles or have batteries charged by the day to perform income-earning activities, such as taxi services. This is becoming popular in urban areas of Sub-Saharan Africa, where the 2W taxi market was estimated to be worth approximately GBP 62 billion in 2019.⁴² Zembo in Uganda, has adopted the lease-to-own model, where riders in urban areas can pay weekly fees over two years to reach full ownership. Fees include the use of the e-2W, maintenance services and battery recharging.⁴³

As digital platforms become more accessible through smart phones, startups targeting Africa are following the Southeast Asian approach to providing instant services through ‘super apps’, where credit facilities and mobility services can be accessed instantly. This is similar to the PAYGo solar sector, which is increasing financial inclusion for marginalised communities. However, this approach is proving difficult for rural areas, where access to smart phones is limited due to very low affordability.

Figure 2. Domestic unit sales of e-2w and e-3w in India^{44,45}



39. CIG Uganda, Electric Mobility – Working Towards Sustainable Urban Transportation. (2021), <https://www.ugandacig.com/news/electric-mobility-working-towards-sustainable-urban-transportation/>
 40. CleanTechnica, 2020, Uganda-Based Bodawerk’s Electric Tractors, Motorcycle Conversion Kits, Threshing & Milling Machines Look Set to Transform lives, <https://cleantechnica.com/2020/07/19/uganda-based-bodawerks-electric-tractors-motorcycle-conversion-kits-threshing-milling-machines-look-set-to-transform-lives/>
 41. Goyal, Six Key Trends Driving Affordable, Low-Carbon Growth.
 42. BBC, Why motorbike apps are scrambling for Africa. (2019), <https://www.bbc.co.uk/news/world-africa-50228185>
 43. EEP Africa, Electric Boda Boda. (2020), https://eepafrica.org/wp-content/uploads/2020/09/IBM_Zembo_DigitalVersion.pdf
 44. Lovdeep Brar et al., The India Electric Vehicle Opportunity: Market Entry Toolkit. (Energy Systems Catapult, 2021), https://cp.catapult.org.uk/wp-content/uploads/2021/03/210318_1020_CPC_India_Report.pdf
 45. HT Auto, Electric vehicle sales slump 19.4% in FY2021 to 238,120 units. (Hindustan Times, 2021), <https://auto.hindustantimes.com/auto/news/electric-vehicle-sales-slump-19-4-in-fy2021-to-238-120-units-41619346113748.html>.



Business Model

CHARGING-AS-A-SERVICE

Charging-as-a-service can offer battery swapping or renting. Battery swapping enables drivers to replace their discharged battery with a fully charged one for a small fee. This business model innovation addresses two major barriers to the adoption of micro e-mobility: high upfront costs of vehicle ownership and long charging times. The model also eliminates the need for fast charging, which accelerates battery degradation.⁴⁶ It is more established in India, where the swapping market is expected to generate revenues of USD6.1million by 2030.⁴⁷ Battery swapping stations tend to be offered in partnership with vehicle rental, so that vehicles are essentially being offered to users without the battery included, resulting in a 40-50% price reduction. In Nairobi, Kenya Stima Mobility offers urban riders a service that combines battery swapping with a PAYGo system.

Under this Stima take responsibility of battery management and health, so that riders do not have to incur the cost of ownership.⁴⁸ In rural Kenya, Powerhive is piloting locally assembled battery swapping units in combination with vehicle rental as part of their mini-grid services.⁴⁹ However, due to very low utilisation of e-mobility in rural areas, commercial viability is harder to achieve and requires patient capital.

A battery rental model can be offered on its own or as part of a larger service. For a small fee, the start-up Asobo rents out electric motors with batteries and charging to fisher-people on the shores of Lake Victoria, Kenya. The batteries are charged during the day at their hubs using solar energy and then transported back to the shore, ready for night-time fishing.⁵⁰ Users have seen their operational costs reduce by 25% compared to when they were using petrol and diesel-engine boats.⁵¹

46. Parveen Kumar et al., Battery Swapping: An Alternative Fast Re-fueling Option for E-2Ws and E-3Ws in India. (WRI India, 2021)

47. Id.

48. Techcabal, Electric mobility in Africa could be the next big thing for global investors. (2021),

49. Efficiency for Access, Research and Development Fund Project Spotlight, Powerhive Inc UK (2020)

50. Baird Maritime, Dutch Startup to Refit Kenya's Small Fishing Boats with Electric Motors. (2020),

51. Africa News, Motorboat company launches electric fishing boats on Lake Victoria. (2021), <https://www.africanews.com/2021/02/26/motorboat-company-launches-electric-fishing-boats-on-lake-victoria/>.

Consumer Impacts

The introduction of e-mobility into different contexts and use cases can bring a multitude of benefits to consumers. Environmental benefits include reduced localised air pollution and greenhouse gas emissions. If user-centric business models are adopted, e-mobility can empower women and girls and help serve the medical needs of the elderly and sick.

E-mobility can reduce air pollution and greenhouse gas emissions. A decline in tailpipe emissions lowers the volume of toxic gases released into the atmosphere, reducing localised air pollution. WHO ranked Kampala, Uganda as one of the top polluting cities globally due to vehicle emissions from traffic. Moreover, until 2018, the average age of the vehicles in use was over 15 years old, making them highly inefficient with large carbon footprints.⁵² In recent years, the government has encouraged electric buses and e-2W, the most common forms of transport in the city.⁵³ It is estimated that emissions could be cut by 11 billion tonnes of CO₂ by 2050 if 90% of global 2w sales were battery-electric by 2030.⁵⁴

Expansion of e-mobility in rural areas can strengthen food systems and increase the incomes of small-holder farmers in the least developed areas. Box 2 highlights the benefits e-mobility can enable in productive-use applications.

Improved mobility empowers women and enables autonomy. Rural African women spend 40 billion hours a year walking to carry out various tasks, from collecting water to working in the fields. As many tasks are performed with children close by, e-mobility solutions present a healthier and more convenient option, with no exposure to toxic fumes. With high maternal mortality rates in rural areas, e-mobility can also aid in attending to urgent medical needs. For example, using light e-2w that allow medical professionals to travel greater distances faster, especially during a medical emergency.⁵⁵ Mobility for Africa committed a few of its electric Hambas to serve the rural health sector during the COVID-19 pandemic and delivered food and supplies to families in need.⁵⁶

Electric motors can eliminate toxic fumes and reduce engine noise on fishing boats. Fossil fuel-powered fishing boats are noisy and pollute the local environment. Fisherpeople on Lake Victoria, have reported that the reduction in noise with the use of electric boats has allowed them to hear commands easily and listen to the radio whilst waiting for a catch, making their job more pleasant.⁵⁷

Monetary savings can lead to financial empowerment and contribute to SDG 1. Since the TCO of an e-2w is much cheaper per kilometre than that of ICE-powered bikes, African e-moto-taxi business models offering pricing for charging- and mobility-as-a-service, suitable for those with the lowest incomes, have already enabled riders to make significant savings. A Zembo driver was able to save almost USD 300 in three weeks of using an e-2w.⁵⁸ Similarly, the income of a driver working for the Rwandan e-moto taxi service, Ampersand, increased by 42% after leasing an e-2w.⁵⁹ With more disposable income, they have been able to provide meals consistently for their family and save for their children's school fees and healthcare.



52. The Conversation, How we're measuring air quality in Kampala - and why it works for African cities. (2020), <https://theconversation.com/how-were-measuring-air-quality-in-kampala-and-why-it-works-for-african-cities-143006>.

53. Foreign, Commonwealth and Development Office, Country scoping of research priorities on low-carbon transport in Uganda. (2020).

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55. IEA, Africa Energy Outlook, pg.95.

56. Remeredzai J. Kuhudzai, Mobility For Africa Shows How Electric Vehicles Can Transform Lives Where It Matters Most – Part 2. (2020),

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58. EEP Africa, Electric Boda Boda, pg.11.

59. Benoit Faucon and Alexandra Wexler, How EVs Could Transform the Streets of Africa. (The Wall Street Journal, 2021), <https://www.wsj.com/articles/ev-electric-vehicle-africa-11620854230>.



Photo: Ecolife

A fossil-fuel 2 wheeler transports product to a local market.

Potential Impacts

E-MOBILITY IN PRODUCTIVE USE APPLICATIONS

Small-holder farmers in Sub-Saharan Africa produce 80% of the food consumed on the continent.⁶⁰ Access to rural transport plays a large role in addressing SDG 2, Zero Hunger, as it can enable faster, safer and cheaper transportation of fresh food by market traders and farmers to nearby urban areas. With more reliable and increased access to fresh food, producers will benefit from higher incomes through reduced food spoilage and consumers will have increased food security.

Innovation will see the integration with other sectors, such as cooling. Currently, food supply chains rely on fossil fuel-powered vehicles to transport food to local markets.⁶¹ Devidayal Solar Solutions is one company working on providing truck-mounted solar refrigerators to reduce food spoilage and increase income for women farmers in India.⁶² Although these are ICE-powered trucks, advancements in battery technologies by 2030 will enable lighter, more energy dense solutions that may unlock opportunities to power the mobility of commercial vehicles.⁶²

Mobility for Africa's Hamba (e-3w) is designed for women and has a maximum load capacity of 400kg, allowing for the transportation of both children and agricultural produce.⁶³ A shared use and community-based service business model allows the Hamba to be leased to groups of up to five women engaging in productive use activities, resulting in higher utilisation and lower operational costs. WeTu piloted battery-assisted pedal e-cargo bikes in Kenya that have a maximum load capacity of 160kg and are assembled locally for job creation in Mbita.⁶⁴ They are designed for off-road use and for the delivery of goods and services in rural areas, such as for transporting ice boxes to keep fish fresh in transit from the Lake Victoria region.⁶⁵

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65. Remerudzai J. Kuhudzai, Strong E-Mobility Focus At The Recent Lake Basin Region Innovation & Investment Week In Kisumu. (CleanTechnica, 2019)

Current Success and Remaining Challenges

The growing number of technology and business model research and development (R&D) pilots and deployments in sub-Saharan Africa have demonstrated strong demand for e-mobility and highlighted some key trends and early successes. However, there is a clear need for continued financial support for new entrants to the sector who are tackling the challenges that remain around affordability, manufacturing and infrastructure provision.

Successes

- **Increasing private sector investment and donor interest.** Despite a nascent market, a mixture of private sector financing is enabling technology and business model R&D. EkoRent Africa received investment of EUR 1 million in 2020 to support the scale-up of its Nairobi-based e-taxi-hailing service.⁶⁷ An e-mobility start-up in Rwanda recently secured USD 3.5 million in venture capital funding, the largest private investment made in the clean transport sector in sub-Saharan Africa.⁶⁸
- **Supportive government policies can boost local assembly and manufacturing.** The FAME scheme in India requires 50% of components for e-mobility to be sourced locally, which has encouraged a stronger and more sustainable local vehicle manufacturing industry. Various start-ups in Sub-Saharan Africa are also striving to adopt this approach by assembling bikes and battery swapping stations locally. It presents opportunities for employment, faster production and cost savings for the business and local resilience and independence.⁶⁹
- **A rise in business models that offer pricing suitable for low-income individuals and combined services.** The emergence of innovative business models, such as battery swapping, has shown interest from investors and users alike.⁷⁰ Battery swapping and 'hub' models that provide solar charging for mobility are examples that are fostering local employment. The hubs allow for other solar powered services to be easily accessed, such as clean water and mobile phone charging, and are proving popular with riders participating in field pilots.⁷¹

Challenges

- **Limited reliable market data in emerging economies.** The market is more nascent in Sub-Saharan Africa than in Asia, with few to no established players with proven viable business models. Therefore, the needs of the rural end-users are still largely unmet. This impacts the entry of influential stakeholders who can catalyse a step-

change in business model and technology scale-up, such as financiers and potential companies looking to expand into emerging markets. These stakeholders require more evidence and data on rural sector needs to reliably assess viability and allow them to make decisions with confidence to finance the piloting of appropriate business models and vehicle R&D.

- **The integration of open and interoperable software and hardware communication technologies in rural areas.** Integrated software solutions, such as battery management systems with cloud platform services, can enable data to be easily harnessed. The collection and communication of data between the different aspects of the long and diverse e-mobility value chain can result in real-time visibility of operations, increasing productivity and reducing operational costs. However, a lack of infrastructure, network and technology access in rural areas presents challenges in implementing these advanced communication systems, elongating project delivery times and requiring patient capital.

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Finance all aspects of the value chain

Business models, vehicles and energy technologies are all key areas of the wider value chain of electrifying mobility. They have the potential to drive positive social impacts in emerging markets and profits for service providers. Due to the nascent nature of the rural e-mobility market, financiers, particularly investors, need to be patient, as inclusive pricing will both attract a large customer base and enable them to prove viability to be achieved over the long-term.⁷² Access to equity and debt financing will encourage companies to scale-up. Rural populations have different needs from urban areas, therefore financing capacity building and initial assessments around the needs of the market should be prioritised.



Promote specialisation of different business and technology areas

The full e-mobility picture requires energy systems, charging infrastructure, vehicle technology, appropriate business models, specific local operations and maintenance expertise. The commercial viability of the solution will improve if companies specialise and collaborate. For example, a company providing an affordable e-2W leasing can reduce operational costs by partnering with a charging as a service company to offer battery swapping. Specialisation can aid economies of scale, which is what the sector needs to accelerate environmental and social impact, as well as commercial viability.



Ensure a clean and reliable power supply

A clean and renewables-powered transition to e-mobility will help to achieve SDG 7, 11 and 13 and deliver net-zero benefits to investors, donors and governments. Simultaneously, having charging kiosks or hubs entirely powered by solar cannot be relied upon to provide consistent power for battery swaps. Therefore, appropriate energy systems need to be realised. Cases may require hybrid solutions in the form of smart solar mini-grids and largely renewables-powered national grid connections, to ensure reliable and clean power .



Reduce e-waste and build a circular economy

Ethics, sustainability and e-waste are all crucial aspects that will take time to be established into systems as the production and uptake of batteries increases. They must also be both profitable and supportive of the circular economy in order to function successfully. Establishing local manufacturing may present a solution to this, as sourcing parts becomes easier and less costly for local companies. This would present opportunities for recycling systems to also be locally integrated into manufacturing bases.




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