Peeter Viisimaa via Getty Images

Financing the transition to electric vehicles in sub-Saharan Africa

January 2022

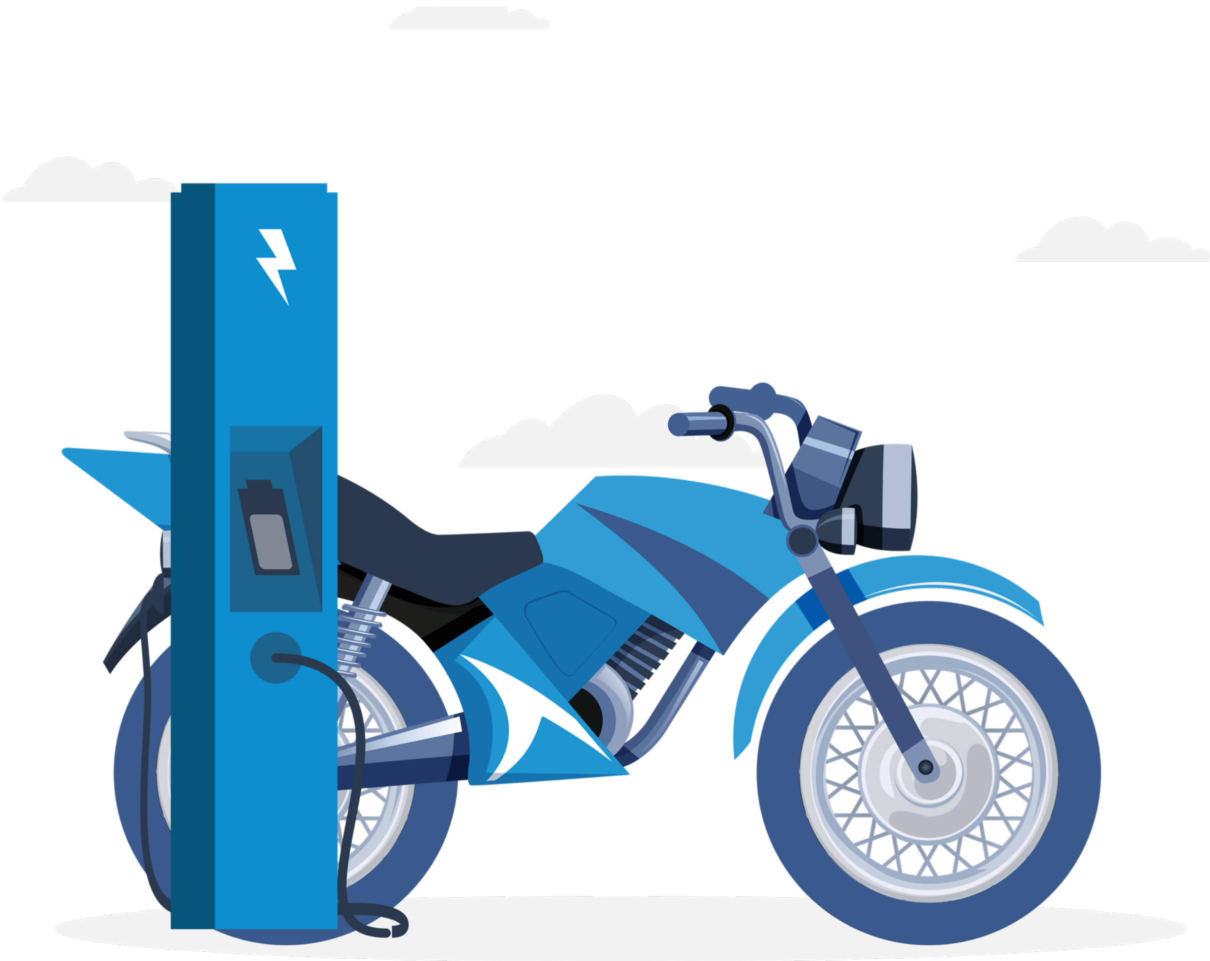
Shell Foundation

Foreword

In 2021, Shell Foundation commissioned an analysis to determine the opportunities to finance e-mobility in five countries in sub-Saharan Africa (Ethiopia, Kenya, Nigeria, Rwanda, and Uganda), including assessing total market potential, the existing financing landscape, the financing need, and potential financing solutions.

Several actors were engaged as part of this analysis, including e-mobility players in the five focus countries, financiers (including asset financiers, venture funds, private equity funds, commercial banks, and development finance institutions), and development partners.

This report draws on multiple sources, including analysis from McKinsey & Company. The authors are responsible for the conclusions and recommendations of the research. Shell Foundation would like to thank all those who generously shared their time and insights



About Shell Foundation

Shell Foundation is a registered independent charity, founded by Shell in 2000, that exists to support people living in low-income communities to escape poverty and ease hardship. Shell Foundation creates and scales business solutions to two major barriers to poverty alleviation: access to energy and sustainable mobility. Our geographical focus is on Africa and Asia, where issues such as access to energy and mobility are major obstacles to sustainable development.

We use a market-based approach. Shell Foundation supports innovators to test new technology and enterprise models to provide the energy and transport services that people living in low-income communities need to improve their health, education and income. Once demand for a new product or service is proven, we co-create supply chain intermediaries, blended funds and non-profit institutions to support replication and market growth. We use grant funding and non-grant instruments as appropriate, alongside extensive business support, and allocate a third of our budget to build a stronger enabling environment for social enterprises in target countries.

To-date, our work has contributed to the reduction of over 48 million tons of carbon emissions, leveraged $8.4 billion in finance, supported creation of nearly 600,000 jobs, and improved livelihoods for nearly 194 million people.

Abbreviations and terminology

2W	two-wheeler
3W	three-wheeler
4W	four-wheeler
BaaS	battery-as-a-service
Bn	billions
CBU	completely built up
CKD	completed knocked down
CO	carbon monoxide
CO_2	carbon dioxide
DC	direct current
DFC	development finance corporation
DFI	development finance institution
E2W	electric two-wheeler
E4W	electric four-wheeler
E-LCV	electric light commercial vehicle
E-Minibus	electric minibus
EV	electric vehicle
g	gram
GDP	gross domestic product
ICE	internal combustion engine
IoT	internet of things
km	kilometer
kWh	kilowatt hour
LCV	light commercial vehicle
Mn	millions
mpg	miles per gallon
NO_2	nitrogen dioxide
OEM	original equipment manufacturer
PE	private equity
PM	particulate matter
R&D	research and development
RBF	results-based financing
SO_2	sulfur dioxide
UNEP	United Nations Environment Programme
VC	venture capital

Terminology

"parc" refers to the total stock of vehicles on the road

"range anxiety" is the concern that the battery may lose charge while on the road without access to charging

2Ws go by different names in different countries and are referred to here as *boda bodas* (East Africa), or *okadas* (Nigeria)

Minibuses (14-seater passenger vehicles) go by different names in different countries and are referred to here as *danfos* (Nigeria) or *matatus* (Kenya, Uganda)

4Ws typically denote a passenger car/SUV/station wagon; occasionally, these are referred to generically as "cars"

LCVs are vehicles less than 3.5 tons, including panel vans, utility vans, and pick-ups

"used vehicles" are those that have already been driven and then re-sold

EVs here refer to BEVs unless otherwise specified

Sub-Saharan Africa excludes North Africa (Algeria, Egypt, Libya, Morocco, Tunisia). In general, unless otherwise specified, this analysis refers to sub-Saharan Africa excluding South Africa

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Market outlook

Growing vehicle parc...

43Mn 2040

14Mn today

50% will be 2Ws

Increased adoption...

Forecasted electric vehicle adoption:

80% by 2050 globally across all segments

50-65% by 2040 in SSA

20-40% by 2040 in SSA

3.8-4.9Mn electric vehicles sold in focus countries in 2040 (80-90% E2Ws)

...underpinned by 'green' power sources in many countries

70-90% renewable energy mix in East Africa

Thriving ecosystem...

20+ Startups with innovative business models in sub-Saharan Africa as of 2021

Impact

Reduction of up to **25%** of CO_2 **emissions** from transport in SSA by 2040

5-25%

Potential **reduction in air pollutants** (as seen from example countries)

Financing required

By 2030, at least

$ $ $ $ $

$3.5-8.9Bn

of total cumulative costs will need to be financed for E2Ws alone

Immediate financing needs include:

- **Validating and scaling asset financing models dedicated to E2Ws**
- **Launching an incubator for E2W assemblers / importers** to help them scale, including piloting business models and supporting collaboration on topics such as battery interoperability
- **Piloting different charging infrastructure models** to determine best solution

Analysis for five focus countries in sub-Saharan Africa (Ethiopia, Kenya, Nigeria, Rwanda, Uganda)

The transition to e-mobility in sub-Saharan Africa

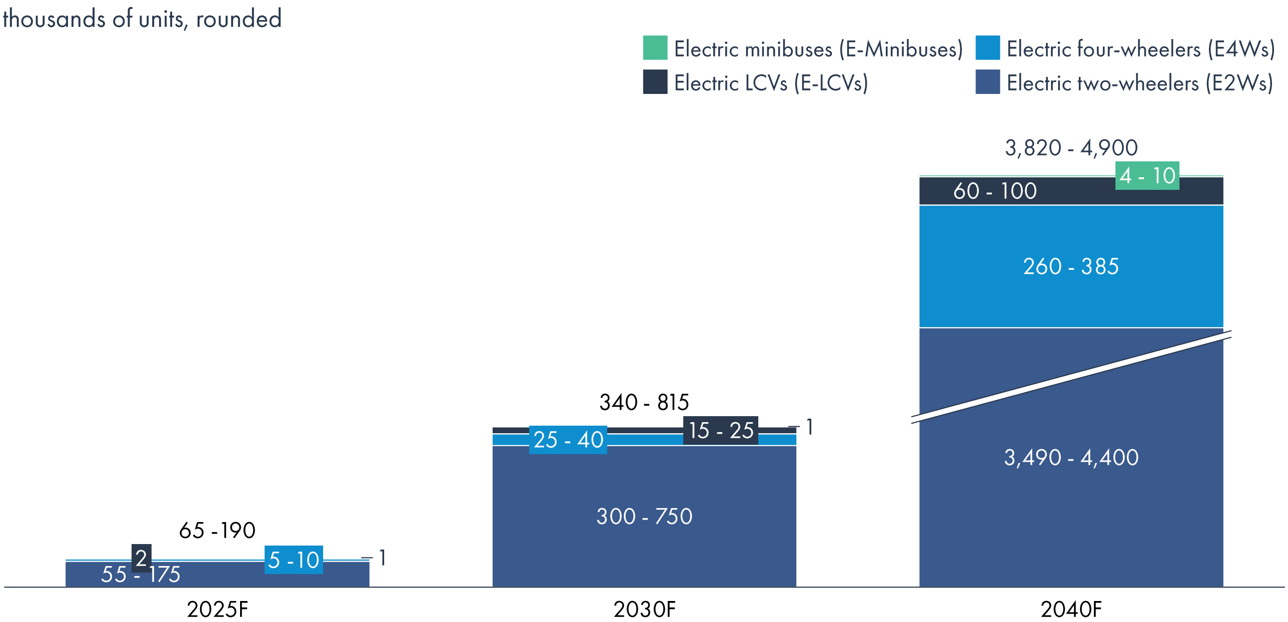
The global electric vehicle (EV) market is expected to reach 80% of sales across all segments by 2050. An article by McKinsey & Company, *Why the automotive future is electric*, defines three main drivers for this transition: increased regulation in support of EVs, changing consumer behavior, and advancements in EV and charging technology. Globally, OEMs are making commitments to cease production of internal combustion engine (ICE) vehicles meaning that, over time, new vehicles purchases will inevitably be EVs.

Sub-Saharan Africa faces unique challenges when it comes to the e-mobility transition, such as low rates of electricity access, low electricity reliability, and low affordability. However, this does not mean that the continent has to be left behind in the electrification of transport. Several governments (e.g., Rwanda and Kenya) have announced targets for electrification of transport and Rwanda has approved incentives for EV adoption, such as tax exemptions. Moreover, over 20 start-ups have emerged in sub-Saharan Africa focusing on e-mobility, particularly electric two-wheelers (E2Ws).

Recent analysis focusing on five sub-Saharan African countries (Ethiopia, Kenya, Nigeria, Rwanda, and Uganda) suggests that sales of EVs in these countries could be 340 – 820 thousand units in 2025 growing to ~3.8 – 4.9 million units by 2040 (see Exhibit 1). Most of these sales will be E2Ws due to their low charging requirements, high fleet turnover, and lifetime cost competitiveness. This suggests that 4-8% of the vehicle parc in these five countries will be electric by 2030, growing to ~25-35% by 2040.

Countries will also vary in terms of their adoption based on factors such as access to electricity, electricity reliability, degree of current EV market activity, and government electrification targets. A larger urban population also supports the use of EVs given that electricity access is much higher in urban areas and EVs are more likely to be used for short distance travel. In fact, vehicles going less than 70 km per day typically can recharge overnight using a standard wall socket (for two-wheelers, this could be up to 100 km per day depending on battery size). Further, restrictions on importation of used vehicles is an important factor for two reasons: (1) sales of newer vehicles are more likely to be electric and (2) EVs are more likely to be competitive when fewer low-cost, old ICE vehicles are available. Note that as

Exhibit 1: Annual sales of electric vehicles by segment expected in the five focus countries



Source: McKinsey Center for Future Mobility used EVs become available at-scale (in the 2030s), these reasons become less important.

Based on these factors, Kenya and Rwanda are likely to adopt EVs faster and Nigeria and Ethiopia slower (see Exhibit 2). However, in absolute terms, given that Kenya and Nigeria have the largest vehicle parcs in the five focus countries, they will also have the absolute largest number of EVs on the road.[1]

Exhibit 2: Country-specific factors considered for EV adoption

Favorable for EV adoption; Somewhat favorable for EV adoption; Unfavorable for EV adoption; Neutral

	Gasoline pump price $	World Bank Electricity reliability score (2017 data) Out of 7	Electricity price (household) $/kWh	Population access to electricity %	GDP per capita $	Urban population %	Age restrictions on used vehicle imports (2020 data) Years	Degree of EV market activity[1]	Stated electrification goals
Ethiopia	0.75	3.2	0.257	48	856	22	None	Low	12% of all vehicles to be hybrid and electric by 2050
Kenya	0.95	4.1	0.216	70	1,817	28	8	High	Aim for 5% of all imported vehicles to be electric by 2025
Nigeria	0.46	1.4	0.059	55	2,230	52	15	Medium	None
Rwanda	1.17	4.4	0.257	38	820	17	None	Medium	9% of vehicles to be electric with 20% being buses by 2030
Uganda	0.94	3.4	0.191	41	794	25	15	Medium	None

1. Qualitative assessment based on activity of start-ups or OEMs, or government programs in each country

Note: data is from 2021 unless otherwise specified

Source: World Bank, ICCT, UNECE, UNEP, country statistical agencies, press search

METHODOLOGY

EV sales were derived on a country-level based on an analysis of factors including rate of fleet turnover, consumer affordability for vehicles over time, access to electricity, driving behavior, economics of switching to EVs, and availability of EVs (particularly in the 2020-2030 timeframe). From this, consumer segments within each vehicle segment were derived with specific expected EV adoption behaviors. These segment specifics are discussed in later sections. Two cases were modelled, including a base case assuming current market forces and an accelerated case, assuming greater intervention from governments and private sector, including incentives for EV adoption and increased R&D in designing products targeted at the African market.

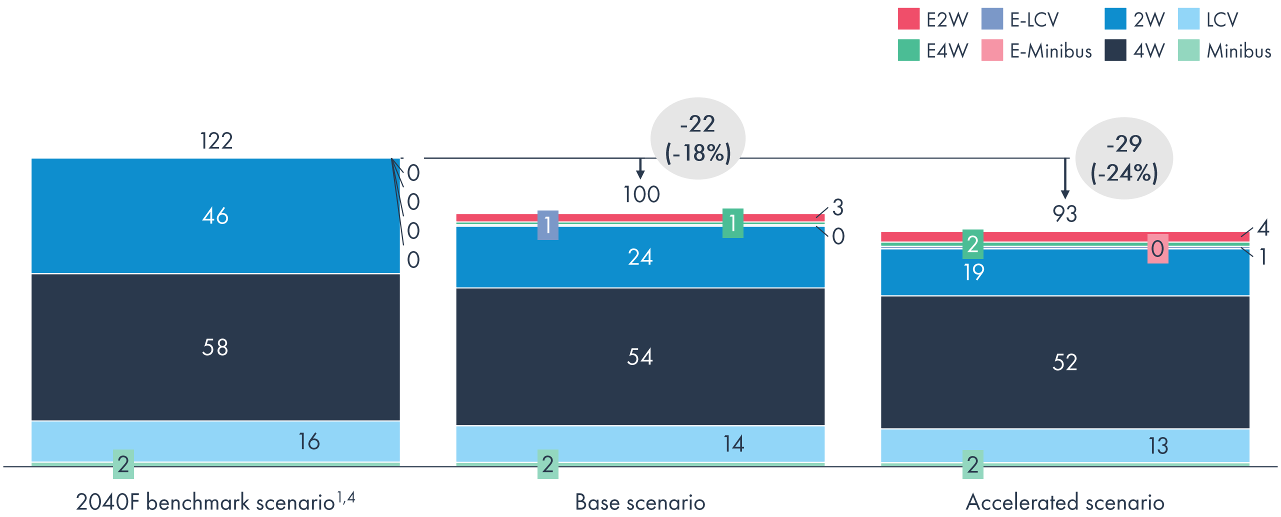
[1] Together, Nigeria and Kenya make up ~80% of the vehicle car parc of the five focus countries and are projected to represent 85% of all EVs on the road in these countries by 2040

Implications on carbon emissions and air quality

These market projections suggest that tailpipe emissions are likely to be 20-30% lower in 2040 compared to if there were no EVs on the road (see Exhibit 3). This is accounting for growth in the vehicle parc expected by 2040 and assumes the current electricity generation mix across the five focus countries. For example, an electric four-wheeler (E4W) in Kenya is likely to produce 80% less tailpipe emissions than an ICE 4W due to predominantly renewable electricity generation (primarily hydroelectric and geothermal) whereas this is 45% less in Nigeria due to a primarily thermal electricity generation mix.

Exhibit 3: Emissions reduction from projected adoption of EVs in the five focus countries

Tailpipe emissions 2040F, millions of tons CO_2, 5 focus countries for 2Ws, 4Ws, LCVs, and minibuses[1,2,3]



1. Assumes an CO_2 emission intensity of 88 gCO_2/km (ICE-2W), 142 gCO_2/km (ICE-4W), 154 gCO_2/km (ICE-LCV), 241 gCO_2/km (ICE- Mini bus)
2. Assumes battery efficiency of 0.04 kWh/km (E-2W), 0.18 kWh/km (E-4W) , 0.21 kWh/km (E-LCV), 0.5 kWh/km (E-Mini bus)
3. Assumes that both ICE and EV travel the same for the same segment
4. This scenario assumes there are no EVs in 2040 and that the vehicle parc has grown in-line with projections

Source: Expert interviews, country officially reported generation mix, EPA, Transport Sector Climate Change Annual Report (GIZ)

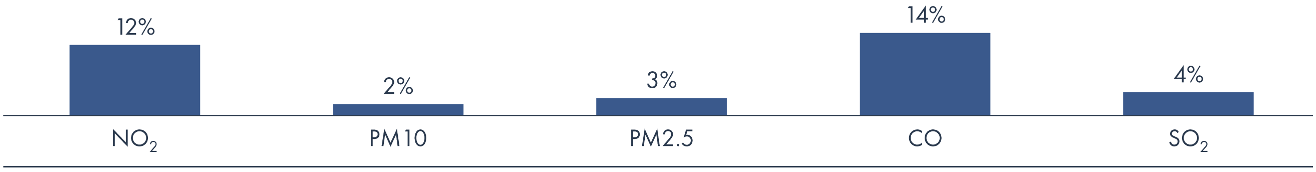
In addition to reducing CO_2 emissions, using EVs also decreases the concentration of air pollutants such as particulate matter (PM10 and PM2.5), nitrogen dioxide (NO_2), carbon monoxide (CO), and sulfur dioxide (SO_2). In China, for example, an impact study showed that 30% EV penetration by 2025 could reduce concentration of air pollutants by 5-15%. Some real impact has already been observed in major cities with significant EV adoption. In Taipei, early results show an 18% decrease in PM2.5 concentration in the air (from 22 to 18 µg/m3) thanks to the government EV program. Refer to Exhibit 4 for details on these results.

Exhibit 4: Findings on impact of air pollution from EV adoption

In Spain...

Research proved that 26% EV penetration could reduce the concentration of air pollutants by 3-14% in Madrid:

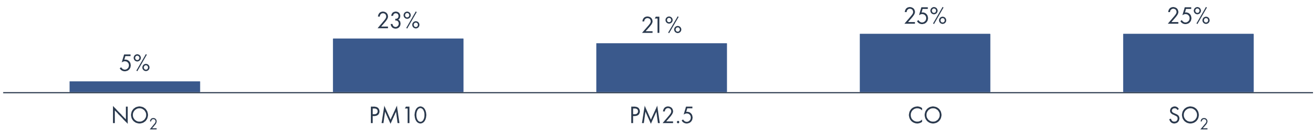
Potential pollutants concentration reduction (%)[1]



In China...

Another study on Shanghai indicated that 30% penetration of EV by 2025 could reduce the concentration of air pollutants by 5-25%

Potential pollutants concentration reduction (%)[2]



1. Albert Soret and al., "The potential impacts of electric vehicles on air quality in the urban areas of Barcelona and Madrid", 2014
2. Xiaojian Hu and al., "The Potential Impacts of Electric Vehicles on Urban Air Quality in Shanghai City", 2021

Source: UNEP, Research gate, RMI India, Elsevier, Standard, Press search

Emerging activity in EVs in sub-Saharan Africa

Momentum for EVs in Africa is growing. As mentioned, countries such as Rwanda are rolling out incentives like exemptions or reductions on import duties and taxes for EVs and their components. These initiatives are further supported by the development of an EV start-ups ecosystem, especially in the E2W segment. As of 2021, there are over 20 startups in the five focus countries focusing on E2Ws, with a range of business models, including local assembly and sales, battery-as-a-service (BaaS)[2], and asset financing. These startups are already attracting funding to scale. For example, Ampersand in Rwanda raised a $9 million loan from DFC in Q4 2021 to scale up the number of electric motorcycles on the road in Rwanda and Kenya to several thousand by the end of 2022. Opibus in Kenya raised $7.5 million in November 2021 for expansion in Kenya. Tugende, a Ugandan technology-enabled asset finance company, announced that it has closed $3.6 million in a Series A extension round in 2021.[3] As part of its support to the sector, Shell Foundation provided early catalytic grant and venture building support to Ampersand and Tugende.[4]

2 Examples of this model include selling the E2W without the battery and offering the battery on rental
3 Publicly-announced funding from Ampersand (ampersand.solar), Opibus (www.opibus.se), and Tugende (gotugende.com)
4 https://shellfoundation.org/news/mobility-partners-tugende-and-ampersand-close-investment-rounds/

Deep dives on specific vehicle segments

This analysis focuses on four vehicle segments: two-wheelers (2Ws), four-wheelers (4Ws), light commercial vehicles (LCVs), and minibuses. Three-wheelers (3Ws) are also suitable for EV adoption but were not analyzed due to poor data availability on the number of 3Ws in Africa. In general, 3Ws should have similar characteristics to 2Ws in terms of EV adoption (e.g., driving behavior, charging requirements), with the caveat that most 3Ws in Africa are in secondary towns or the outskirts of major towns (often banned in major urban areas), implying slower transition to electric.

Electric two-wheelers

There were 6 million 2Ws on the road in 2020 across the five focus countries, and projections suggest this number will grow significantly to reach 21 million by 2040, driven by increased urbanization and greater demand for delivery and ride-hailing services.

In most of the focus markets, the dominant use for 2Ws is commercial, particularly for passenger transport or deliveries. For example, in both Kenya and Nigeria, 90% of all 2Ws are estimated to be for commercial use. This contrasts with Asia, where the dominant use for 2Ws is for personal transport. These commercial 2W drivers are primarily independent owners who contract to ride-hailing, taxi, or delivery services or are self-employed taxis. They often work 10-12 hours per day, with 1-2 hours of idle time during the day. They also tend to purchase a new 2W every 2-5 years (in Kenya and Nigeria, the two largest markets, new purchases are every 1.5-3 years).

In Kenya, most 2W owners buy their vehicle on a hire-purchase basis (typically an 18-month loan) from a network of specialized dealers or asset financiers (for example, Watu, Mogo, and Tugende). In Nigeria, most 2W owners also buy on a hire-purchase basis, but often rely on loans from family and friends or from local *okada* associations.

All these factors support faster adoption of EVs. Commercial drivers tend to drive longer distances per day, which improves the lifetime economics of an E2W versus an ICE 2W due to greater operating cost savings.

However, feedback from vehicle owners and E2W companies in the focus countries as well as the experience from Asian markets suggests a few key factors will need to be in place to drive up E2W adoption:

- **Strong powertrain to carry heavy loads.** Given that most 2Ws in Africa are for commercial use and often carry passengers and heavier loads over rough roads, ensuring the E2Ws have a strong powertrain is critical. Some E2W models from Asia have been found to be less suitable in sub-Saharan Africa as a result and many local E2W assemblers are investing in local product development to develop E2Ws more tailored to the local market. **Long-lasting battery with conveniently located charging or battery swap stations to ensure that work is not disrupted.** Battery swapping (switching out a depleted battery for a charged battery at a swap station) has become the norm is some Asian countries. For example, Gogoro in Taiwan offers an extensive self-service battery swap network (as of August 2021, reported at 2,100 stations doing 270,000 swaps per day). Most commercial 2Ws in Africa will go 130-150 km a day, which may require up to one battery swap during the day (or ability to charge over lunch and intermittently during the day) in addition to overnight charging at home. Some E2W assemblers in Africa are looking to create bikes that have two batteries to create longer ranges for the vehicles as well as investing in creating a battery swap network.
- **Lowering the upfront cost to purchase.** As with all EV segments today, the cost of an E2W is much higher than for a 2W. Analysis by UKAid's Manufacturing Africa program in Kenya in 2021 suggests that the average price for a locally assembled ICE 2W is $1,300 while the average price for a locally-assembled E2W is currently

$1,800[5]. Decreasing battery costs may bring this price down slightly in the next 5 years; however, bringing the cost down to full parity with the ICE 2W within that timeframe would require incentives, product innovations, or innovations in business model (e.g., selling the E2W without the battery and then renting the battery to reduce the upfront cost).

Multiple business models are emerging across the five focus countries (see Exhibit 5). While some companies are importing and selling completely built up units (CBUs), several are importing completely knocked down kits (CKDs) and assembling locally. Most are investing in product development to tailor the E2Ws to the local market, including adding space for two to three batteries to facilitate longer driving distances, improving the power of the vehicles to facilitate carrying passengers or heavier loads, and tailoring the design to match the look-and-feel of familiar ICE 2W brands. Many have expressed interest in further developing the local manufacturing value chain to allow for local manufacturing of components. For example, Opibus has stated it sources 35% of its components locally and is aiming for 65%. Bodawerk in Uganda has set up a lithium-ion battery pack assembly unit.

Players are also innovating on battery servicing and swap models. For example, Ampersand in Rwanda is using a BaaS model, selling the E2Ws without the battery but offering the battery on a rental basis including access to a network of battery swap stations. As with the E2Ws themselves, further experimentation is needed to determine the best charging infrastructure product for sub-Saharan Africa, particularly to minimize the capital burden of funding an extensive network of swap stations with a large battery inventory or public charging points. In fact, a large swap network

Exhibit 5: Overview of business models adopted by E2W players

[5] Taxes included

with low battery utilization can be loss-making, particularly as costs for swaps might have to stay in the $1-2 range to continue to maintain the E2W competitiveness against the ICE 2W. African players can leverage the experience of Asian players when experimenting with charging infrastructure to reduce the cost burden of charging infrastructure. These include limiting the number of swaps per customer per month, focusing on self-service swap stations to minimize labor costs, standardizing battery technology across OEMs to gain scale economies, and conducting geospatial mapping (in partnership with ride-hailing companies, for example) to place swap and charging stations in the highest through-put points to increase overall utilization (see Exhibit 6).

"Our experience in Asia is that ***swapping fees need to be very high to justify the costs of swap stations****, which is why we are experimenting with different models like battery-as-a-service"*
– Southeast Asian E2W market expert

Exhibit 6: Example approaches adopted in Asia to improve cost effectiveness of battery swap infrastructure

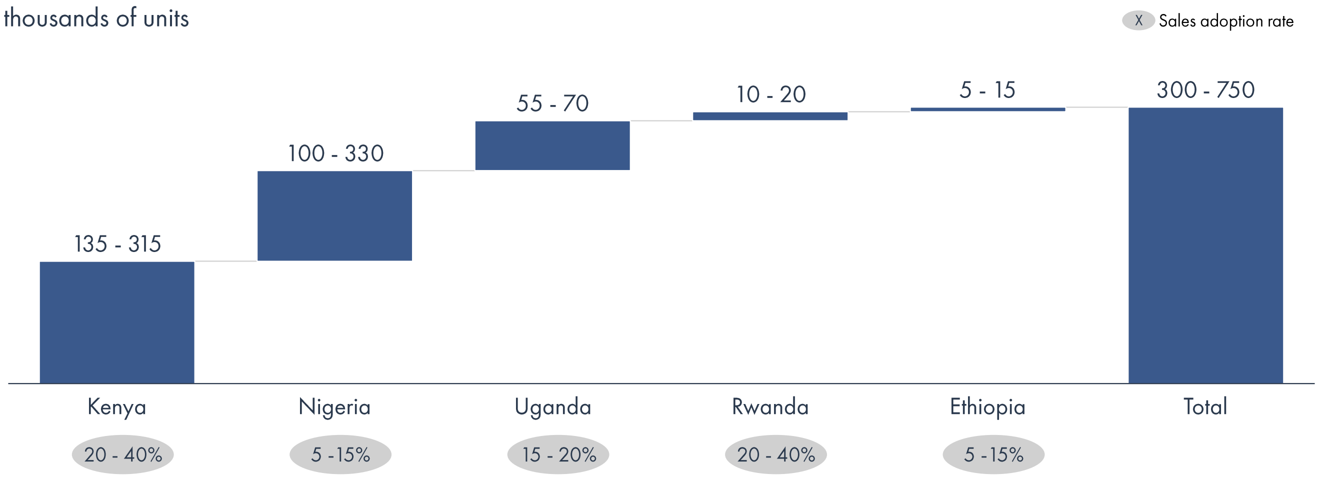
Initiative	Impact	Example
Battery interoperability with common batteries across E2W models to enable sharing of battery swapping infrastructure	Promotes **scale** and therefore **optimises capex** and labor spend, and increase revenues	gogoro: Gogoro sells its battery technology to partner OEMs, and then charges drivers subscription fees for use of battery and charging infrastructure
Discount on electricity tariff for charging station owner	**Decreases energy cost**, therefore improves profitability of charging stations (which might otherwise be uneconomical)	Bluebird, PLN: Bluebird, a transportation company in Jakarta with an EV fleet, received a 50% power price discount from PLN
Self-service battery swap stations	**Decreases labor cost**, therefore improves profitability of swap stations (which might otherwise be uneconomical)	Grab, gojek: Grab/Gojek, a delivery service in Indonesia, has developed a self-service battery swapping cabinet that provides standardized batteries The company expects the cabinets to have high enough utilization to be profitable and therefore is attracting local partners such as convenience stores to install and operate them without requiring extra labor cost
Optimizing battery swap station locations	**Increases swap station utilization**, therefore reducing battery stock requirement	
Battery-as-a-Service with a monthly subscription fee, limiting **number of swaps or using tiered fees for usage levels**	**Decreases battery stock required** (encourages home charging) Improves **profitability per battery**	gogoro: Charges a tiered fee model depending on level of usage

Source: Company websites, expert interviews

Finally, several asset financiers are developing dedicated models for financing E2Ws. For example, Tugende in Uganda and MAX.ng in Nigeria are piloting asset finance for E2Ws, building on their existing know-how for ICE 2W asset finance.

As a result, and following the trend seen in Asia, the E2W segment could to rise rapidly in sub-Saharan Africa. By 2030, annual sales of E2Ws could be 300-750 thousand units in the five focus countries, majority in Kenya and Nigeria as they are larger markets (see Exhibit 7).

Exhibit 7: Estimated annual sales of E2Ws in 2030 by country



Electric four-wheelers

There were 7 million 4Ws on the road across the five focus countries in 2020, and this number could grow to 18 million by 2030, driven by population growth, growing income levels, and increased urbanization.

The findings suggest that the lifetime cost of an E4W is better than the lifetime cost of a comparable ICE 4W, even in countries with comparatively high electricity tariffs (e.g., Kenya, where the average tariff is $0.22). Moreover, almost all 4W owners have access to electricity and park in a parking space at home and at work, meaning that access to charging infrastructure is feasible with some modifications. Moreover, most 4W owners using their vehicles for personal use do short trips meaning that basic wall charging should be sufficient. However, 4W owners that use their vehicle for commercial use (e.g., taxi drivers) would likely require increased charging infrastructure as they go longer distances per day and might need to charge on-the-go. This means that commercial 4Ws are likely to face lower EV adoption without investments into charging infrastructure.

However, even for those that might have access to charging infrastructure today, the primary barrier to the transition to E4Ws in sub-Saharan Africa is affordability. Over 80% of all 4Ws in the focus countries are purchased used and are relatively old. A United Nations Environment Programme (UNEP) report found the average age of imported cars in Kenya to be 7 years and in Rwanda and Uganda, 15 years.[6] With a supply of low-cost used ICE vehicles available, adopting a new E4W will be challenging for most vehicle owners without significant incentives. However, once used E4Ws become more available in the mid-to-late 2030s, adoption will start to grow in this segment, particularly as ICE vehicles start to become less available due to global OEM commitments to cease ICE vehicle production.

Getty Images

[6] UNEP, *Used Vehicles and the Environment,* 2020

Electric light commercial vehicles:

There were 1.5 million LCVs on the road in the five focus countries in 2020, and this number could reach 3 million by 2040, driven by increased economic activity. LCVs have three different customer segments, each of which have different adoption rates for EVs:

- **Commercial – privately-owned:** These are LCVs purchased and owned by an individual and on hire for commercial use, estimated to make up 45-50% of all LCVs in the focus countries. These vehicles tend to be purchased used and are parked at the home of the driver overnight. Despite more favorable lifetime costs for E-LCVs compared to ICE EVs, EV adoption in this segment is likely to be low in the near-to-medium term due to affordability barriers for private owners.
- **Commercial – company-owned:** These are LCVs purchased and owned by a company. Vehicles in this segment are mostly new and represent 45-50% of the total parc. They are typically parked at a depot. This segment is the most likely to transition to electric, given that corporates are more likely to value the operating cost savings from an E-LCV when making purchasing decisions, have access to funds that allow them to purchase E-LCVs, and have sustainability commitments encouraging adoption. Nonetheless, interviews with corporate fleet owners suggest many in sub-Saharan Africa are still unaware of the lifetime cost savings from E-LCVs and are concerned about the performance of the technology for their needs. This suggests piloting and testing in this segment are still required and adoption is unlikely to be fast without company-wide policies encouraging the switch.
- **Privately-owned for personal use:** These are LCVs privately owned and used for personal use (e.g., as farm vehicles). Vehicles in this segment are mostly used and represent less than 5% of the total parc. Non-commercial LCVs have lower mileage, meaning that the high upfront cost will take longer to recover. EV adoption is then likely to be low in this segment.

Electric minibuses

This segment is the smallest with ~260,000 vehicles estimated across the five focus countries in 2020 and ~350,000 parc size projected by 2040. This analysis focuses primarily on minibuses (14-seater vehicles, often referred to as *matatus* in Kenya or *danfos* in Nigeria) as they make up 50% of the total bus parc and are most likely to be suitable for EV adoption as they are smaller (therefore, requiring smaller batteries) and predominantly used for urban transport, travelling comparatively shorter distances and therefore requiring less charging infrastructure.

Route dynamics are critical in determining which minibus sub-segments might be feasible for EV adoption. There are three such sub-segments:

- **Intracity minibuses:** These minibuses typically travel the same routes every day with an average driving range of up to 150 km per day. This sub-segment represents 85% of the minibus parc size and is the most suitable for transition to electric given that these vehicles should be able to get sufficient charge from an 8-10 hour overnight charge (likely with a Level 2 charger). An analysis of the driving behavior of these minibuses suggest that this should be possible as often these vehicles park overnight in a petrol station or depot (see Exhibit 8).
- **Sub-urban minibuses:** These minibuses typically travel the same routes every day but go much farther, potentially into areas around major urban centers and therefore will have an average driving range of 150-250 km per day. This sub-segment represents 10-15% of the minibus parc size. Due to the driving distance, it is much less suitable for EV adoption without expensive fast-charging infrastructure en-route.
- **Intercity minibuses:** These minibuses are typically travelling the same routes but between cities, with an average driving range of greater than 250 km per day. Approximately 5-10% of minibuses are in this sub-segment. This segment is the least suitable for transition to electric given high charging infrastructure requirements en-route to support the long distances.

Shell Foundation is currently supporting applied research of electric matatus in Kenya through a pilot.

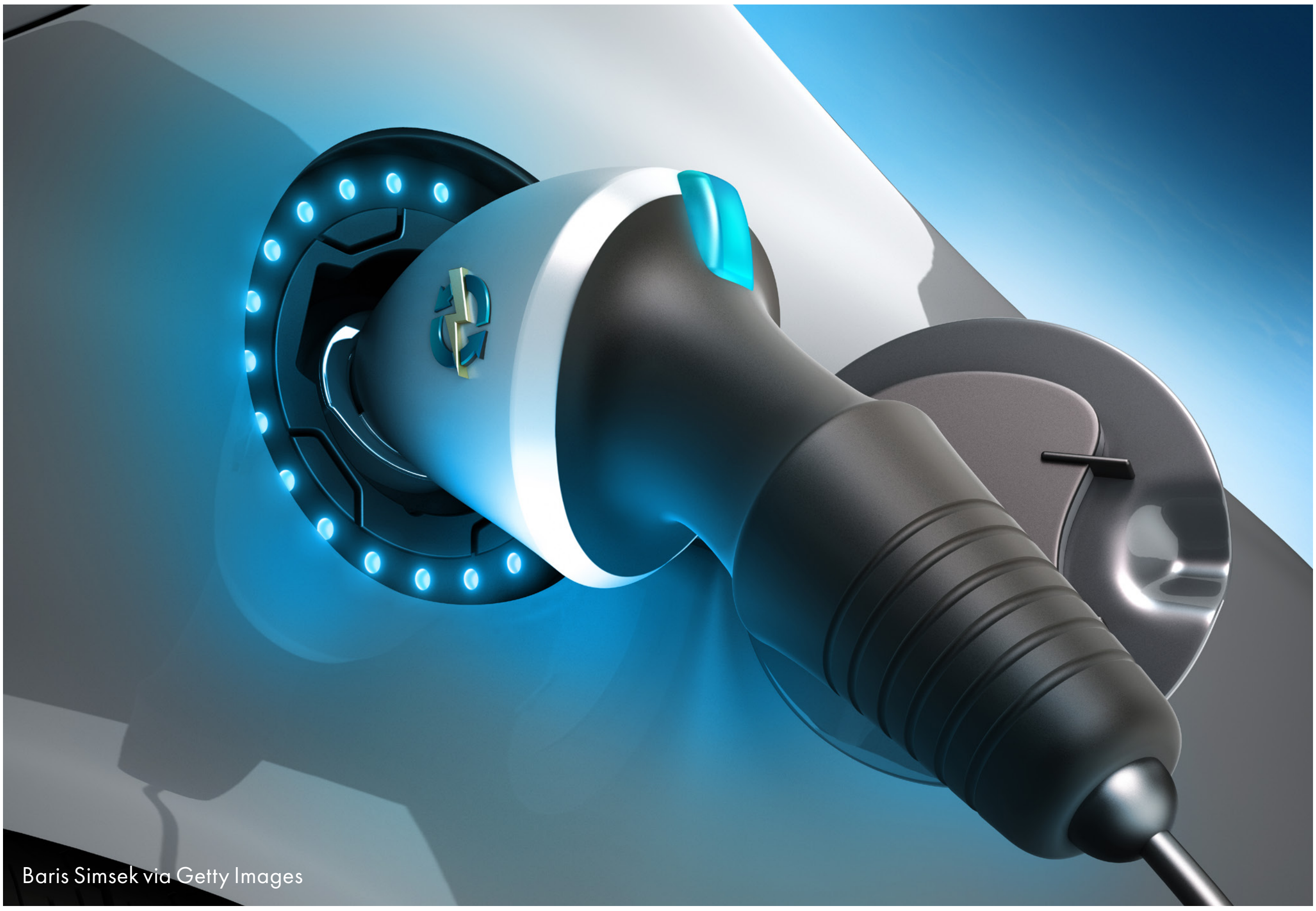
Exhibit 8: Intracity minibus driver journey in Kenya

Activity description	Driver **parks** the minibus at a **petrol station** overnight	Per arrangement with the petrol station, drivers **fill up at the petrol station where the bus was parked overnight**	Drivers **typically travel the same routes every day** within the city, covering up to 150km per day	Drivers stop at **crowded stages** where they **wait for customers to board.** Time spent waiting varies from 15 minutes to an hour	Drivers return to petrol station after a **10-14 hour day**
Implications for electrification	Drivers can **charge** buses **overnight** but this requires petrol stations to install at least **Level 1 charging infrastructure** to ensure batteries are fully charged for the following day		Drivers will need to access **fast charging infrastructure** during the day if they travel greater than 150 km per day	Drivers of minibuses that **travel less than 150 km** may be able to **transition to electric**, assuming they have access to Level 1 charging at night Drivers travelling further than this **may require Level 2 or or DC fast-charging** which may act as a **barrier to adoption** given the cost of these charging stations	

Source: Interviews with matatu associations

Through this, Shell Foundation seeks to understand electric matatus' performance, commercial viability, and the path for potential scale-up through working with key stakeholders.

However, even while some minibuses might be suitable for EV adoption, affordability and range anxiety are likely to be significant barriers. Despite being the predominant form of public transport in many sub-Saharan Africa countries, minibuses are mostly private owned by individuals or minibus associations and are also primarily purchased used. This means the upfront cost to purchase an EV is again likely to be the major barrier. Moreover, even while an overnight charge should be sufficient to support a full days' driving for some routes, the fear of running out of charge while on a route (particularly given little downtime for the minibuses during the day) is significant. This suggests that a scale-up in E-minibus (and E-bus) adoption will require government incentives as well as investment in charging infrastructure.



Baris Simsek via Getty Images

Financing solutions to scale e-mobility

$3.5-8.9 billion in costs will need to be financed by 2030 for E2Ws alone in the five focus countries

Scaling e-mobility in Africa will require financing for consumers (asset financing for the vehicle), for EV assemblers and importers, and for charging infrastructure (including both "light" charging infrastructure such as battery swap stations for E2Ws or modifications to enable at-home Level 1 charging as well as "heavy" charging infrastructure such as fast-charging and electricity grid upgrades).

Given that E2Ws are likely to be the majority of EVs on the road in sub-Saharan Africa, this analysis focused particularly on this segment in determining financing needs and solutions. For E2Ws alone, $3.5-8.9 billion in costs will need to be financed by 2030, with the range depending on different cases for EV adoption (see Exhibit 9)[7]. This includes $200-560 million until 2023 for the start-up phase as E2W assemblers, importers, and asset financiers start scaling. This is based on assuming 85% of all E2Ws are purchased with some form of asset financing, that most E2Ws are locally assembled (as is true for ICE 2Ws), and that a network for charging and battery swap stations is built to service the full market in the five focus countries. Note that this number represents cumulative total costs (e.g., the total cost of inventory and the value of the asset financing receivables) so depending on the structure of the financing provided, the financing need could be much smaller. For example, if working capital is financed as a revolving facility that finances only net cashflows, then the maximum financing need by 2030 would be $350-1,000 million.

This financing need breaks down into three categories:

Asset financing for E2Ws: As mentioned above, most 2Ws in the focus countries are purchased with some form of financing, whether formal financing via specialized asset financiers or informal financing via loans from friends and family. In structure, asset financing for E2Ws is similar to existing asset financing for ICE 2Ws. However, asset financiers are currently faced with the challenge of being unfamiliar with E2W credit cycles and technologies, such as the life cycle of batteries and the residual values of E2Ws. Consultation with EV assemblers and importers in Africa and experts in Asian markets has shown that battery life will depend on the technology leveraged and can vary from ~3-7 years. Further research and piloting are therefore required to inform asset financiers and mitigate technology risks.

> *"**Consumer financing for EVs** should not be considered different to **consumer financing for ICE vehicles** ... Consumer financing for EVs should be piloted to **understand the residual value of electric vehicles"*** – **Development partner**

E2W assembly / import: Like asset financing, financing E2W assemblers and importers is similar to financing for ICE 2W assemblers and importers. However, E2Ws assemblers and importers in Africa today are still early-stage and small-scale. As a result, E2W assemblers and importers face cashflow constraints because they are unable to negotiate favourable payment terms from suppliers. One assembler interviewed indicated that they pay six months in advance for imported E2W CKD kits. Addressing working capital constraints will therefore be essential to enabling E2W assemblers and importers to scale.

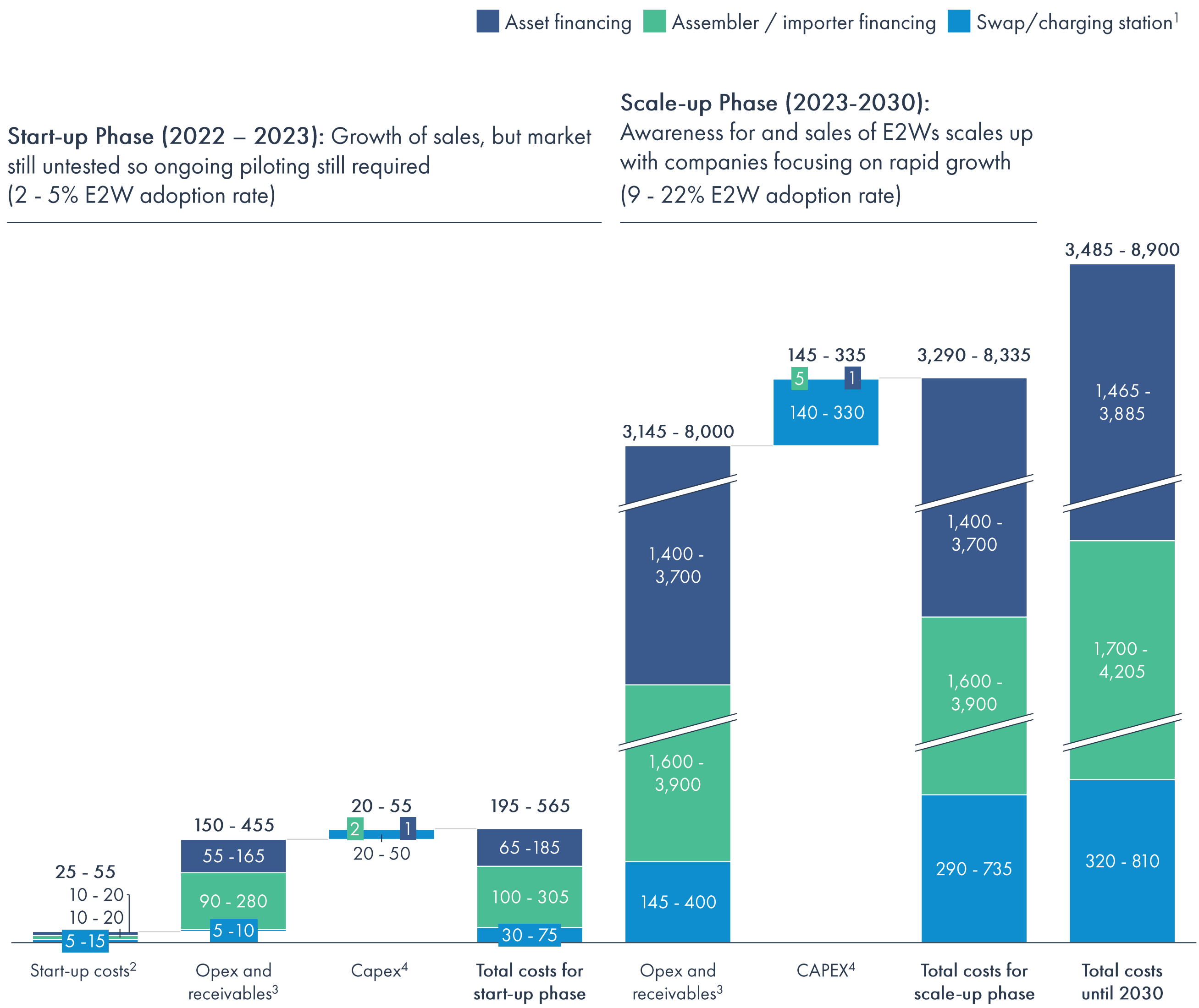
> *"E2W assemblers / importers are **unable to import at scale** because they **cannot meet upfront payments"*** – **Financier**

[7] This is based on two different methodologies for sizing financing needs. The $3.5-8.9 billion assumes all cash outflows need to be financed (e.g., the full cost of an imported CKD). On the other hand, the $350-1,000 million assumes that only capital expenditure and working capital needs to be financed (e.g., only the working capital required to finance the import of a CKD for a few months before its sale needs to be financed). These two values are not additive and instead represent two different approaches to sizing.

Battery swap and light charging infrastructure for E2W: This is the most capital-intensive part of the value chain. As discussed above, depending on the model, this part of the business model can also have the most challenging economics as companies need to support a large inventory of batteries or charging stations with small revenues (e.g., cost charged per battery swap is typically $1-2).

Exhibit 9: Total costs for scale-up of E2Ws in the five focus countries from 2022-2030

USD millions, E2Ws only, range represents base to accelerated case



1. Figures based a combined swapping and charging station model. A charging-station-only model would have much lower costs
2. Including personnel and overhead costs plus R&D and upfront marketing / customer acquisition costs. Assumes 10 companies and that some will fail
3. Includes inventory, receivables (for asset financing), and other operating costs, such as personnel, warranty costs, etc.
4. Required for software and product development costs, assembly facilities, and swap / charging stations as required by the different business models

Seven financing solutions to scale e-mobility in sub-Saharan Africa

Given the size of the opportunity, interest in financing e-mobility (particularly E2Ws) is growing among financiers in sub-Saharan Africa. As mentioned above, in the past year alone and in a very nascent market, EV start-ups have raised $25 million in financing (publicly disclosed funding only). In discussions with over 20 financiers in sub-Saharan Africa, including commercial banks, VC funds, PE funds, and DFIs, all expressed interest in e-mobility and many identified it as a priority sector. However, they all expressed the need to address the challenges in financing EVs described above.

Through this analysis, seven financing solutions for e-mobility in Africa were co-developed with a range of financing players in the five focus countries (see Exhibit 10). These financing solutions will require collaborations among different types of financiers such as grant providers, DFIs, venture and equity funders, and commercial banks.

Exhibit 10: Seven financing solutions to scale E2Ws in sub-Saharan Africa

		Financing solutions	Primary financier
Asset financing	1	Create a dedicated (ring-fenced) financing facility for E2Ws with a first-loss guarantee. Option to incorporate a results-based financing (RBF) facility with a grant provider designed to reduce cost of lending to the end-consumer, with either a: • Tiered subsidy depending on sales volume to reduce end-price to the consumer • Tiered loan interest rate that reduces with achievement of certain sales targets Pilot the asset financing solution above to prove out the credit cycle and residual values for E2Ws	Asset financer Grant provider (for RBF) DFI or grant provider (for first-loss guarantee)
	2	Co-develop (with a payment provider, asset financier, ride-hailing company, etc.) an IoT-enabled payment model that allows payment of loan based on income for commercial vehicles	Asset financier Payment provider / FinTech
EV assembler / importer	3	Set up an incubator for EV assemblers / importers with grant financing to assist companies to become investment ready, conduct pilots, and help match companies to investors	Grant provider / Incubator
	4	Provide credit facility through a commercial bank that de-risks inventory financing for EV assemblers / importers	Commercial bank / DFI / Equity provider
	5	Negotiate better payment terms with suppliers (e.g., of CKDs of CBUs) to reduce working capital burden, potentially underwritten by first-loss guarantee (*also applies for swap station battery imports)*	EV assemblers / importers Grant provider / DFI for first-loss guarantee
	6	Raise a green corporate bond (with associated "greenium") to fund assembly and inventory costs (can also be done for swap stations / charging infrastructure) – *typically requires ~$40-50M to be viable*	Commercial bank / DFI
Charging and battery swapping infrastructure	7	Receive carbon credits earned by setting up charging infrastructure to fund an affordable swapping and charging cost (e.g., effectively a 'subsidy' on the swap fee or electricity price)	Carbon market facilitator and verifier

1. Dedicated asset financing facility for E2Ws with a first-loss guarantee and potential results-based financing mechanism

This facility would encourage asset financing availability for E2Ws despite the credit and technology unknowns described above. This facility might need to incorporate an upfront pilot to test the credit cycle, but can then scale potentially with a first-loss guarantee to cover the risk around the technology. It could also incorporate a form of results-based financing (e.g., a tiered subsidy or interest rate) as volumes of sales increase to continuously incentivize E2W sales and potentially bring down the cost of finance (see Exhibit 11).

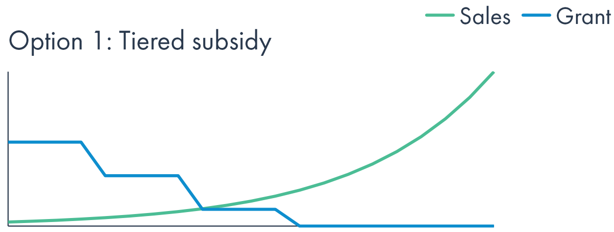
2. IoT-enabled payment model to de-risk loan repayments

EVs could also present an opportunity for piloting different models for repayment of asset loans for commercial vehicles using IoT. For example, this could enable better tracking of routes and driving behavior to assess credit worthiness of different vehicle owners or using fintech partnerships to deduct loan payment at-source as the driver receives payment from passengers or for deliveries. This would serve to de-risk asset loans and potentially also allow extension of asset finance to new segments given the increased data on customer creditworthiness that can be accessed.

3. Long-term Incubator for EV start-ups to support the scale of individual companies as well as the ecosystem

Developing and scaling business models that work for the EV ecosystem of sub-Saharan Africa will require financing and technical advice. An incubator for these start-ups can fund pilots (potentially through grant financing) but with the aim to develop viable business models and connect start-ups to investors and financiers. The incubator can also help familiarize investors with EV business models. The incubator can also play a role in developing the ecosystem. For example, this could include supporting collaborations on developing interoperable battery technology, joint development

Exhibit 11: Use of results-based financing for asset financing for E2Ws



Cost of bike partly subsidized in early stages. Subsidy can be passed on to the consumer or enable company to innovate around different structures such as lower deposits

As business scales, grant decreases as companies should have access to economies of scale to bring costs down

Concessional interest rate that decreases over time with sales targets achieved

Designed to make cost of financing lower for consumers and also enable expansion of lending of a local supply base, and joint product design. See Exhibit 12 for examples of the roles for this incubator.

4. Credit facility for inventory financing

Inventory finance for importers or assemblers of vehicles exists via commercial bank finance in the focus countries. Discussions with some commercial banks indicate that they finance everyone from the larger assemblers to smaller dealers. However, given the nascency of the EV market and many assemblers and importers being asked to pay upfront for CBUs or CKDs, a financing structure that eases this cashflow burden for inventory purchases may be important upfront. For example, this could include credit guarantees that enable a payment holiday on repayments for a short timeframe of a few months to ease the cash burden. Over time, as the market scales and EV players are able to negotiate improved payment terms and become more established businesses, this can transition to full commercial finance.

5. Improved payment terms with suppliers

Another option on inventory finance could be to directly negotiate improved payment terms with the CBU or CKD suppliers. This might require an upfront guarantee or letter of credit that could be provided through a concessional financier to start, transitioning to full commercial terms as businesses scale.

6. Green corporate bond

As a medium-to-longer-term financing option, EV companies could raise green corporate bonds, accessing a "greenium" to gain funding cost advantages. Green bonds are nascent in the five focus countries. For example, Kenya closed its first green bond in 2019 – a $40 million bond raised by Acorn Holdings Africa to finance green and environment-friendly accommodation for 5,000 university students in Nairobi. However, as green bonds continue to be developed in sub-Saharan Africa, this could become an increasingly attractive option, particularly when EV companies reach the $40-50 million financing need that is the minimum threshold to make a green bond viable.

7. Carbon credits, particularly for charging infrastructure

Carbon credits for transport are still nascent globally, with as-yet underdeveloped standards for development, verification, and monitoring of carbon credits for EVs and the EV ecosystem. Moreover, the costs of monitoring, reporting, and verification

Exhibit 12: Example roles for an EV incubator in sub-Saharan Africa

Support start-up scale-up and ecosystem building

- Collaborate on ecosystem-building activities, including setting up shared charging infrastructure, creating standards for battery interoperability, joint product design, and joint value chain development (e.g., for local component production)
- Support piloting of business models and financing models (e.g., testing of carbon credit model)
- Help collaborate on policy advocacy and building and maintaining market data

Mobilize funding

- Maintain and build investor pipeline interested in investing in EV players
- Develop investor education and attraction materials
- Support scale-up and fundraising efforts

(MRV) in transport can also be prohibitive, given the need to conduct detailed practical testing of several hundred vehicles combined with manual checks and certifications of vehicles. As a recent analysis conducted by South Pole for Shell Foundation on this topic suggests, digital technologies could provide simplified and cost-effective MRV for EVs.[8] Moreover, recently, carbon credits for EV charging infrastructure have emerged. In 2020, SCS Global Services, Electrify America, and Verra announced the first validated and registered carbon offset project for charging infrastructure, funding credits for 3,500 DC fast chargers operating in 430 stations in the United States.[9] If deployed in sub-Saharan Africa, carbon credits could contribute to improved economics for switching to EVs and for charging and battery swap infrastructure.

*"EV assemblers / importers have been unable to utilise carbon credits due to the challenges of proving additionality; however, there are **emerging examples of charging infrastructure receiving carbon credits on the voluntary market** "*
– Carbon market expert

[8] South Pole. *Scoping carbon market instruments to unlock carbon finance for sustainable mobility in Sub-Saharan Africa*. 2021. Available online: https://shellfoundation.org/app/uploads/2021/11/SouthPole-report.pdf

[9] https://www.scsglobalservices.com/news/worlds-first-validated-and-registered-carbon-offset-project-for-electric-vehicle-chargers

Conclusion

E-mobility presents significant economic opportunities and environmental benefits for Africa, and the transition is already gaining traction in certain parts of the continent. For 2Ws (which are expected to comprise >80% of the EVs on the road in Ethiopia, Kenya, Nigeria, Rwanda, and Uganda), $3.5 – 8.9 billion of costs will need to be financed across asset financing, vehicle import and assembly, and charging infrastructure. As other vehicle segments scale up (largely post-2030), additional financing will be required for those segments and in particular to strengthen the electricity grid to support charging of larger vehicles. Seven potential financing solutions could be deployed over the next years to help fill the financing needs, with a particular focus on E2Ws. A range of different types of financiers will need to collaborate to unlock these solutions.

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