FINAL REPORT

ENVIRONMENTAL IMPACT OF E-MOBILITY IN THE LAKE VICTORIA REGION, WESTERN KENYA

Environmental Impact of E-Mobility in the Lake Victoria Region, Western Kenya

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EED Advisory Limited
145 Isaac Gathanju Road, Lavington, Nairobi
P.O. Box 66053-00800, Nairobi, | T: +254 (20) 2574927
E: contact@eedadvisory.com | W: www.eedadvisory.com

Acronyms

BAU	Business As Usual
CKD	Completely Knocked Down (CKD)
E2W	Electric Two Wheelers
EVs	Electric Vehicles
FAME	Faster Adoption and Manufacturing of Hybrid and Electric (FAME)
GHG	Greenhouse Gas
HOV	High Occupancy Vehicle
KEBS	Kenya Bureau of Standards
KPLC	Kenya Power and Lighting Company
Li-ion	Lithium ion battery
MAAK	Motorcycle Assemblers Association of Kenya
NEMP	National Electric Mobility Mission Plan
NSE	National Securities Exchange
OEM	Original Equipment Manufacturers
SGST	State Goods and Service Tax (SGST)
SKD	Semi-Knocked Down (SKD)
TTW	Tank to Wheel Emissions
VKT	Vehicle Kilometres Travelled

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Executive Summary

Engagement for e-mobility in rural Sub-Saharan Africa has become an international trend in the fight against climate change. Siemens Stiftung in collaboration with its local implementation partner, WeTu, has piloted an incubation program for e-mobility technology solutions factoring in production, charging infrastructure and innovative business models in the Western Region of Kenya, specifically, Migori, Siaya and Homa Bay counties. As the rural economy utilizes two- and three-wheeled vehicles, light transport vehicles and fishing boats, it presents an opportunity to leapfrog conventional mobility to sustainable alternatives. Although environmental benefits such as Greenhouse Gas (GHG) abatement can be assumed from the early adoption of e-mobility, it is crucial to quantify and accurately represent these benefits with data.

Siemens Stiftung, with support from the German Development Cooperation, mandated this study on the environmental impact of e-mobility in the Lake Victoria Region in Western Kenya. The objective of the study is to establish the GHG abatement potential as well as any other environmental benefits accruing from the adoption of e-mobility through a fleet assessment of the conventional two-, three-wheelers and diesel outboard engines. This included a review of the policy landscape, highlighting existing policies aiding the shift and offering insight on future policy considerations needed for sector growth as well as an in-depth understanding of the impact of EV's on energy demand. An assessment of carbon trade through government CO_2 compensation instruments and the voluntary mechanisms also contributed to the findings of the study.

The study , which was carried out in Siaya, Migori and Homa Bay counties from March to September 2020, incorporated a cross-sectional design using both quantitative and qualitative approaches including primary data collection through key informant interviews (KIIs) with relevant stakeholders and focused group discussions (FGDs) and secondary data through literature review .

Findings

Fleet Assessment and GHG Modelling

Boundaries

The boundaries set for the Greenhouse modelling included: a regional geographical boundary accounting for three counties of Homa Bay, Migori and Siaya; the accounting only factors in the fleet numbers reported within the counties thereby excluding trans-county travelling. Emissions were determined only at the use phase, that is, the GHG emissions associated with fuel switch or adoption of EVs and emissions associated with charging electric alternatives. A bottom-up approach was used to estimate the GHG emissions as stipulated in Intergovernmental Panel on Climate Change guidelines for mobile combustion.

2-Wheelers

The fleet assessment estimated a total of 88,845 two-wheelers for Mbita, Homa Bay and Migori Counties. 2-wheeler operators, more so those operating their fleet for public transport, reported an average distance of 175 km/day for the town services. The annual vehicle kilometres travelled was 54,600km. The fuel economy was estimated at an average of 2.1 l/100 km. Considering only the tank to wheel emissions (TTW), the total CO_2 emissions from motorcycle use for the year 2019 was estimated at 250,042.08t.

3-wheelers

The total fleet number for 3-wheelers for Migori, Homa Bay and Siaya was approximately 3,063. Three-wheelers reported an average daily distance of 175 km/day which amounted to 54,600 km annual vehicle kilometres travelled. The fuel economy or approximate fuel consumption was 3.71 l/100km. The total emissions from the 3-wheelers were estimated at 22,896 t CO_2 for the year 2019.

Outboard engines

Through FDGs with Beach Management Units (BMUs) and secondary data sources, the total number of diesel outboard engines for the Kenyan Lake Shore were estimated as 15,031 boats. Fishermen reported operating for 20 days in a month with an average fuel consumption of 25 l/day. Emission values for fishing vessels was estimated using the default values as indicated in the Intergovernmental Panel on Climate Change Guidelines amounting to 319,732 t CO_2 for Y2019

Environmental Impact of eMobility

Abatement Potential from eMobility

The current penetration rate for eMobility in Kenya is negligible. However, with technological advancements, reduction in battery prices, higher future motorization rates and the current shift from fossil fuels, electric mobility presents a pathway for GHG abatement in the transport sector. To estimate the abatement potential, projections were made for two scenarios: i) business as usual (BAU) and ii) a partial electrified fleet with increasing eMobility penetration rates.

Due to the limitation in historical data for the diesel outboard motors and three-wheelers, scenarios assessing abatement potential were only considered for the 2-wheelers. The partial electrified fleet assumed penetration rates of 0%, 10%, 25%, 50% for the year 2019, 2029, 2039 and 2049. The total emissions from a BAU scenario over the period 2019 – 2050 was estimated at 13,028,717 t CO_2. However, with the penetration of eMobility the estimate emissions reduce by nearly half to about 7,770,717 t CO_2. Therefore, the total abatement potential (tank to wheel) of shifting from conventional motorcycles to a partially electrified fleet was estimated as 5,258,001 t CO_2 for the period of 2019 – 2049.

Battery Disposal

Typically, the battery lifespan for mobility applications is approximately 15 years. Therefore, even with increased uptake of electric vehicles, bulk battery waste will likely feature as an issue in future rather than present scenarios. The growth of e-waste streams will also cascade into the growth of companies well equipped to handle e-waste.

The current challenges with E-waste management in Kenya include the lack of legislation and infrastructure for e-waste management; absence of frameworks for end-of-life; no elaborate extended producer responsibility systems. The 2019 draft regulations on e-waste management partially intends to address these gaps.

The disposal options include reuse, recycle or recovery. Since the end of life, batteries are at 70% capacity and can hold and discharge electricity for another 7 to 15 years, the study concluded that re-use of the batteries in second life applications is the recommended disposal method. Efforts to ensure successful disposal will include developing a take-back mechanism and consumer education on the need for proper disposal.

fleet assessment estimated a total of

88,845 **two-wheelers**

3,063 **three-wheelers**

operating in **Migori, Siaya** and **Homa Bay Counties**

the total **diesel outboard engines** were estimated as **15,031** boats

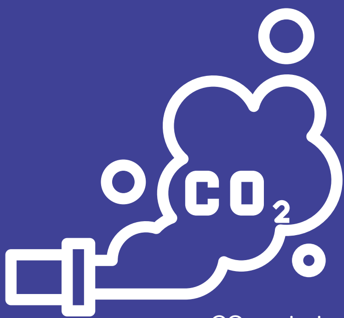
fuel economy was estimated at

1.6 l/100km

for the two-wheelers

and **3.7 l/100km**

For the three-wheeler



CO_2 emissions from motorcycle use was estimated at **250,042.08** **tonnes**

& 22,896 tonnes

from autorickshaw use for the base year of **2019**

Policy and legal environment

Policies are crucial enablers for overcoming market entry barriers. In Kenya, a number of early stage policies have been proposed and instituted to support the uptake of EV's elements. The study highlights further policy solutions to existing barriers at the market's nascent stage:

i) **Expanding EV model availability through incentivizing manufacturers or offering mandates on production.** The Kenyan government intends to offer financial incentives to enable investors to utilize more local content as well as supporting research and development to motivate innovation and technology acquisition. These incentives, though not explicitly elaborated, can include offering subsidies, low-interest or interest free loans for the set-up of manufacturing units, stamp and land registration charge exemptions or discounts and offering a discount tariff for power.

ii) **Improving EV cost competitiveness** through exemptions and discounts on import duty of electric two and three wheelers, road tax, registration fees and state goods and service tax and exempt tax on parking fees. A reduction or tax emption of components such as battery technologies will also play in tune to reduce the cost of locally manufactured EVs.

iii) **Accelerating EV deployment across the public and private fleet**s - Through a public leasing policy for the public sector, the government intends to expand access to locally manufactured vehicles which will encourage deployment of public EVs. The reduction of excise duty for high capacity vehicles is also expected to encourage the uptake of EVs. Financial incentives such as tax holidays for private companies operating EV fleets will also encourage the uptake of EVs.

iv) **Developing charging infrastructure network** include unifying charging standards and interoperability, streamlining the permitting and inspection process, integrating electric mobility zoning laws and land-use policies, defining a clear role of distribution companies, tariff design, permitting process and data privacy.

v) **Raising public awareness** – Mass communication and campaigns to raise awareness on the benefits of EVs will be necessary to drive demand.

Charging Infrastructure

At present, setting-up of charging infrastructure in Kenya has been driven by private players in urban settings such as malls interested in attracting traffic to the business premises. Whereas energy utilities are best placed to build both public and private charging infrastructure, interviews with a KPLC representative indicated that the utility does not have the capacity to set-up infrastructure.

The study concludes that in this case the recommendation is to adopt a similar approach to India's Regulatory Commission which has put forth a proposal of new business models for charging infrastructure which allows for distribution companies to operate charging infrastructure.

This could include:

- Equipping residential buildings and parking spaces
- Retro-fitting existing networks of petrol stations into charging stations
- Swapping stations set-up by private actors to allow for cheaper E2Ws

However, this must be accompanied by setting standards and enabling wayleave policies for infrastructure spearheaded by the energy regulatory authority, EPRA, KPLC and the Ministry of Energy.

Conclusions and Recommendations

Based on the findings, the following are the key conclusions and recommendations:

- Supporting policies are crucial enablers in creating enabling environment for the EV market. Notably, a reduction of excise duty for high capacity vehicles and establishing standards for EVs is a start point, however, government agencies need to develop policies offering both financial and non-financial incentives to spur growth and demand for the sector. Key considerations are policies which will enable the setting-up of charging infrastructure and lower tariffs that will carter to charging of electric alternatives.

- Because of the increased uncertainty of the Carbon markets, there is a decline in the number of private sector players interested in selling Carbon credits. Consequentially, with consideration of a project's size, scale and timelines, alternative schemes and sources of funding such as climate funds are more tenable as a financial resource. Any considerations for carbon trading in the voluntary markets will require a project developer match the project characteristics with the interest and the needs of that buyer. Most of the voluntary buyers are often motivated by the uniqueness, the story and the additional benefits to the communities and their ecosystem such as conservation of wildlife in areas where such projects are developed.

- The set-up of charging infrastructure in the rural areas, at this nascent stage, will fall on private actors. Ideally, KPLC is best placed to set-up charging infrastructure network but it is noted that they lack present capacity to carry out the task. Additionally, the grid reliability in the Western region is problematic and altogether unavailable for more remote areas. This presents an opportunity for mini-grid developers to set-up charging stations within areas for operation.

- Streamlining sectoral coordination is necessary to advance the sector. Importation of EVs still encounters different challenges. There is no provision for prototype registration, under KRA and NTSA. All imported EVs are marked as Nissan Leafs while NTSA has no drop-down menu for EVs to separate them by vehicle type and segment. Developing a prototype registration for the different vehicles requires institutional coordination between NTSA, Ministry of Transport and KRA. Though there is goodwill to see the growth of the sector, the efforts at present are fragmented in each department.

1. Introduction

1.1 Program context and objectives

Siemens Stiftung aims to deliver sustainable and innovative solutions to improve lives in rural Kenya through three product lines: water services, solar lanterns and e-Mobility with WeTu, its implementation partner. The primary area of operation is the Lake Victoria Region in Kenya where they've set up 7 hubs in three counties, namely, Migori, Siaya and Homa Bay. E-mobility is the latest initiative, supported by GIZ (The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH), and aimed at increasing economic capacity, tackling unemployment and providing environmentally sustainable transport in the Lake Region.

The current pilot has a deployment of six e-cargo bikes, two e-motorcycles and 6 outboard engines, however, there's a focus to expand the venture further to include more cargo bikes, e-motorcycles and e-outboard engines. It also seeks to create a new value chain and to this end, is setting up and upgrading workshops to assemble and service electric two-wheelers, three-wheelers and engine board motors. It has also put in place circular economy measures to ensure e-waste at the hubs are recycled.

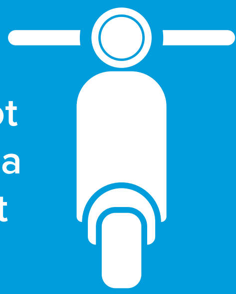
While the benefits (especially environmental benefits) of embracing e-mobility for rural and peri-urban areas in Africa are obvious, most business decisions are made based on assumptions and unstructured data. Siemens Stiftung sought to address this information gap by assessing the environmental benefits to be accrued from using e-mobility as an alternative to conventional solutions through this study. This was accomplished through the following objectives

i. Fleet assessment and data modelling (based on 2-wheeler, 3-wheeler and e-outboard engines) to assess the GHG emissions of the proposed solutions and other environmental benefits including other particles

ii. Environmental Impact Business Modelling: Structuring the approval process of the Kenyan Government for CO_2 compensation instruments and potential participation in carbon trade.

iii. Charging infrastructure assessment which involves the review of the regulatory framework for charging infrastructure and suggest options for business models and payment structures and the impact of uptake of EV's on energy demand

Current pilot project has a deployment of



- 2 e-motorcycles
- 6 e-cargo bikes,
- 6 outboard engines

iv. Policy Review related to the non-technical aspects of the introduction of charging infrastructure for electric vehicles such as regulations on import of vehicles, taxation and duty procedures.

1.2 Definitions

Electric two wheelers can be broadly categorized into two types, based on the presence or lack of operating pedals: electric bicycles (e-bikes) and electric scooters (e-scooters) or electric motorcycles (e-motorcycles). E-bikes are further classified into pedal-assisted bicycles (pedelecs) and throttle-controlled electric mopeds with the option of pedal power. Pedelecs are the most common in Europe, while in China and some Southeast Asian countries, throttle-controlled e-bikes are the most dominant. This discussion covers electric two wheelers in general.

1.3 Approach and Methodology

A four-step approach was adopted to capture the qualitative and quantitative assessment as summarized in Figure 1. The information and data used in this report was collected through literature review and primary data collection analysis. This was then analyzed and synthesized into a unitary report.

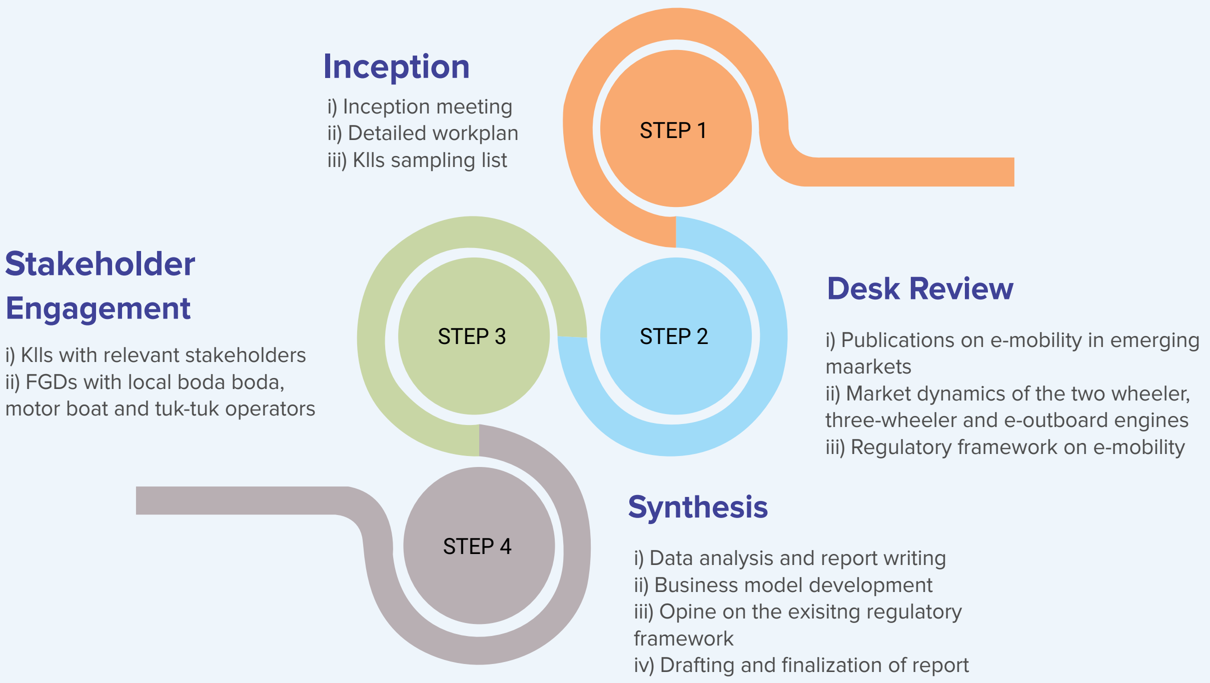


Figure 1: Summary of the approach

1.4 Study Limitations

The study design was meant to assess the possible fleet composition at the county level and quantify environmental benefits arising from the introduction of an electrified fleet. One of the major limitations experienced was the lack of responses from a few stakeholders likely due the prevailing conditions of the COVID-19 Pandemic.

2. Growth of Electric Two Wheelers (E2Ws)

The origin of electric two wheelers (E2Ws) can be traced back to China where the production of e-bikes reached 10,000-20,000 units in early 1980s. Favored by supportive policies and technological advancement among other factors, the country reached 120 million units in 2005 outnumbering conventionally powered scooters at 80 million[1]. Since then, electric two wheelers have been gaining traction alongside other electric vehicles (EVs) and currently 25% of the global market for two wheelers is already electric[2]. Massive growth is anticipated in countries with higher proportions of two wheelers in their vehicles such as those in South and South East Asia including India, Indonesia, Vietnam and Taiwan where two wheelers account for 72%,87% and 95% respectively of the total registered vehicle fleet[3].

In 2013, China, which is still a global leader in electric vehicles sold 32 million e-bikes while only 1.8 million, 440,000, and 185,000 were sold in Europe, Japan and the United States (US) respectively[4]. Overall, there has been an exponential growth in the number e-bikes globally and in 2018 remarkable sales were recorded with Germany coming close to 1 million while more than 400,000 sold in the US and 111,297 in Spain. In the first half of 2019, additional sales of close to a million e-bike were made in Germany[5].

According to estimates by Deloitte, there is an expected global surge in the adoption of e-bikes with more than 130 million e-bikes being sold between 2020 and 2023, and in 2023, e-bike sales are expected to top 40 million units worldwide. The anticipated increase can be attributed to several factors including advances in light weight lithium ion batteries, increase in the use of cargo bikes for delivery and improved performance of bikes. In total there will be about 300 million e-bikes in circulation (both privately owned and shared mobility) in 2023 as compared to the 200 million as of 2019[6].

In the motorcycle and scooter category, India is currently the largest market for conventional motorcycles globally having registered sales of close to 19 million units in 2019 (See Figure 2 below). Other countries such as Pakistan and Philippines are also emerging and already commanding shares in the market. The number of e-motorcycles/scooters have been increasing gradually but may change as countries like India embark on new strategies to transition to cleaner modes of transport. Currently the highest sales are in China where more than 1 million electric motorcycles have been sold[7].

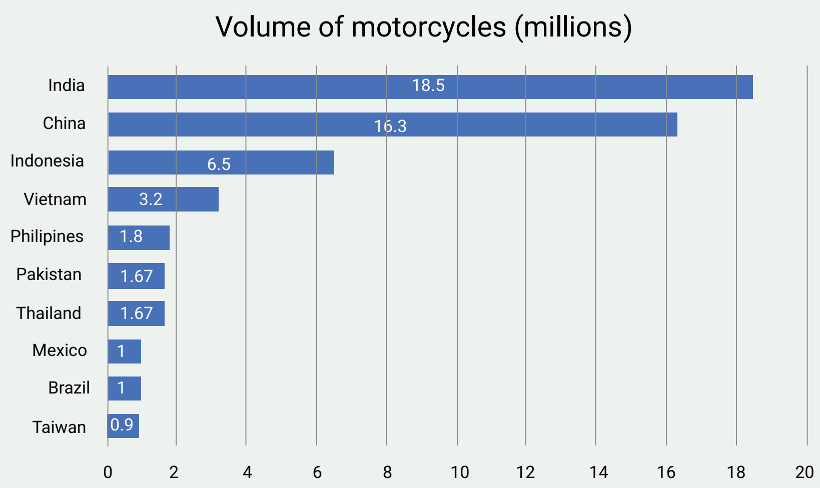


Figure 2: Top ten leading countries in motorcycle sales in 2019, Source-Motorcycles data[8]

1 Weiss, M., Dekker, P., Moro, A., Scholz, H., & Patel, M. K. (2015). On the electrification of road transportation–a review of the environmental, economic, and social performance of electric two-wheelers. Transportation Research Part D: Transport and Environment, 41, 348-366. https://www.sciencedirect.com/science/article/pii/S1361920915001315

2 Black, A. (2020). Managing the Transition to Electric Vehicles Technology. Digital Industrial Policy Brief 11. https://www.competition.org.za/ccred-blog-digital-industrial-policy/2020/4/21/managing-the-transition-to-electric-vehicle-technology

3 Bakker, S. (2018). Electric two-wheelers, sustainable mobility and the city. https://www.intechopen.com/books/sustainable-cities-authenticity-ambition-and-dream/electric-two-wheelers-sustainable-mobility-and-the-city

4 Deloitte (2019). Technology, Media, and Telecommunications Predictions 2020. https://www2.deloitte.com/content/dam/insights/us/articles/722835_tmt-predictions-2020/DI_TMT-Prediction-2020.pdf

5 Ibid

6 Ibid

7 Koyanagi, K. (2019). Electrifying market: India poised to rival China in e-motorbikes: Manufacturers accelerate production despite Modi policy curveballs. Nikkei Asian Review. https://asia.nikkei.com/Business/Industry-in-focus/Electrifying-market-India-poised-to-rival-China-in-e-motorbikes

8 Motorcycles Data (2020). Beyond Corona Virus: The road ahead of the Motorcycles Industry. https://www.motorcyclesdata.com/2020

Africa, though not featuring in the top ten, is experiencing a boom in the uptake of motorcycles with the main drivers being attributed to demand for public transit, easy two-wheeler financing, and increasing influx of cheap imports from Indian manufacturers[9]. Motorcycles have found varied uses in most countries including delivery services, taxi services ferrying people to and from different destinations and as connectors between rural and urban areas. The top three runners are South Africa, Nigeria and Tanzania and are closely followed by Kenya, Algeria, Morocco, Angola and Ethiopia. While there are very few electric wheelers on the continent, there is great potential for two wheelers given that in most countries public transport systems remain inadequate and poorly developed.

According to a 2018 study on Africa's Automotive Insights, multi-modal transportation in Kenya is common with 71% reporting the prominent use of the informal public transport minibuses, *matatus,* followed by the Motorcycle taxis, *bodaboda,* at 39%[10]. Though the motorization levels in Africa are generally low, with rapid economic and population growth, this market expansion is set to continue more so for the two-wheeler and three-wheeler automotive[11]. Prior to 2006, registration of motorcycles and auto rickshaws was lower than 10,000 vehicles annually as seen in Figure 3. However, with the zero-rating of import duty on motorcycles of an engine capacity lower than 250 cubic centimeters (cc) in the 2006 National Budget, an immediate uptake was observed in subsequent years. In 2007, new registrations rose to 16,293 from 6,250 in 2006, registrations as per 2018 were equivalent to 188,994. New registrations of the auto rickshaws, also known as three wheelers or *tuktuk,* have also been observed to increase over the years from a low of 10 in 2003 to 6,259 in 2018[12]. For this report, the terms motorcycle and auto rickshaw are used interchangeably with *bodaboda* and *tuktuk* respectively.

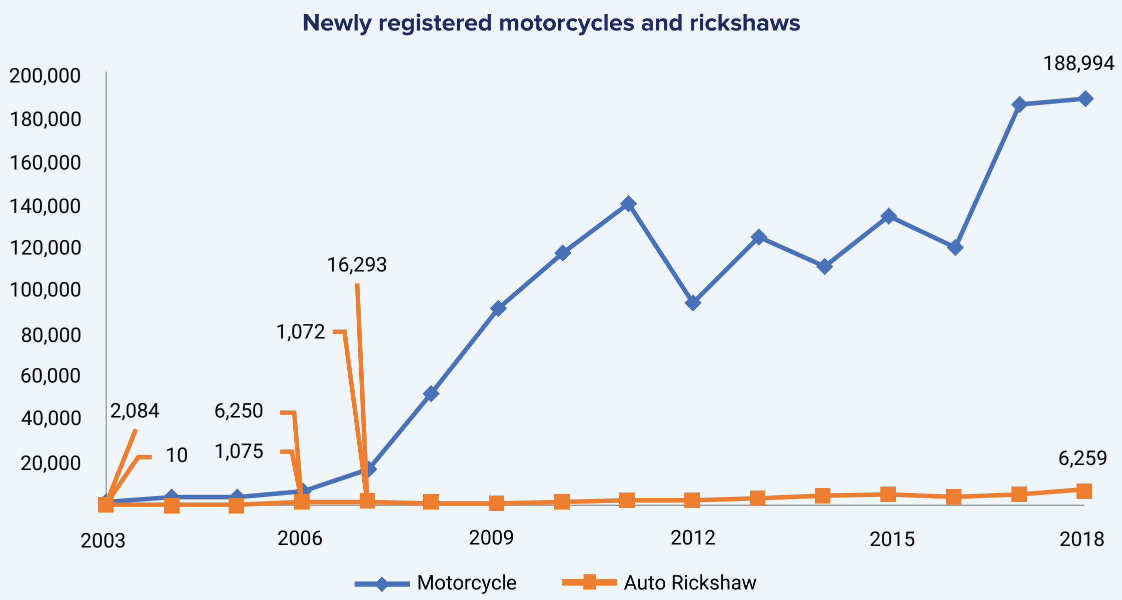


Figure 3: Newly Registered Motorcycles and Auto Rickshaw for the period 2003 – 2018

9 Dahir, A.,L. (2016). The value of motorcycle public transport will more than double in Africa. Quartz Africa. https://qz.com/africa/800070/the-value-of-motorcycle-public-transport-will-more-than-double-in-africa/

10 Deloitte (2018). Africa Automotive Insights: An East African consumer perspective 2018

11 Black, A., Barnes, J., Makundi, B., and Ritter, T. (2018). Electric two-wheelers in Africa? Markers, production and policy.

12 KNBS (2019). Leading Economic Indicators – (2013 -2019)

Motorcycle Assemblers Association of Kenya estimated an annual *bodaboda* industry turnover of KES 219 billion, with daily average earnings of KES 1,000 for 99% of the *bodaboda* operators[13]. The association also recorded at least 600,000 commercial motorcycles by the end of 2017 serving a total of 4.8 million people[14]. Whereas the use of *bodabodas* and *tuktuks* in urban areas is driven by traffic congestion, a rise in the use of low capacity alternatives has also been experienced in rural areas due to poorly developed conventional motorized transport services, poor infrastructure and difficult terrain which makes the operation of other types of vehicles challenging and in most cases unprofitable[15,16]. *Bodabodas* have significantly improved the livelihoods of rural residents with counties of Bungoma and Kwale baseline surveys estimating a daily contribution of KES 15.6 million to the economy[17].

The conventional local motorcycle assembly sector is dominated by two players, Auto Industries Ltd. and Car & General; other players and their respective market share is included in the Table 1[18].

Table 1: List of conventional motorcycle assemblers and their respective market share

Company	Brands or Franchise Holder	Market Share (%)
Auto industries Ltd	Bajaj	39.04
Car & General	TVs	21.29
Captain motorcycles	Captain, Tiger, Dayun	13.39
Honda	Honda	7.64
Makindu Motors	Skygo	7.03
Abson Motors	Haojin	4.75
Ryce E. A	Hero	0.99
Toyota	Yamaha	0.98

Source National Automotive Policy (2019)

The local assemblers of the EV two-wheelers and three wheelers include solar E-Cycles, Opibus and WeTu hub. Associated Battery Manufacturers is the only battery manufacturing company in Kenya. It produces lead acid batteries for use in both solar and automotive industry[19]. Electricity suppliers and distributors include the main offtaker – Kenya Power and Lighting Co. and mini-grid developers Powergen, Powerhive, Virunga Power and Kudura, among others.

2.1 Narratives in the uptake of E2Ws

Three different narratives have evolved to support the increased adoption of E2W globally -environmental, socio-economic and energy safety/security.

Environmental

The transport sector is a lead contributor of greenhouses gas (GHG) emissions and accounted for about 23% of GHG emissions globally as of 2014[20]. It is also considered the largest source of particulate matter $PM_{2.5}$ pollution[21]. Most countries, therefore, view it as an opportunity for reducing their emissions and in meeting the Paris Agreement Climate Change targets of maintaining the temperature rise to below 2°C. Studies carried out in the past have shown that electric vehicles and two wheelers perform better than their counterpart gasoline powered engines when it comes to tail pipe emissions. In a study performed in China and India for small ranged E2Ws using the tank-to-wheel method, it was found that E2Ws emit less CO_2 gram per kilometer than their counterpart gasoline vehicles. Similar studies conducted in the UK found that the E2Ws emit 3.8 and 1.8 times less GHG emissions than gasoline cars and motorcycles, respectively[22]. This gets even better when the electricity mix is from cleaner sources such as renewables and when the system is efficient (reduced transmission losses). The enormity of the emissions from gasoline two wheelers is evidenced in Thailand where deploying a fleet of 13.6 million motorcycles to replace their gasoline counterparts would result in a reduction of between 42% and 46% of two-wheeler life cycle CO_2-eq emissions[23]. In Vietnam on the other hand, e-bikes have been singled out as the second largest option for CO_2 abatement potential in the transport sector.

It is further argued that the large parts of emissions associated from E2Ws are often away from densely populated areas such as cities hence reducing exposure rates and intake fractions as compared to those resulting from conventional two-wheelers and cars.

13 Sosi, J. (2018). Revealed: Why bodaboda business is a multi-billion venture. Business today. https://businesstoday.co.ke/revealed-boda-boda-business-multi-billion-venture/
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15 Bishop, T., Barber, C., Charman, S. and Porter, G., (2018). Enhancing understanding on safe motorcycle and three-wheeler use for rural transport
16 Dennis, R., and Pullen, K. (2017). Vehicles for rural transport services in sub-Saharan Africa. Proceedings of the Institution of Civil Engineers
17 ibid.
18 GoK (2019). National Automotive Policy 2019
19 ABM Kenya (n.d) About Us: https://www.abmeastafrica.com/about-us.
20 IPCC (2014). Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5): Transport (2014). https://www.ipcc.ch/site/assets/chapter8.pdf
21 Bakker, S. (2018). Electric two-wheelers, sustainable mobility and the city. In Sustainable Cities-Authenticity, Ambition and Dream. IntechOpen. https://www.intechopen.com/books/sustainable-cities-authenticity-ambition-and-dream/electric-two-wheelers-sustainable-mobility-and-the-city
22 Rajper, S. Z., & Albrecht, J. (2020). Prospects of Electric Vehicles in the Developing Countries: A Literature Review. Sustainability, 12 (5), 1906. https://www.mdpi.com/2071-1050/12/5/1906
23 Bakker, S. (2018). Electric two-wheelers, sustainable mobility and the city.

Social-Economic

In China and other Asian cities marked with high population densities and considerable traffic congestion, two wheelers have provided a better and efficient means of transport as compared to car transport. Moreover, they are space efficient and are relatively affordable. Other benefits cited include reduction in air pollution and noise and low operational costs. While cars may be out of reach for most households, two wheelers such as motorcycles are affordable to most households. One advantage of electric two wheelers unlike electric vehicles is their portable battery. This allows for charging at multiple points such as standard outlets, offices or in some instances at home thus eliminating the need for dedicated charging infrastructure. It is anticipated that if E2W replaces car trips in China, it could eliminate the need for large charging infrastructure which is a requisition for four-wheeler electric vehicles[24]. The drive for sustainable urban mobility aims to minimize and/or eliminate the negative externalities including congestion and air pollution that are associated with different modes of transport. Additional benefits of E2Ws include flexible ownership structures that promote sharing economy and improved asset financing through flexible payment options such as pay-as-you-go (PAYGO).

Energy Security/Reduction on oil Dependency

Prices for fossil fuels remain volatile mostly driven by geopolitical factors yet they remain crucial for the transport sector. Governments are thus continually striving to attain energy security-the continuous availability of energy in varied forms, in sufficient quantities, and at affordable prices[25]- and they are already working towards decarbonizing their national grids to provide cleaner alternatives. Renewables are considered less sensitive to external factors hence promoting a sense of security by reducing the overdependence on oil. In particular, E2Ws have been found to be more efficient than gasoline powered two wheelers. In their review, Rajper & Albrecht (2020) found that E2W utilizes 3–5 times less energy than a gasoline-based two-wheeler. In a study conducted in the UK, using the tank-to-wheel process, it was found that E2Ws consume 6.1 and 2.9 times less energy than gasoline cars and motorcycles, respectively[26]. It is posited that the transport sector would greatly benefit by switching to EVs. Coupled with their efficiency, EVs in general would provide a twin solution for reduction in greenhouse gas emissions and ensuring energy savings. Sector experts suggest that stringent government regulations on emissions could push for adoption of EVs to avoid overdependence on oil.

Table 2: Comparative analysis among different electric mobility modes considering tank-to-wheel energy use[27]

Mode	Tank-to-wheel Energy Use Represented in kWh per km
E-Bicycle	0.015 ± 0.005
Midsize E2Ws or Electric Scooters	0.045 ± 0.02
Midsize gasoline powered two wheelers	0.25 ± 0.09
Large E2W or electric motorcycles	0.07 ± 0.03
Large gasoline-powered two-wheelers	0.41 ± 0.13

Note: Tank to Wheel (TTW) refers to the use of fuel in the vehicle and emissions during driving

Besides the three factors discussed above, other factors that have contributed to adoption of E2Ws have included evolution of technology especially batteries which has seen improvements in cost and performance. Battery prices are expected to fall further due to scale effects, technological advances and indigenization. Different business models have also emerged across the EVs value chain with some car companies setting up fast charging stations and providing free charging options for customers while in other countries battery swapping for E2Ws are being implemented.

2.2 Factors Limiting Uptake of E2Ws

Lack of incentives

Looking at successful countries in adoption of E2Ws such as China, it is evident that policy will continue to have a major influence on the EV market and their uptake. China for instance benefited from a range of polices including total ban on gasoline motorcycles and subsidy schemes. There was an astounding increase in the sales in China after 2010 following the introduction of the ban on petrol/gasoline motorcycles across 29 major cities which had registered enormous levels of pollution. Currently the government is introducing quotas to manufacturing companies to spur the growth of the EV sector[28].

24 Rajper, S. Z., & Albrecht, J. (2020). Prospects of Electric Vehicles in the Developing Countries: A Literature Review
25 Miller. B. G (2011). Coal and Energy Security. Clean Coal Engineering Technology. Retrieved from https://www.sciencedirect.com/topics/engineering/energy-security
26 Ibid
27 Rajper, S. Z., & Albrecht, J. (2020). Prospects of Electric Vehicles in the Developing Countries: A Literature Review
28 Black, A. (2020). Managing the Transition to Electric Vehicles Technology

India with its ambitious goal to transition to electric technology by 2030 introduced the Faster Adoption and Manufacturing of Hybrid and Electric (FAME) Vehicles scheme in 2015 which is part of the National Electric Mobility Mission Plan (NEMP) 2020. The first phase had 4 focus areas with one of them being demand creation through incentives targeted to all vehicle segments including electric 2- and 3-wheelers[29]. As a result, sales of E2Ws in India increased significantly from 54,800 to 126,000 as of March 2019[30].

Fiscal incentives remain key given the fact that gasoline engines are relatively cheaper than EVs. These can be complementary to regulations that boost value proposition of EVs such as fuel economy or lower environmental emissions. Other policy benefits could include tax exemptions, lower import duties, sales tax breaks, and direct subsidies to the sector. To increase affordability, approaches such as tax deduction schemes for employees to buy e-bikes that have been adopted in Netherlands would be required.

Additionally, non-fiscal incentives including restrictions for parking and access to designated zones as is in China where cars with EV plates are exempt from the restrictions of entering the city on certain days (in Beijing) and EVs have special parking access or discounts, lane access and congestion zone discounts can play a significant role in promoting the uptake of EVs in general.

Range Anxiety and Long charging time

The more developed gasoline distribution network provides a sense of security in accessing fuel compared to EV charging infrastructure which is still geographically limited in most countries. With this shortcoming comes range anxiety which has become a major impediment in adoption of EVs at large and E2W as well. Compared to E2W, gasoline powered two-wheeler engines perform better than at average range of 80 km-200 km against 30-70 km offered by E2Ws fitted with lead acid batteries[31]. This challenge however has been partly addressed through manufacturing with the new EV models having higher range resulting from the use of li-ion batteries which have higher energy densities. The focus however, has been on cars and not E2Ws.

The long charging time has also created a negative reputation for the technology thus influencing the end user adoption. E2Ws have a battery capacity of 0.5–15 kWh, which require eight hours recharging from the standard wall outlet[32]. The situation gets worse for countries that suffer from grid instability, frequent black outs, load shedding and poor quality of power. Kenya for instance, experiences 6.3 outages in a month lasting at least 5 hours[33]. Power access challenges by themselves can thus limit the adoption of these technologies. Battery swapping models, developing better batteries and construction of extensive charging infrastructure or using off-grid energy sources are some of the ways to address these two hurdles.

Harmful lead emissions

While EVs have been lauded for their low carbon emissions their battery related emissions from production, recycling and disposal have considerable environmental impact. The solid lead waste from E2Ws are considerably higher than that from conventional two-wheelers ranging from 5-10 grams/100 km[34]. These lead emissions can result in contamination of groundwater and crops. In China where Lead acid batteries are prevalent, 95% of the total lead emissions occur at the end-of-life stage, due to an improper recycling process[35]. In 2011, the government of China force-shut more than 80% of the country's lead acid battery plants due to health related and environmental concerns from lead poisoning[36].

Transitioning to better battery technologies such as metal-nickel hydride and lithium ion which weigh half as much and have higher battery life and which are currently being used in the European market would guarantee a reduction in lead emissions and their subsequent impacts on the environment. Better disposal and investment in battery recycling (60% of lead acid batteries are recyclable) technologies also have potential to reduce these grave impacts.

29 Government of India, Ministry of Industries and Public Enterprises: Faster Adoption and Manufacturing of (Hybrid &) and Electric Vehicles in India. Retrieved from https://dhi.nic.in/UserView/index?mid=2418

30 Koyanagi, K. (2019).

31 Rajper, S. Z., & Albrecht, J. (2020). Prospects of Electric Vehicles in the Developing Countries: A Literature Review

32 Ibid

33 EED Advisory (2016) Energy Access Review, Energy, Environment and Development Advisory, Publication number; 16-Q1EA, Nairobi, Kenya.

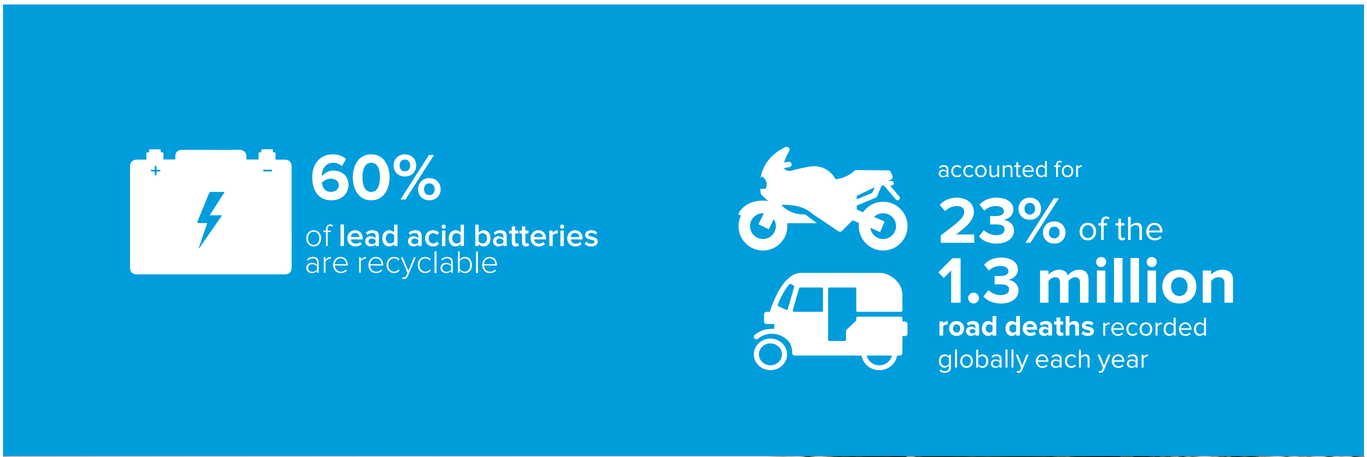
34 Rajper, S. Z., & Albrecht, J. (2020).

35 Ibid

36 Bakker, S. (2018).

Road safety of E2Ws

Two and three wheelers contribute to a significant share of fatalities from road accidents and accounted for 23% of the 1.3 million road deaths recorded globally each year[37]. In the Netherlands, an increase in road deaths in 2017 was associated with the rising use of e-bikes among the elderly, as these are more difficult to handle than bicycles. In developing countries, the safety of E2Ws would be a major issue since there are no separate lanes for two-wheelers on the road. With increased adoption there will be need for additional and stringent traffic safety regulations and adaptations of urban infrastructure. In Kenya for example, data from the National Transport Authority shows that at least 262 fatalities have occurred from motorcycles in just four months in 2020 (January-April 23rd). This is 28% more than those who died by the same date in 2019[38].

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37 World Health Organization (2020). Road Traffic Injurie. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries
38 National Transport Safety Authority of Kenya, Accident statistics. https://www.ntsa.go.ke/index.php?option=com_content&view=article&id=213&Itemid=706

3 Policy and Regulatory Frameworks for E-Mobility

Globally, the transport sector is responsible for almost one-quarter (23%) of the total energy-related carbon dioxide equivalent emissions[39]. As of 2015, Green House Gas emissions (GHG) of the transportation sector was equated to 12% (11 $MtCO_2e$) of the total emissions for Kenya which is projected to increase to 16% (21 $MtCO_2e$) by 2030 under the business as usual (BAU) scenario. According to a report by the Global Fuel Economy Initiative in Kenya, the combustion technology in use for the two wheelers is the four-stroke engine which predominantly uses carburetors; an inefficient technology causing high evaporative emissions through breathing losses and leakage through fuel lines/conduits. The evaporative emissions are hydrocarbons, of which, higher emission volumes are now attributable to the motorcycles and auto rickshaws than from passenger cars[40].

Given the current focus on de-carbonization, the global community acknowledges the need to transition from fuel-dependent transportation to more sustainable forms of mobility through innovations such as electric vehicles, shared mobility, and automated vehicle collectively termed as the “Three Revolutions”[41]. There are opportunities for Kenya to move to e-alternatives especially for the two-wheeler and three-wheeler markets, though the uptake of e-vehicles is currently still low. Significant supporting frameworks and incentives need to be realized to allow for up-take of these vehicles.

3.1 Policies adopted globally to support the uptake of EVs

Policy is crucial in enhancing the uptake of EVs. The nature of the policies adopted throughout the world vary but studies on some of the countries with the largest EV market share indicate that a mix of financial incentives, traffic regulations and infrastructure measures are effective in increasing the uptake of EVs.

Monetary measures

Financial incentives adopted include purchasing subsidies and tax benefits. These may be applicable at the national level such as the federal tax credit of between US$ 2,500 – US$ 7,500 for the United States and exemption from road and registration taxes for BEV owners for Netherlands. Additional incentives at the subnational and state levels e.g. rebates of up to US$2,500 for California. Other incentives include the reduction or zero rating of import duty for EVs e.g. Brazil and Russia[42].

Traffic regulations

Traffic regulations incentives include the access to highways, high occupancy vehicle (HOV) lanes, toll bridges, ferries and roads for free in Canada, Norway and the United States. Some of the EVs are entitled to free or reduced parking spots in Germany, Korea and the UK. Other favourable regulations include the free use of bus lanes in Norway and Germany. In China, the provision of free number plates for EVs is a major boost to adoption as acquiring number plates for the conventional vehicles is an arduous process[43].

Charging infrastructure

Charging Infrastructure and regulations to incentivize investments in infrastructure is noted to be a major driver for EV adoption[44]. From the end-user perspective, high cash grants for the purchase of EVs is attractive, however, combinations of lower grants with charging facilities may result in similar market shares[45]. European countries such as Belgium, UK, Norway and Italy provide nationwide incentives like subsidies or tax deductions for installations of private charging stations, public funding or the free use of infrastructure[46]. For India, the e-mobility plan is established at the national level, however, each state is tasked with developing policies and regulatory frameworks that would enable the adoption of EVs and deployment of charging infrastructure.

39 Axsen, J., and Sovacool, B. K., (2019). The roles of users in electric, shared and automated mobility transitions. Transportation Research Part D (71) 1-21.
40 Global Fuel Economy Initiative Study in Kenya 2014
41 Sperling, D. (2018). Three Revolutions: Steering automated, shared and electric vehicles to a better future.
42 Rietmann, N., and Lieven, T., (2019). How policy measures succeeded to promote electric mobility – Worldwide review and outlook. Journal of Cleaner Production 206 66 – 75.
43 Rietmann et al (2019).
44 Rietmann ,et al (2019).
45 Lieven, T. (2015). Policy measures to promote electric mobility – A global perspective. Transportation Research Part A 82 78 -93.
46 Rietmann et al (2019)
47 MoENR (2016). Kenya National Adaptation Plan 2015 -2030. Government of Kenya. https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Kenya_NAP_Final.pdf

3.2 Existing policy and institutional frameworks on EVs in Kenya

E-mobility as a potential low carbon pathway for the transport sector is recognized but still largely unexplored in Kenya. As a move towards sustainable mobility, the immediate focus of the government has been to climate proof infrastructure through improved transport networks[47], design and implementation for a Bus Rapid Network in Nairobi, Electrification of the Standard Gauge Railway and improved Non-motorised Transport facilities for pedestrians and bicycles[48]. This has also been accompanied by aims to create an enabling environment for e-mobility in three facets, i) technology, ii) capacity development and iii) policy. Table 3 depicts the action and timeline of expected results as stated in the NCCAP 2018 – 2022.

Table 3: Adopted approach to creating an enabling environment for e-mobility by the GoK.

Action (Create an enabling environment)	Expected Results by 30th June 2023
Technology	i. Encourage domestic technology development for electric modes of transport ii. Undertake research on the use of renewable energy for powering different modes of transport
Capacity Development	i. Build awareness on fuel economy and electric mobility options, including exploring infrastructure needs for electric mobility
Policy and Regulation	i. Develop and implement standards for electric cars and two-wheelers by 2019

The action points that have been legislated and included in policy[49]:

i. **Reduction of excise duty on electric vehicles** – The Finance Bill of 2019 proposed a reduction on the excise duty for all vehicles with only electric motor for propulsion (BEVs) from 20% to 10%.

ii. **Development of standards for electric vehicles** – Kenya Bureau of Standards has developed and adopted standards that apply to electric vehicles imported into the country. A total of 24 standards had been developed and adopted, covering the specifications and testing procedures for safety aspects as well as performance and power consumption elements.

3.3 Gaps and opportunities in building e-mobility in Kenya

At this nascent stage of the market, most of the proposed policies should act to overcome entry barriers. The barriers currently envisaged in the Indian market which are partially used as a proxy for the challenges that would be encountered for the Kenyan include: i) Expanding EV model availability ii) Improving EV cost competitiveness iii) Accelerating EV deployment across public and private fleets, iv) Developing charging infrastructure network and v) Raising public awareness[50]. Figure 4 indicates policy considerations for each barrier.

47 MoENR (2016). Kenya National Adaptation Plan 2015 -2030. Government of Kenya. https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Kenya_NAP_Final.pdf
48 GoK (2018). National Climate Change Action Plan: 2018 – 2022. http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2018/10/8737.pdf
49 GIZ (2019). Electric Mobility in Kenya: The Facts. https://www.changing-transport.org/wp-content/uploads/2019_Electric_Mobility_in_Kenya.pdf
50 Menon, A., Yang, Z. and Bandivadekar A. (2019). Electric Vehicle Guide for Indian States. International Council on Clean Transportation.

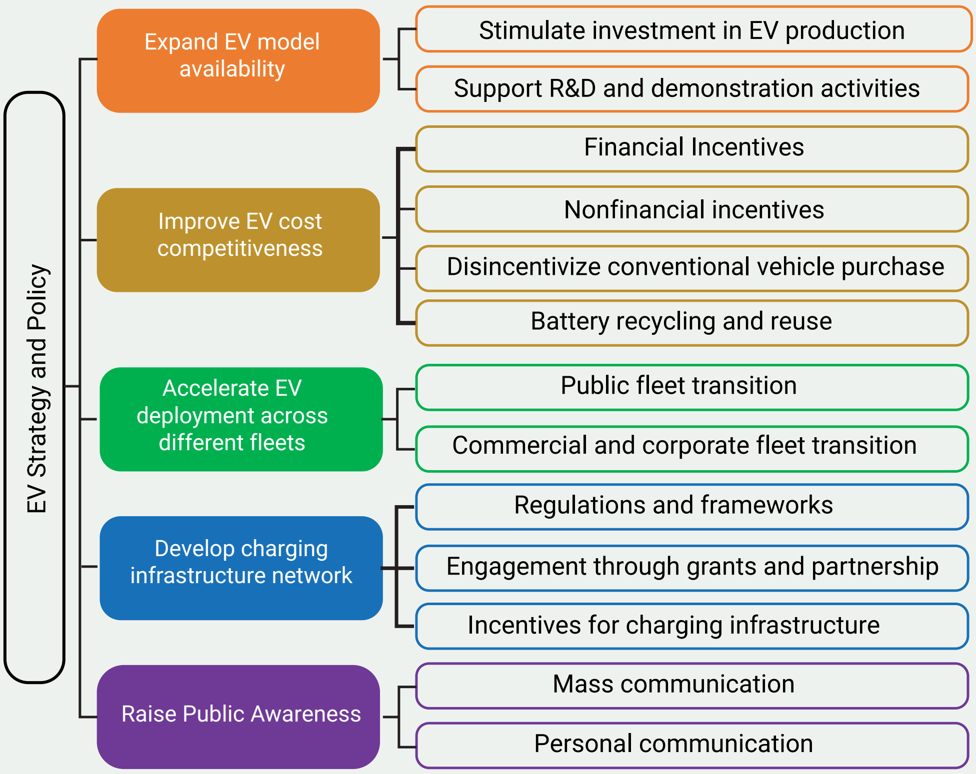


Figure 4: EV Strategy and Policy to increase uptake (Adapted from Menon et al (2019)[51]

Expand EV Model Availability

Stimulating investment in EV production can occur either through mandates or financial incentives. Mandates would require that current manufacturers fulfil a certain quota of production for EVs based off their share for conventional vehicles sales. Alternatively, the government may also offer financial incentives to set up manufacturing units such as subsidies, low-interest or interest-free loans, stamp duty and land registration charge exemptions or discounts, discounts on power and water tariffs, subsidies for setting up effluent treatment plants, making land and ready-made infrastructure for manufacturing available[52].

The government already drafted a national automotive policy[53] as a measure to support the emerging local vehicle manufacturers, specifically for the two-wheeler, three-wheeler and quadbikes, the policy aims to address the absence of Completely Knock Down (CKD) regulations that will be necessary to support local Motorcycle assembly. Although there is no specific mention of electric vehicle manufacturing, the overall target of the sector is to enhance market access through increasing exports to the East African Community from the current 5% to 15% by 2022 while also taking advantage of the Africa Continental Free Trade Area (AfCFTA) by 2030[54]. Measures to increase market access include the adoption of technologies for distinguishing between locally assembled and fully built imported units.

The government also aims to provide incentives on different levels of vehicle breakdown. The level of incentivization will depend on local value added; degree of technology transfer; improvement in level of expertise; level of foreign exchange earnings; strengthening of manufacturing value chain; developing linkages within the industry and investment in Research and Development (R&D).

51 ibid
52 Menon et al (2019).
53 GoK (2019). National Automotive Policy 2019. Retrieved June 2019 http://www.industrialization.go.ke/images/downloads/Draft-National-Automotive-Policy-Executive-Jan-2019.pdf
54 ibid

These will hasten the progression and phased advancement from semi-knocked down (SKD) to completely knocked down. The standards developed for electric vehicles also form part of harmonizing regulations and standards affecting the motor vehicle industry as outlined in the automotive policies.

The government with support of assemblers and original equipment manufacturers (OEMs) intends to promote local component and parts manufacturing by identifying products which can be manufactured locally and used in vehicle assembly and after sales while also developing and implementing Kenya's motorcycle regulation. The government intends to offer financial incentives to enable investors to utilize more local content in their local assembly lines. To support R&D the government aims to offer additional incentives to motivate innovation, R&D and technology acquisition.

These policy measures are applicable to all local automotive manufacturing and should be combined with the additional financial incentives highlighted to attract EV manufacturing investors.

Improve EV Cost Competitiveness

EVs are still more expensive than the conventional types, however, the prices are expected to drop as battery technology costs drop. Currently, the government has a blanket policy to develop schemes to enable the purchase of new locally assembled vehicles. The government also intends to support a progressive leasing policy for the public sector to expand access to new vehicles made in Kenya[55]. The scheme would be applicable to EVs made or assembled in Kenya. However, additional incentives are required to increase the uptake of EVs.

The financial incentives that could potentially be introduced include: providing purchase subsidies for electric vehicles, exemptions and discounts on road tax, registration fees, and state goods and service tax (SGST), exempt tax on parking fees and road tolls, subsidize and regulate fees for electric vehicle charging, offer vehicle replacement subsidies, offer vehicle replacement subsidies, offer low-interest or interest-free loans, offer vehicle usage subsidies, initiate time-of-use tariffs, provide discounts on vehicle insurance and SGST exemptions on insurance premiums. The nonfinancial incentives include providing designated parking, establish low/zero emission zones, provide registration and license benefits, exempt from road access restrictions, provide preferential land access and exempt from pollution under control checks. These incentives are in line with global practises as outlined in section 2.2. For battery recycling and reuse, incentivize end-of-life recycling and commercialize battery second life[56].

Accelerate EV deployment across different fleets.

The public fleets are predominantly operated by private owners and therefore, mandating the purchase of EVs would present a challenge. The government would have to rely on incentivizing such as the current reduction in import duty on vehicles with a carrying capacity of 10 or more passengers and emulating the exemption of duty for conventional two wheelers. Relaxed regulations on permits, offering open permits for commercial fleets which would provide flexibility for owners. The leasing policy for the public sector is applicable to locally manufactured EVs, although it should be extended to the purchase of EVs. Additionally, the government should standardize guidelines to streamline the electric vehicle procurement process and facilitate government purchases. Collaboration with ride-sharing companies, app-based aggregators and manufacturers such as Safe Boda and Uber would also be crucial in promoting electric ride sharing.

Developing charging infrastructure

There are currently no regulations nor frameworks set up to develop charging infrastructure networks. For this reason, proposed policy actions include unifying charger standards and interoperability, streamline the permitting and inspection process, amend building codes, integrate electric mobility zoning laws and land-use policies, implement electric vehicle parking regulation.

Several polices are noted to either potentially aid and enable the EV charging service provider or the user of the charging infrastructure[57]. The supply side policies will need to clearly define the role of distribution companies, tariff design, incentives, permitting processes and data privacy and the demand side will need to address payment methods, minimum facilities, charging station, user registration and consumer complaints. A brief guide to the policy considerations at each stage of market growth are indicated in Figure 5[58].

55 ibid

56 Menon et al (2019).

57 Bhagwat, P. (2019). Electric Vehicle charging policy in India. Retrieved (June 2019) https://fsr.eui.eu/electric-vehicle-charging-policy-in-india/

58 Bhagwat P., Hadush S., Bhagwat S., (2019). Charging up India's Electric Vehicles. Florence School of Regulation. https://cadmus.eui.eu/bitstream/handle/1814/64925/RSCAS_PB_2019_15.pdf?sequence=1

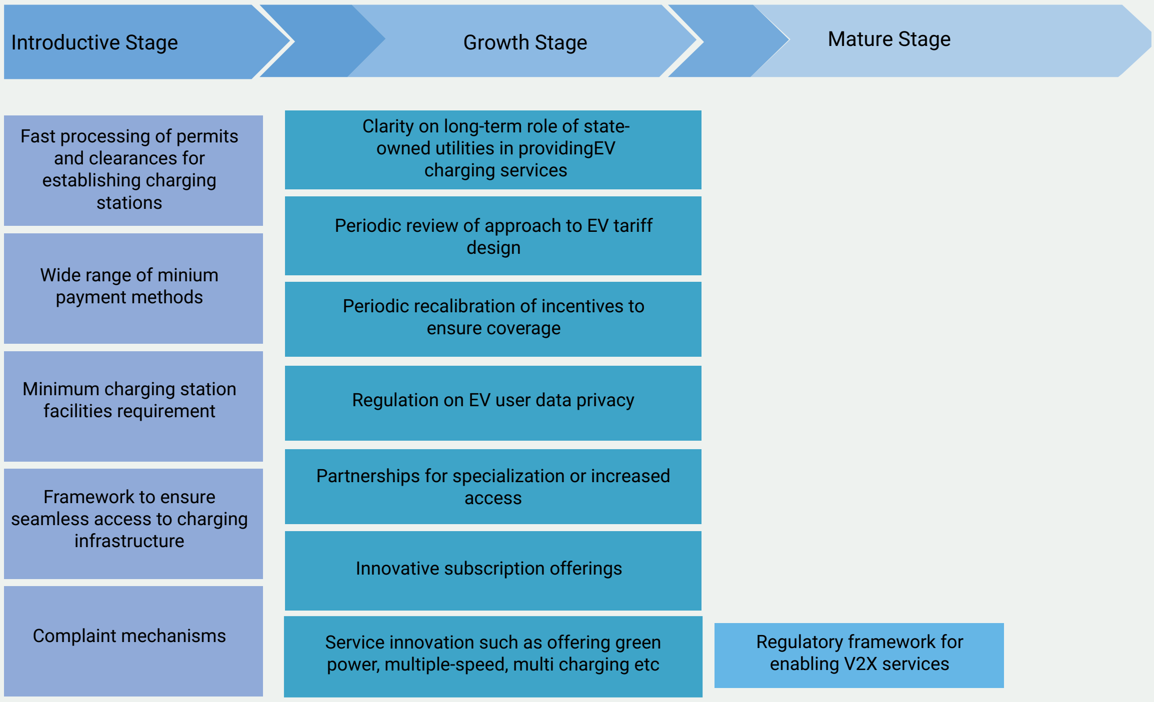


Figure 5: Policies to enable charging infrastructure deployment at different market development stages (Source: Bhagwat 2019)

The ability for Kenya and developing countries to offer financial incentives for the uptake of EVs may be precarious. However, discussions with various stakeholders advocating for e-mobility pointed to other monetary measures that could stimulate the market. For end users, policies such as offering tax holidays to corporations with electrified fleets, offering favourable financing schemes for the purchase of EVs and instituting local financing reforms such as lower interest rates from lenders are feasible policy mechanisms.

The supply side will require several supporting policies. Essential to boosting local EV production and assembling is zero rating and duty exemption of vehicle components such as batteries and battery cells and the knock-down kits, subsidies on CAPEX and access to varied financial options such as concessional loans and grants. The cost of electricity in Kenya is high and inhibitive, driving up the production costs and final price of the EVs and there is need to have lower tariffs if locally manufactured EVs are to be competitive. The question of lower tariffs applies to the main offtaker, KPLC as well as minigrid developers both mandated with providing electricity to different regions of the country. The current standard set-up needs to expand to capture distribution systems such as the charging ports, guidelines on safety and final disposal of the battery after economic life.

For charging infrastructure, the current way-leave policies need to incorporate allowance for the construction of a network for charging infrastructure. Sectoral coordination is also necessary and will be crucial in combining the fragmented efforts by the various government institutions to realise growth. For example, one of the main challenges reported is during the importation and registration of different EV vehicle types. Every registered EV is assigned as a Nissan Leaf during importation and a few stakeholders reported delays in receiving vehicle registration, some having to go over a year, due to the lack of classification for EV vehicle segments. The latter possess a challenge when trying to register vehicles of a different classification from Nissan Leaf.

4. Charging Infrastructure

The practicability of EVs depends on the wide availability of charging infrastructure and particularly getting to parity with the fuel refill experience. Charging infrastructure needs are determined based on the ratio of EVs to public charging points. However, there is no consensus on whether public charging infrastructure is necessary and how much of it would be needed to support and increase EV adoption[59]. A regular charging option such as work or home charging, by contrast is important for the success of early EV markets. This is consistent with recent findings that 50-80% of all charging events happen at home or in the office[60].

50-80%

of all charging events happen at home or in the office[58].

About 290 million charging points are needed globally to support growing EV fleets. Home charging is the leading category but around 12 million public charging points will be needed[61]. Currently, almost 1 million public charging points are installed globally with the numbers rising in Europe and China mainly. The EU Alternative Fuels Directive recommends a ratio of one publicly accessible charger for every ten EVs[62]. This ratio, however, may end up being lower with markets like Norway having one charger for 19 cars.

Charging infrastructure can be classified into parking charge and ongoing charge. Parking charge happens when the EV is parked for a duration such as at home, an office, parking lot, and so on. This is typically done using slow chargers which are used in normal outlets. Ongoing charge is characterized by battery swapping options or fast charging on road points or along highways intended to quickly replenish batteries while on long journeys. The characteristics that differentiate chargers include:

- Power output range of the Electric Vehicle Supply Equipment (EVSE) outlet
- The socket and connector used for charging
- The communication protocol between the vehicle and charger

Table 4: Overview of the Electric Vehicle Supply Equipment characteristics

	Conventional plugs	Slow chargers		Fast chargers	
Level	Level 1	Level 2		Level 3	
Current	AC	AC		AC, tri-phase	DC
Power	≤ 3.7 kW	> 3.7 kW and ≤ 22 kW	≤ 22 kW	> 22 kW and ≤ 43.5 kW	Currently < 200 kW

Normal charging uses power levels typical to outlets in residential and commercial installations. These would be level 1 and 2 chargers as shown in Table 4. Most two-wheelers use level charging. Globally, standards are being developed for high-power chargers (up to 600 kW) such as the CHAdeMO DC charging protocol[63].

To support growth in charging infrastructure, policy makers will need to provide appropriate signals and regulatory frameworks such as requiring parking lots and new or refurbished buildings are 'EV ready', supporting deployment of chargers in cities and on highway networks.

58 Bhagwat P., Hadush S., Bhagwat S., (2019). Charging up India's Electric Vehicles. Florence School of Regulation. https://cadmus.eui.eu/bitstream/handle/1814/64925/RSCAS_PB_2019_15.pdf?sequence=1

59 Funke, S. A., Sprei, F., Gnann, T., Plotz, P. (2019). How much charging infrastructure do electric vehicles need? A review of the evidence and international comparison. Transportation Research Part D: Transport and Environment Volume 77, Pages 224-242 https://doi.org/10.1016/j.trd.2019.10.024

60 Hardman, S. et al. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. Transportation Research Part D: Transport and Environment Volume 62, Pages 508-523 https://doi.org/10.1016/j.trd.2018.04.002

61 Bloomberg New energy Finance, 2020. Electric Vehicle Outlook 2020

62 IEA, OECD, 2018. Global EV Outlook 2018: Towards Cross-Modal Electrification.

63 IEA, 2019. Global EV Outlook 2019: Scaling up the Transition to Electric Mobility

Table 5: EV-related policies in selected regions. Source: IEA

		Canada	China	Euroapean Union	India	Japan	United States
Regulations (chargers)	Hardware standards**	✓	✓	✓	✓	✓	✓
	Building regulations	✓*	✓*	✓	✓		✓*
Incentives (chargers)	Fiscal incentives	✓	✓	✓		✓	✓*
Targets (chargers)		✓	✓	✓	✓	✓	✓*

Notes: * Indicates that the policy is only implemented at a state/province/local level. ** Standards for chargers are a fundamental prerequisite for the development of EV supply equipment. All regions listed here have developed standards for chargers. Some (China, European Union, India) are mandating specific standards as a minimum requirement; others (Canada, Japan, United States) are not. Check mark indicates that the policy is set at national level. Building regulations refer to an obligation to install chargers (or conduits to facilitate their future installation) in new and renovated buildings. Incentives for chargers include direct investment and purchase incentives for both public and private charging.

Charging infrastructure remains key in the uptake of electric vehicles in Kenya. Private sector players are already setting up charging stations in the country especially in malls. This however is driven by desire for increased traffic to these outlets with the expected impact being increased sales. As is in other countries, private sector has great potential to build, operate and maintain EV infrastructure. The current limitation is the fact that the electricity sector in Kenya is not deregulated hence fixing a price for energy becomes hard. Further, the current price of electricity is relatively high.

Energy utilities are also better placed to build both public and private EV charging infrastructure. In India for instance, Rajasthan Electricity Regulatory Commission has put forth a proposal of new business models for charging infrastructure in the country allowing for Distribution Companies (DISCOMs) to own and operate charging infrastructure[64]. Energy utilities have the advantage of distribution networks and customer base that they already serve and could quickly tap into. The drive for utilities to develop infrastructure is backed by the fact that EVs could potentially increase demand for energy increasing thus increasing revenue. For KPLC in Kenya, interest in the area is growing, however, .interviews with stakeholders indicate that the utility does not have the capacity to build a central charging infrastructure.

Charging Infrastructure can also be built through public investments. In China for example, the central government promotes the development of EV charging network as a national policy. This involves setting targets, providing financing and setting standards and mandates. In 2015 the country through the State Council issued the *Guidance on Accelerating Construction of Electric Vehicle Charging Infrastructure* which called for construction of charging infrastructure sufficient for 5 million EVS by 2020[65]. It also required that all new residential buildings to be equipped with EV charging and 10% of parking spaces to be available for EV charging. This approach however remains sensitive to the prevailing political conditions which have direct impact on the longevity of the initiative and the budget allocations

Practical models that have been proposed is retro-fitting the existing network of petrol stations into charging stations. Through this there can be a buy-in from the actors in the oil and gas sector whose business will be distracted by increased uptake of EVS. This approach also partly addresses the concerns of range anxiety which is associated with lack of adequate charging infrastructure.

64 India: Rajasthan Commission proposes new business models for EV charging infrastructure. (2020, June 12). Vehicle Telematics, ADAS, Connected and Autonomous Vehicle. https://www.telematicswire.net/india-rajasthan-commission-proposes-new-business-models-for-ev-charging-infrastructure/

65 Hove, A., & Sandalow, D. (2019). ELECTRIC VEHICLE CHARGING IN CHINA AND THE UNITED STATES. https://energypolicy.columbia.edu/sites/default/files/file-uploads/EV_ChargingChina-CGEP_Report_Final.pdf

4.1 Business model innovation to enable EV charging services.

At this nascent stage, the dominant business model of EV charging in India, an emerging market also trying to shift its fleet to electric models, is provision of charging solutions to business (B2B) such as bus and taxi fleets with a few service providers offerings to customers (B2C). Charging station roll-out is by the public sector, Utilities and Public sector undertakings (PSUs). As the market grows, the expected innovations in business models will grow beyond just basic vehicle charging to the incorporation of more value-added services which will factor in services (promoting green power, providing a choice between multiple speeds, multiple sockets, multiple power retailers, developing software applications for users), partnerships (wider charging network and partnering to offer specific services) and pricing (offering of subscriptions)[66].

Specific to E2Ws, battery swapping has been highlighted as a very pragmatic approach by various stakeholders in the sector. Though it's considered quite capital intensive, this model is ideal for situations posed by motorbike users who might not be able to afford the batteries but are willing to pay for a small rental charge. The other benefits to be accrued from this model is the ability to stay in control of the use and disposal of the batteries. An elaborate battery management system is key in monitoring battery performance and keeping track of their locations and charge levels. This ensures that users do not drain the battery cells beyond the allowable levels.

Failures have been registered in setting up battery swapping models in the past including the Israeli battery-swap start-up Project Better Place, which had planned a network of swapping stations for passenger cars failed in 2013; Tesla, which abandoned its swapping station plans after developing its first demonstration facility in 2015. One possible explanation offered for the failure of the two projects is that at their time of implementation the number of electric vehicles were not high enough to meet the high upfront cost of setting and running the swapping stations[67]. CATL (an electric-vehicle battery company in China) and Ant Financial Services Group are collaborating with Hello Bikes (a bike sharing company) to set up a battery-swapping network for electric bikes in China[68]. With the high use of electric bikes this project may overcome the challenges faced by previous projects discussed above. In Africa, Bodawerk and Zembo in Uganda are currently setting battery swap stations in the country targeting commercial motorcycle users.

4.2 Energy Demand for EVs in Western Kenya

Western Kenya has for a long-time experienced grid unreliability due to lack of evacuation lines from major electricity generation hubs such as Olkaria. The region is currently the most challenging to manage with a peak demand of 411 MW[69]. The challenges arise from the limited line loading-currently the two Owen Falls lines that serve the region and which are designed to carry 73 MVA have to carry up to 92 MVA which is not ideal. The region also has only three generation sources: Sondu Miriu (60MW), Sangoro (21MW) and Muhoroni (60MW) which is supplemented by electricity imported from Uganda. The government is currently addressing this challenge through the construction of an evacuation line from Olaria through Lessos to Kisumu. Though delayed, this line is expected to improve the electricity reliability in the region[70]. Remote areas in the region are also served by minigrids and microgrids.

The transition from conventional petrol engines to e-motorbikes is anticipated to create an increase in demand for energy. In countries with higher adoption rates of EVs, there has been an increase in energy demand for charging. In Kenya, this will be progressive beginning with very minimal effects on the grid and later increased demand as the fleet grows. As it is, currently the country has excess generation capacity and e-mobility offers a potential solution to utilize the excess power. Additional generation supply is also planned as is indicated in the Least Cost Power Development Plan which is revised every two years.

66 Bhagwat (2019).
67 Anders Hove and David Sandalow (2019). Electric Vehicle Charging in China and The United States. Center on Global Energy Policy; Colombia SIPA
68 Quartz News. Retrieved from https://qz.com/1642427/chinas-ant-catl-partner-on-battery-swaps-for-scooters-bicycles/s
69 Data from Kenya Power and Lighting Company, October 2019
70 Western Kenya to wait longer for stable power supply. (n.d.). Daily Nation. Retrieved August 24, 2020, from https://www.nation.co.ke/kenya/business/western-to-wait-longer-for-stable-power-supply-1446614

While the grid would be ideal for setting up charging infrastructure given the existing distribution network and affordability relative to the off-grid options, its unreliability makes the latter option more preferred. Minigrids have proven to be more agile and reliable. Moreover, they are modular and hence the energy output can easily be adjusted depending on demand.

4.3 Batteries

Batteries have been said to hold the key to transitioning away from fossil fuel dependence. The performance of EVs is closely related to the capability of the battery pack that powers the engine. Thus, advances in EV batteries and associated technologies such as charging infrastructure will be the major drivers of growth in the global EV market. In the following sections, we address batteries for EVs broadly then focus on lithium-based technologies which are the main energy storage technology for two and three wheelers. This discussion also assumes fully battery powered electric vehicles although certain aspects may be relevant to plug-in hybrid electric vehicles (PHEVs).

4.3.1 Battery types

There are three main rechargeable battery types for the automotive industry in the market, namely: Lead acid, Nickel based, and Lithium-ion batteries. Other types are still in the R&D stages and are yet to reach commercial maturity. These may be briefly mentioned but will not be discussed in detail. While comparing battery types for EVs, several parameters are considered. These include:

- **Specific energy:** This refers to the energy density of the battery i.e. the energy stored per unit mass (Wh/kg). It's particularly important because batteries form a significant part of the vehicles weight and so batteries like lead acid are disadvantaged due to their heaviness.

- **Specific power**: This is the amount of power that a battery can deliver per unit mass and indicates loading capability. EVs have better torque than ICE vehicles and therefore have better acceleration.

- **Cost**: This is a major challenge for EVs since battery systems cost almost as much a small internal combustion engine (ICE) vehicle.

- **Lifespan**: A battery's lifecycle is influenced by several factors, among them the purpose it will be used for, the depth of discharge/cyclability, the operating conditions and so on. Lifespan is typically given in years and/or distance covered.

- **Performance**: Battery performance is affected by operating temperatures. Batteries are optimised for either high or low temperatures but pose significant challenges when engineering them to function without degradation over a wide range of temperatures.

Lead acid batteries

Of the three types, lead acid batteries are the most mature and reliable, although they are now becoming obsolete at least for the purposes of electric vehicles. Their main applications were as starter batteries and deep cycle batteries[71]. However, they still find some use in special applications for deep cycle purposes such as in forklifts and golf carts. In addition to a short lifespan of about 3 years, lead acid batteries have poor specific energy rate (34 Wh/kg). Because the batteries are heavy, in an EV application they could represent 20 to 25 percent of the vehicle's total mass in order to produce enough energy[72]. Poor performance in cold temperatures and negative environmental impacts also impede their use.

Nickel-based batteries

Like the lead acid battery, nickel-based batteries are mature technologies and were used in early electrical vehicles such as General Motor's EV1[73]. These fall into two categories, Nickel-Cadmium (NiCd) and Nickel-metal-hydride (NiMH). They have double the specific energy of lead acid batteries, ranging from 60 – 120 Wh/kg. Although the NiCd was developed first, it was replaced quickly by NiMh due to drawbacks from Cadmium's toxicity, memory effect and reduced cycle count. The main advantage of NiMH is durability, recyclability, and its ability to ultra-charge without stress.

71 Battery University, (n.d.). How does the Lead Acid Battery Work? https://batteryuniversity.com/learn/article/lead_based_batteries

72 Osmanbasic E. (2019). What you need to know about batteries for Electric Vehicles: Explore some key points about electric vehicle's battery system. Retrieved from https://new.engineering.com/story/what-you-need-to-know-about-batteries-for-electric-vehicles

73 Mok B. (2017). Types of Batteries Used for Electric Vehicles. Retrieved from http://large.stanford.edu/courses/2016/ph240/mok2/

The disadvantages include low charging efficiency, high self-discharge as seen in Table 4 and deteriorating performance at higher temperatures[74]. These disadvantages have limited the use of nickel-based batteries in EVs, shifting the focus to Li-ion technology.

Table 6: Specifications of commonly used EV batteries.

Battery type	Life span (cycle)	Nominal voltage (V)	Specific energy (Wh/kg)	Specific power (W/kg)	Charging efficiency	Self-discharge rate (%/month)	Safety
Li-ion	600-3,000	3.2-3.7	100-270	250-680	80-90	3-10	Safe
Lead acid	200-300	2.0	30-50	180	50-95	5	Risky (generate harmful gases)
NiCd	1000	1.2	50-80	150	70-90	20	Risky (highly toxic)
NiMH	300-600	1.2	60-120	250-1,000	65	30	Safe

Source: Liu, K., Li, K., Peng, Q. et al. (2019)

Lithium-ion batteries

Currently, the heart of electric vehicles is the Lithium ion (Li-ion) battery. Experience gained in the production of Li-ion for consumer electronics became a major competitiveness driver for these batteries in EV applications. Based on recent assessments, Li-ion is expected to remain the technology of choice for this decade[75]. The term is a catchall for different batteries with lithium as the anode and different metal variations/compounds as the cathodes. There are five principal lithium-ion battery technologies shown in Figure 6 each with varying performance in the parameters under observation. Li-ion batteries have multiple advantages including having a reasonable charge cycle rate, high energy density (40 percent higher than NiMH batteries), higher cell voltage, and a better self-discharge rate. While other technologies may pose competition later in the decade, li-ion cells are still expected to have the dominant market position taking up about 90% share by 2025[76]. As seen above, Li-ion are 3 times more powerful than lead acid batteries and have three times the cycle life for one-third the weight.

The biggest disadvantage is their cost, however over the last ten years prices have fallen as production has reached economy of scale. They now cost around $156 per kilowatt-hour, which is an 87% decline from 2010's $1,100 plus/kWh cost[77]. Continued production and improving efficiencies are set to make prices drop below the $100/kWh price by 2024, which is significant since at this point electric vehicles will reach price parity with ICE vehicles. Also, battery cells already broke the $100/kWh barrier in 2018 in high volume 2-wheeler EV markets[78]. Safety is also a big concern where li-ion have been known to experience thermal runaway/excessive heating resulting in batteries catching fire and exploding.

74 Liu, K., Li, K., Peng, Q. et al. (2019). A brief review on key technologies in the battery management system of electric vehicles. Front. Mech. Eng. 14, 47–64 https://doi.org/10.1007/s11465-018-0516-8

75 IEA, OECD, (2018). Global EV Outlook 2018: Towards Cross-Modal Electrification.

76 Sanderson H. (2017). Rise of electric cars poses battery recycling challenge. Financial Times https://www.ft.com/content/c489382e-6b06-11e7-bfeb-33fe0c5b7eaa

77 Bloomberg New Energy Finance (2020). Electric Vehicle Outlook 2020

78 Viswanathan V., Sripad S. (2019). Better batteries are fueling a surge of electric scooters in India and China. Retrieved https://theconversation.com/better-batteries-are-fueling-a-surge-of-electric-scooters-in-india-and-china-124387

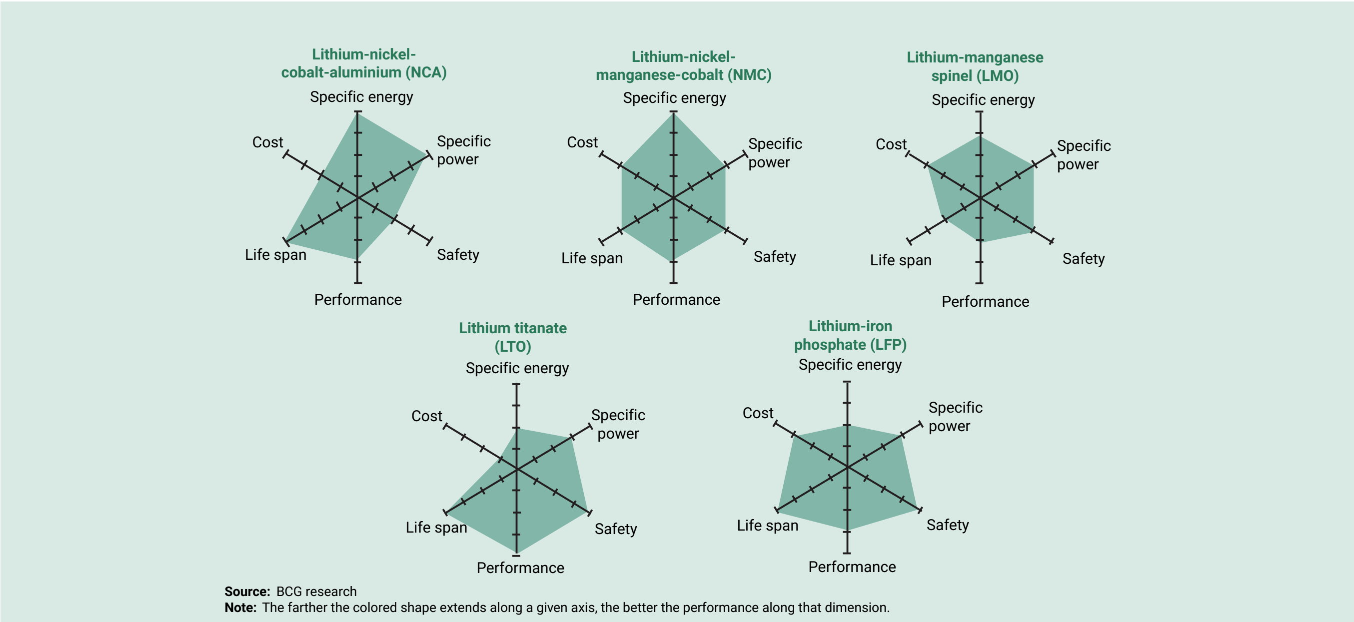
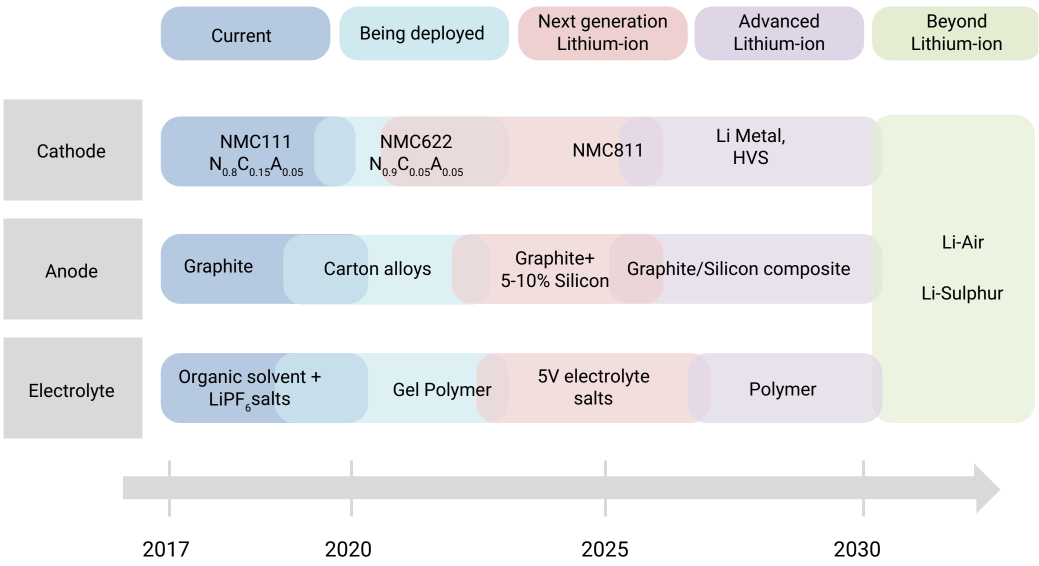


Figure 6: Current Lithium-ion battery technologies

Technology development prospects

Industry players do not expect that batteries based on new chemistries, lithium-based or otherwise will be available for production on a significant scale this decade[79,9]. The main developments in cells that are likely to be deployed will include a reduction in cobalt content to increase energy density and reduce cost, improving anode graphite structure enabling faster charging[80]. Other lithium technologies that are theoretically higher in energy density and lower in costs such as Li-Air and Li-Sulphur as shown in Figure 6 may come up in the period 2025-2030. Battery energy densities are also rising at 4-5% annually[81].



Notes: HVS = high voltage spinel. The diagram shows the likely beginning of commercialisation of a given technology

Sources: IEA analysis based on Howell (2016); Meeus (2018); Nantionale Platform Elekromobilitat (2016); NEDO (2018); Pillot (2017)

Figure 7: Expected battery technology commercialization timeline. Source: OECD/IEA Global EV Outlook 2018

79 Boston Consulting Group. Batteries for Electric Cars: Challenges, Opportunities, and the Outlook to 2020.

80 IEA, OECD, 2018. Global EV Outlook 2018: Towards Cross-Modal Electrification.

81 Bloomberg New Energy Finance (2020). Electric Vehicle Outlook 2020

Solid state batteries are also gaining traction since they boast a few advantages. Since they have solid components, electrolyte leaks or fires (provided a flame-resistant electrolyte is used) are avoided. In addition, they have extended lifetime, decreased need for bulky and expensive cooling mechanisms, and the ability to operate in an extended temperature range.

Electric 2 and 3-wheelers exceeded 300 million by the end of 2018 with the majority being in China[82]. There is a dearth of information regarding batteries for two and three-wheeler vehicles and particularly their adoption in Africa. Majority of the efforts towards transport electrification has been on passenger sedans and public transportation, both locally and globally. A distinction in battery needs for 2 and 3-wheelers is important in order to determine when the 2-wheelers are more cost competitive. For instance, a recent study found that for a range of about 100 kilometres, a battery pack of about 2.5 kilowatt-hours is needed[83], a pack eight times smaller than what is needed for a sedan covering the same range.

4.3.2 Life-cycle analysis of Li-ion batteries

The environmental footprint of manufacturing EVs is heavily affected by the extraction of raw materials and production of lithium ion batteries. Primary production of a ton of lithium takes 250 tons of the mineral ore when mined or 750 tons of the mineral-rich brine resulting in considerable environmental stress[84]. Production of lithium from brine depletes water tables. For instance, in Chile's Salar de Atacama, a major lithium production centre, 65% of the region's water is consumed in mining lithium[85]. Demands on water during the processing of lithium are also substantial, with a ton of lithium requiring 1,900 tons of water to extract which is consumed by evaporation. Secondary production from used Li-ion batteries by contrast would only require 28 tons, around 256 used vehicle batteries.

Lithium is however not the most problematic ingredient in battery production. It is relatively abundant and therefore does not pose major resource constraints presently. Cobalt reserves on the other hand are concentrated in one country, the DRC. The extraction of the mineral raises serious social, ethical, and environmental concerns including artisanal mines employing child labour. In addition, extraction is done by hand without protective equipment in these artisanal mines exposing people to cobalt's toxicity. It is imperative that new battery technologies move towards more environmentally friendly and common materials. Given this nature of raw materials, the demands on end of life dismantling and recycling systems for batteries is significant. For proper management of resources, waste may prove to be a valuable secondary resource for critical materials.

The global stockpile of EV batteries is forecast to exceed the equivalent of 3.4 million packs by 2025[86]. Assuming an average weight of 250 kg per pack, this would result in 850,000 tons of waste. This waste presents several challenges of scale – in the storage of batteries before repurposing or final disposal, the manual testing and dismantling processes, and the chemical separation processes entailed in recycling. In Lansik's ladder seen in Figure 7, re-use is preferable to recycling and recovery. To optimize material-use and lifecycle impacts of li-ion batteries, it has been suggested that their use is cascaded through a hierarchy of applications. Lithium-ion batteries can hold and discharge electricity for another 7-10 years after being taken off the road since they typically have up to 70% of their capacity left[87]. Currently, the economics are in favor of re-use and batteries are finding application in less demanding energy storage tasks. Automakers and other emerging businesses are leading efforts in repurposing li-ion batteries for home energy storage, storing solar energy, and backing up traditional electric grids[88]. Toyota, for example launched an initiative to pair old batteries with solar panels to power 7-Eleven stores in Japan.

These second use applications provide a potential value stream that can help offset the eventual recycling costs. With money to be made, finding second-use applications has overtaken recycling efforts. However, given the sheer numbers of batteries being produced and stockpiling or landfills are unsafe and environmentally undesirable, recycling is inescapable. Currently, batteries are not made for easy disassembly and going forward manufacturers will need to design for recycle[89]. Disassembly poses multiple risks to humans including electrocution, generation of noxious byproducts and chemical hazards. Automating disassembly could reduce these human risks and enhance purity of segregated materials making recycling economically viable. Automation will rely heavily on standardization of battery packs. The net impact of li-ion battery production can be greatly reduced if more materials can be recovered from end of life batteries in as close to usable form as possible[90]. However, recycling alone cannot sustain the mineral supply needed in the current rapid growth phase of EVs.

Regarding recycling, several countries have set standards for battery waste management including the recycling rate for the entire battery. These regulatory frameworks could be strengthened to ensure suitability with the electric mobility transition.

82 IEA (2019). Global EV Outlook 2019: Scaling up the Transition to Electric Mobility.

83 Sripad S., Mehta T., Srivastava A., Viswanathan V (2019). The Future of Vehicle Electrification in India May Ride on Two Wheels. ACS Energy Lett., 4, 11, 2691–2694 https://doi.org/10.1021/acsenergylett.9b02103

84 Katwala, A. (2018). The spiraling environmental cost of our lithium battery addiction. Wired https://www.wired.co.uk/article/lithium-batteries-environment-impact (2018).

85 Harper, G., Sommerville, R., Kendrick, E. et al. (2019). Recycling lithium-ion batteries from electric vehicles. Nature 575, 75–86. https://doi.org/10.1038/s41586-019-1682-5

86 Bloomberg New Energy Finance (2018). Electric Vehicle Outlook 2018

87 Institute for Energy Research (2019). https://www.instituteforenergyresearch.org/renewable/the-afterlife-of-electric-vehicles-battery-recycling-and-repurposing/

88 Ibid.

89 Calma, J. (2019). The electric vehicle industry needs to figure out its battery problem. https://www.theverge.com/2019/11/6/20951807/electric-vehicles-battery-recycling

90 Gaines, L. (2018). Lithium-ion battery recycling processes: research towards a sustainable course. Sustain. Mater. Technol. 17, e00068

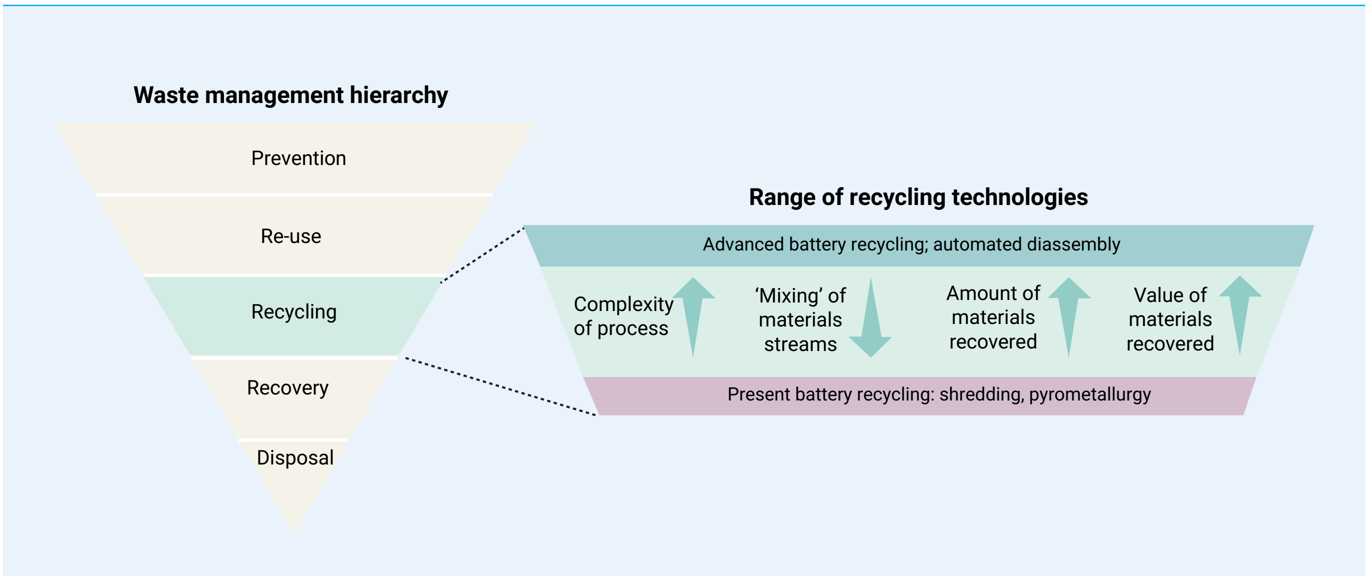


Figure 8: Waste management hierarchy and range of recycling options

There is also a need for the development of a regulatory framework for environmental requirements on the design phase of battery products. It should take account of the need to maximize the recovery of materials at battery end-of-life treatment while minimizing costs.

Emissions from EV batteries are a function of two areas: its production chain and the electricity generation mix. The latter will vary on a country to country basis. The production chain may also have varying impacts since a Li-ion battery pack can vary substantially with its configuration and design. However, a recent life-cycle assessment carried out for a lithium-ion nickel cobalt-manganese battery pack capturing cradle to gate impacts shows that, for a 26.6 kWh, 253-kilogram pack, the global warming potential was 4.6 tCO_2e[91]. Another study supports these findings and concludes that upstream production of battery materials incurs more energy and environmental burdens than cell production and assembling[92].

Several countries have set standards for battery waste management including the recycling rate for the entire battery

91 Ellingsen, Linda & Majeau-Bettez, Guillaume & Singh, Bhawna & Srivastava, Akhilesh & Valoen, Lars & Stromman, Anders (2013). Life Cycle Assessment of a Lithium-Ion Battery Vehicle Pack. Journal of Industrial Ecology. 18. 10.1111/jiec.12072.

92 Qiang Dai, Jarod C. Kelly, Linda Gaines and Michael Wang (2019). Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications

5. Environmental Business Modelling

5.1 Fleet assessment

Kenya's most recent transport sector GHG emissions profile (2015), estimates total emission of 11.25 $MtCO_2e$ using the top-down approach. National contribution for motorcycles was estimated at 674,151 tCO_2e using a bottom-up approach. The fleet numbers and traffic situations used to derive the emission factors were based on the Kenyan context while the emission GHG emission factors were adopted from European context which typically have lower load factors than that of Kenya. This may result in uncertainties and an underestimation of emission factors[93].

A similar approach is adopted in the calculation of emission profiles at the county level for Siaya, Migori and Homa Bay. To estimate the emission profiles at the county level using the bottom up approach, one requires data describing the fleet composition as per the vehicle category, fuel type and the annual mileage as discussed in the next sections

5.1.1 Motorcycles and Autorickshaws

Fleet Composition

Data on in-service vehicle fleets, the actual number of vehicles on the road, is not available as the registries only account for newly registered vehicles and not those written off over the years[94]. At the same time, vehicles registered in one part of the country, for example Nairobi, may be used in other sections of the country making it difficult to estimate the fleet numbers at the county level. The difficulty in sourcing for county specific numbers is partly circumnavigated by primary data from consultations with *bodaboda, tuktuk* and BMU associations. The associations act as a community grass roots organizations which serve to eradicate poverty, foster unity, spearhead development and dispute resolution[95]. The secondary data source used in this study is the census ownership data as indicated in 2019 KNBS Census (Table 7).

93 Government of Kenya (2019). Transport Sector Climate Change Annual Report: Performance and Implementation of Climate Change Actions. Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works. Nairobi, Kenya.

94 Ogot, M., Nyang'aya, J., aTnd Muriuki, R. (2018). Characteristics of the in-service vehicle fleet in Kenya. GIZ TraCS.

95 FGDs with the bodaboda, tuktuk and beach management units

Generally, the associations consist of operators and owners of *bodabodas*[96]. At Mbita they reported a membership of approximately 1,500 with 17 sub-groups. The Sori town operators were part of the Nyatike Sub-County *Bodaboda* group which had a membership of 2,000. Homa Bay Sub-County had a total membership of about 4,000 which included operators, owners and teachers subdivided into 120 sub-units. Beyond the membership numbers, the approximate fleet sizes reported for Homa Bay, Mbita and Sori were 4,000, 1,000 (within Sori town) and 600 (Mbita town). The fleet assessment for Homa Bay town compare favourably with the Census data which reported 3,530 motorcycles for the same Sub-County.

Due to the variation in admission of members, that is, not every member necessarily owns a *bodaboda,* the GHG modelling and accounting will be reliant on the Census Data. Therefore, the total number of motorbikes registered in Siaya, Migori and Homa Bay Counties are 29,422, 31,433 and 27,851 respectively as indicated in the Census Data.

Table 7: Two-wheeler and Three-Wheeler Fleet Numbers as at 2019[97]

County	Sub-County	Two-wheelers	Three-wheelers
Siaya	Siaya	7,575	230
	Gem	4,380	179
	Ugenya	3,724	134
	Ugunja	2,843	79
	Bondo	6,710	202
	Rarienda	4,173	111
	Subtotal	29,422	997
Migori	Awendo	3,269	81
	Kuria East	2,504	86
	Kuria West	6,634	159
	Nyatike	4,802	157
	Rongo	3,075	116
	Suna East & Suna West	7,596	226
	Uriri	3,654	119
	Subtotal	31,433	952
Homa Bay	Homa Bay	3,530	142
	Ndhiwa	5,419	192
	Rachuonyo North	4,458	167
	Rachuonyo East	2,396	136
	Rachuonyo South	3,622	153
	Rangwe	3,022	135
	Suba North	3,055	148
	Suba South	2,404	111
	Subtotal	27851	1301
	Total	88,845	3,063

Source KNBS Census 2019 - Assets Ownership

96 FGDs with Bodaboda Associations.
97 KBNS Census 2019.

The use of *tuktuks* was most prominent in Homa Bay where the total fleet was reported as approximately 100. Similarly, the number compares favourably with the census data which reported 142 *tuktuks*. There were no reported *tuktuks* in Mbita and Sori. The total fleet numbers from for Siaya, Migori and Homa Bay county are 997, 952 and 1301 respectively.

Vehicle Characteristics

The motorcycle engine types in use have customarily comprised of the two and four-stroke. The two stroke is popularly used for outboard motors and motorcycles, although production for the two engine stroke motorcycles has declined[98]. The Kenyan motorcycle fleet is largely classified into three i) > 150 cc, ii) 151 – 250 cc and ii) 251 – 750 cc. Previous data on distribution according to capacity indicates that 64% of the motorcycles in use have a capacity <150 cc while 151 – 250 cc and 251 – 750 cc account for 35% and 2% respectively[99]. The most reported brands in use include Indian, Chinese and Japanese brands of the Boxer-Bajaj, Honda, Sonlik, TVS, KingBird, Hero, Senke and Hapjin. The maximum loading during use, as reported by operators was 300kg and 1 ton for the *bodaboda* and *tuktuks* respectively[100]. The loading capacity varies significantly from the Euro standards used for emission calculations as the latter is not used for public transportation[101].

5.1.2 Motor Outboard Engines

The Beach Management Units (BMUs) reported a membership of approximately 3,800, 1,700 and 300 members for Homa Bay, Sori and Mbita respectively. The fleet sizes at visited landing sites were reported as 36, 92 and 15 motorized engine boats and 32, 71 and 30 sail and paddle boats Table 8

Table 8: Average Fleet numbers for motorized and non-motorized boats at BMU Landing site

Location	Motorized Engine	Sail and Paddle
Homa Bay	36	32
Siaya	92	71
Migori	15	30
Total	**143**	**133**

From the figures above the average number of motorized engines per site is equivalent to 47 boats. There are 321 landing sites[102] identified along the Lake Victoria Shore spread across 5 counties including Kisumu, Migori, Siaya, Homa Bay and Busia. The final tally for the total number of motorized fishing vessels for the figures given is equivalent to 15,301, which is closer to estimations from the study on the challenges of Lake Victoria fisheries co-management which quoted a total of 20,217 outboard motors as at 2012[103].

Boat engine capacity sizes reported varied from 5 to 40hp. The Pursan model was commonly used in Homa Bay and Sori regions due to its cheaper pricing while Yamaha was the most used in Mbita region.

The total number of fishing days reported varied between 30 days specifically for fisher men in Homa Bay while the total number of passenger boats operating per day is mostly limited to 4 boats per day. However, those who indicated 30 days use the manual boats. Fishermen in Mbita reported operating for 20 days in a month. Fuel consumption ranged from 15 to 40 litres. Average trips for Sori consumed approximately 20 l/day and 30 l/day for Mbita.

5.2 GHG Modelling

5.2.1 Boundaries and Assumptions

The geographical boundary of the study is regional accounting for Homa Bay, Siaya and Migori. For the road subsector, the emission calculations include motorcycles and three-wheelers. Additionally, the analysis will also factor in emissions from outboard engine motors. The two primary fuels include petrol and diesel.

The GHG accounting only factors in the emissions from vehicles registered within the region and therefore, any emissions from trans-county travelling is not considered.

98 Energy Regulatory Commission (2016). Report on Global Fuel Economy Initiative Study in Kenya (GFEI).

99 Notter, B., and Fussler, J., (2015). Road transport GHG emission factors for Kenya: Pilot study for 2015. GIZ.

100 Ogot, M., Nyang'aya, J., and Muriuki, R. (2018). Characteristics of the in-service vehicle fleet in Kenya. GIZ TraCS.

101 Mbandi, A., Bohnke, J., Schwela, D., Vallack, H., Ashmore, M., and Emberson, L. (2019). Estimating On-Road Vehicle Fuel Economy in Africa: A Case Study Based on an Urban Transport Survey in Nairobi, Kenya. Energies, 12, 1177. doi:10.3390/en12061177

102 Etiegni, C., Kooy, M. and Irvine, K. (2019). Promoting Social Accountability for Equitable Fisheries Within Beach Management Units in Lake Victoria (Kenya). Conservation and Society 17 ,63-72.

103 Obiero, K., Abila, R., Njiru, M., Raburu, P., Achieng, A., Kundu, R., Ogello, E., Munguti, J. and Lawrence, T. (2015). The challenges of management: Recent experiences in implementing fisheries co-management in Lake Victoria, Kenya. Lakes and Reservoirs: Research and Management 20 1-16

5.2.2 Methodology

The environmental impacts of any mode of transportation can be divided into two categories, occurring during the production processes and those during the use phase[104]. Our GHG accounting for the conventional fleet covers the use phase for fossil fuels and electric vehicles as shown in Figure 9 below.

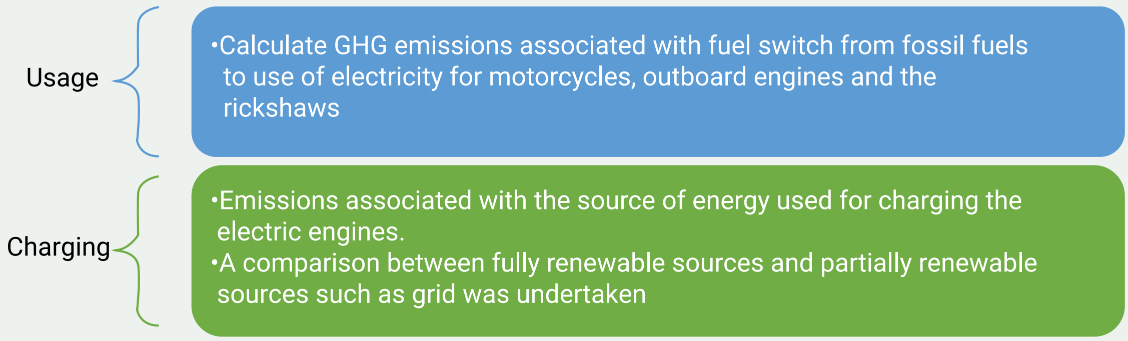


Figure 9: Levels in calculating the GHG emissions

After key informant interviews with local manufacturers of electric vehicles (Opibus) and batteries (Bodawerk), it was evident that the individual components are sourced from foreign markets such as China and only assembled in Kenya. Therefore, the differences in emissions arising from local production vs. importing completely assembled vehicles were deemed quite similar. The focus then shifted to assessing emissions from the use of conventional types.

A tier 2 / Bottom-up approach was applied where the fuel consumed, the VKT was multiplied by the appropriate emission factor for the fuel type as described in IPCC guidelines for mobile combustion[105].

a) Emissions

Equation 1 was used for the CO_2, CH_4 and NO_2 baseline emissions (IPCC, 2006).[106]

$$Emission = \Sigma\,[Fuel_a \bullet EF_a] \qquad \text{Equation 1}$$

Where:

Emission = Emissions of CO_2 (kg)
$Fuel_a$ = Fuel sold (TJ) used as a proxy for fuel consumed
EF_a = Emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12
a = Type of fuel (e.g. petrol, diesel, natural gas, LPG etc.)

The fuel types were reported as petrol for motorcycles and diesel for autorickshaws and engine boards. The default values were as presented for IPCC.

104 Cherry C.R., Weinert J. X., Xinmiao Y. (2009). Comparative environmental impacts of electric bikes in China. Transportation Research Part D, (14) 281-290
105 IPCC (2006). Guidelines for National Greenhouse Gas Inventories Volume 2: Energy
106 ibid

b) Fuel consumption

Fuel consumed for one unit will be determined from estimated from the daily spend on fuel consumption[107]

$$FC = \frac{DMS}{COF}$$

Equation 2

Where:

FC = Fuel Consumption (L/day)
DMS= Daily Money Spend on Fuel
*COF= Cost of Fuel (Ksh/L) * which will be equivalent to the cost on the day of the FGD*

The total amount of fuel consumed is a product of Equation 2, total number of vehicles assessed and total annual mileage of vehicles which was assessed from secondary data sources (see section 5.1.1 and 5.2.2) and FGDs. The total number of motorized fishing vessels are estimated as shown in section (5.1.2)

5.2.3 Findings

The FGDs were used to assess the average daily fuel consumption (FC) / the daily spend on fuel and vehicle kilometers travelled (VKT) as discussed below.

Vehicle Kilometres Travelled (VKT)
From previous reports and studies, the average annual kilometres travelled for *bodaboda* and *tuktuks* is approximately 17,807 ± 3,519 km[108] which varied greatly from 29,090.5 ± 1,569.5 km[109](79.4 km ± 4.3 km/day) reported for operators based in Nairobi. For Mbita, Homa Bay and Sori, the reported average distance was a range of 150- 200 km/day (average 175km/day) for the town services, however this was likely to be longer, upto 300 km, depending on the destination of the customer. Most operators work an average of 6 days/week summing upto a total average of 54,600 km[110] per annum. The distance travelled is almost double that which was reported in Nairobi. Unlike the capital city where *bodabodas* and *tuktuks* are used over concentrated shorter distances to avoid traffic, in the rural areas these vehicle segments represent the main mode of motorized transportation[111].

Fuel Economy
The total spend on fuel varied from KES 200 – 400 for the *bodaboda* operators and upto KES 700 for Tuktuk operators. The estimations for fuel use per km indicate a range of 40 – 56 km/l which translates to 1.7 l/100km – 2.5 l/100 km for motorcycles. Previously a similar study by Mbandi[112] determined the fuel economy of *bodaboda* at 4.6 ± 0.4 l/100km and 8.7 ± 4.6 l/100 km for *tuktuks* operating within Nairobi with an engine capacity respectively. The total fuel consumption for the *tuktuk,* 6.5 l/day at an average of 175 km/day which is equivalent to 3.71 l/100km.

Emissions
Our first consideration is to calculate the tank to wheel emissions for the vehicles. Using the estimated VKT of 54,600 km for a total of 88,845 motorcycles and 3,603 autorickshaws. The total CO_2 emissions from motorcycle use and autorickshaw use was estimated at 250,042.08 t and 22,896 t respectively for the base year of 2019. Emission values for fishing vessels was estimated using the default values as indicated in the IPCC Guidelines which amounted to 319,732 tCO_2. The emission factor for the motorcycles is about 51.62 g CO_2/km which is lower than reported factor of 68.46 g/CO_2/km[113] presented by the Ministry of Transport for the sector annual review. Using the same data and approach, emissions for CH_4 were estimated at 119.23 t for motorcycles and 1.20 t for three-wheelers.

Table 9: Estimated GHG emissions for motorcycles, autorickshaws and engine boards for Homa Bay, Siaya and Migori for the year 2019

Type of motorized transport	CO_2 (t)	CH_4 (t)
Motorcycles	250,042	119
Autorickshaws	22,896	1
Engine boards	319 732	16

107 Mbandi A., Bohnke J., Schwela D., Vallack H., Ashmore M., and Emberson L. (2019). Estimating On-Road Vehicle Fuel Economy in Africa: A Case Study Based on an Urban Transport Survey in Nairobi, Kenya. Energies 2019, 12, 1177.

108 Ogot, M., Nyang'aya, J., and Muriuki, R. (2018). Characteristics of the in-service vehicle fleet in Kenya. GIZ TraCS.

109 Mbandi, A., Bohnke, J., Schwela, D., Vallack, H., Ashmore, M., and Emberson, L. (2019). Estimating On-Road Vehicle Fuel Economy in Africa: A Case Study Based on an Urban Transport Survey in Nairobi, Kenya. Energies, 12, 1177. doi:10.3390/en12061177

110 FGD with bodaboda and tuktuk operators

111 Bishop, T., Barber, C., Charman, Suzy. And Porter, G. (2018). Enhancing understanding on safe motorcycle and three-wheeler use for rural transport. RAF2114A. Amenda and Transaid

112 Mbandi, A., Bohnke, J., Schwela, D., Vallack, H., Ashmore, M., and Emberson, L. (2019). Estimating On-Road Vehicle Fuel Economy in Africa: A Case Study Based on an Urban Transport Survey in Nairobi, Kenya. Energies, 12, 1177. doi:10.3390/en12061177

113 Notter, B., and Fussler, J. (2015). Road transport GHG emission factors for Kenya. Pilot study for 2015. GIZ.

To establish the trend for future scenarios we considered projections for the motorcycles only for two reasons i) they are the highest emitters and therefore have the greatest potential for abatement intervention and ii) historical data was present from the Census 2009 data on ownership of motorcycles from the three counties therefore we could easily establish a past trend for future forecasting. The assumptions are at that the baseline scenario observed for the motorization and population increase rates observed over 2009 to 2019 would hold. The final projections of the subsequent 3 decades till year 2049 are indicated in the table below.

The assumptions for projecting the growth of motorcycles include i) the observed motorization and ii) population increase rates for 2009 to 2019 remains the same. The final projections of the subsequent 3 decades till year 2049 are indicated in the Table 10 below. The motorization rates are also indicated in the Table 10 and Figure 10.

Table 10 : Future / projected growth in number of motorcycles based on historical asset ownership census data

Year	2009	2019	2029	2039	2049
Motorcycles	25,736	88,706	305,746.68	1,053,829.89	3,632,279.61
Population	2,723,268	3,738,820.00	5,133,088.26	7,047,302.37	9,675,358.82
Motorization Rate	0.00945	0.02	0.059563886	0.15	0.38

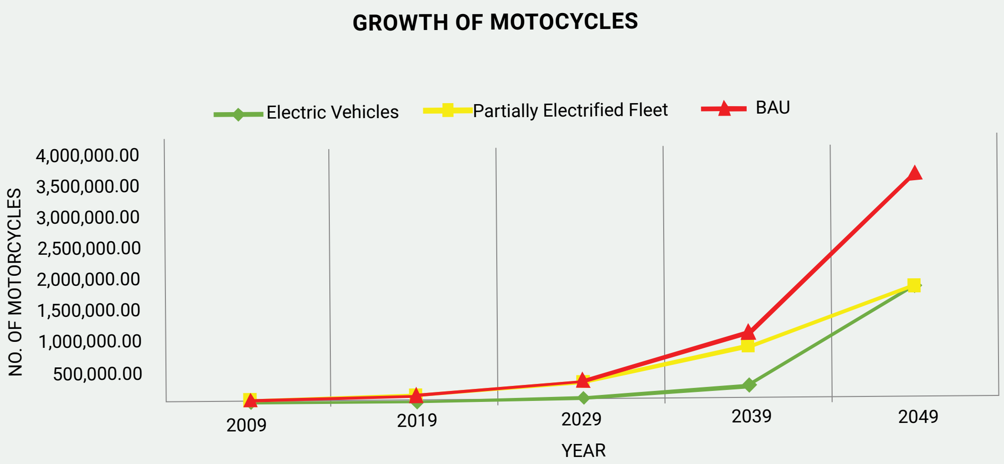


Figure 10: Projected Growth in Motorcycles Numbers in Siaya, Migori and Homa Bay. BAU is assuming a 100% growth in conventional vehicles / 0% penetration in electric vehicles as seen today.

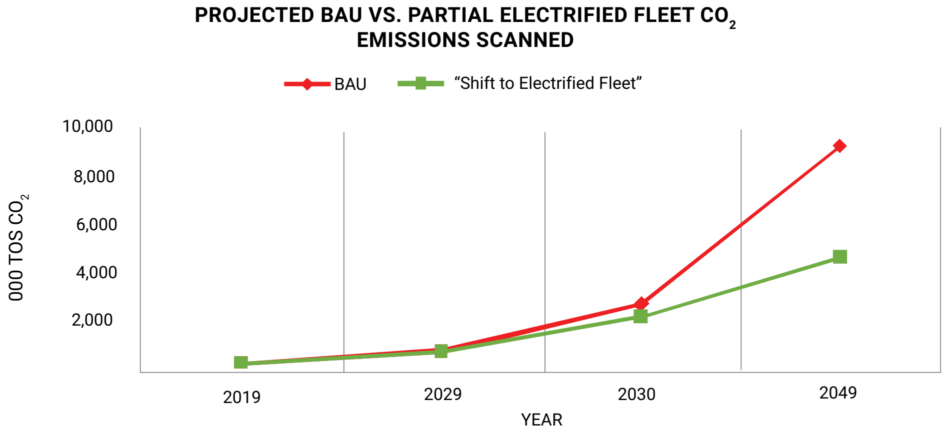
From the projections, two scenarios were considered i) a business as usual model which assumes 0% EV market penetration and ii) a partial shift to electrified fleets in increasing adoption rates of 10%, 25% and 50%, for the years 2029, 2039 and 2049. The latter mirroring global projected electrified vehicular fleets for 2050. The EV penetration rate of 2019 is negligible and assumed to be 0%.

The initial emission factor reported as per this study was approximately 51.62g CO_2/km assuming a similar technology improvement for internal combustion engines (ICE) as that observed in the study by GIZ and with a partially electrified fleet the emission projects are observed (Table 11). Please note the emissions indicated in the shift represent emissions from the ICE motorcycles.

Table 11: Projected CO_2 emissions (t) For conventional fleet for the BAU Scenario and a partial shift to electrified fleets

Year	BAU (t CO_2)	Shift to Electrified Fleet (Emissions from remaining Conventional Fleet) (t CO_2)	Abatement Potential (t CO_2)	Abatement Potential in (t CO_2 Equivalent)
2019	250,014	250,014	0	-
2029	800,625	720,563	80,063	81,980.5
2030	2,703,670	2,162,936	540,734	553,687.7
2049	9,274,408	4,637,204	4,637,204	4,748,291.0

Figure 11: CO_2 abatement potential from shifting to an electrified fleet



Emission from charging Electric Vehicles

Although the switch from fossil fuels to electric mobility will result in a reduction of emissions from tail pipe sources (Tank to wheel, TTW), it is noted that the emissions during charging from the grid are expected to rise as the penetration of EVs increases. For this reason, an additional assessment of the emissions arising from charging from the 'shift to electrified scenario' was carried out. The projected grid emissions factors as indicated in the Kenya Second National Communication[114] to the UNFCC were used for the calculations. The total VKT were maintained at 56,400 km per annum. The energy consumption used was maintained at 17 kWh/100 km[115], no adjustments were made for future technological advancements. The total projected emissions arising are indicated in the Figure 12 below.

Table 12: Emissions arising from charging through motorcycles through the grid.

Year	Number of EVs	Grid emission Factor gCO_2Eq/ MJ	Emissions t CO_2Eq
2019	0	96.1	0
2029	305,747	103.2	105,435
2039	1,053,830	89.3	628,920
2049	3,632,280	87.9	5,334,358.72

The grid emission factors adopted are wholly dependent on the electricity mix and the reliance of fossil fuels for production of electricity. A low carbon development pathway incorporating more renewable energy sources will result in lower emissions.

Uncertainties

a) The historic data on in-use vehicle segments at the county and country level is not available / regularly recorded. For this reason, analysis of trends is reliant on KNBS census 2009 and 2019 results which only factor motorcycles. It should also be noted that the regions as presented in Census 2009 were slightly different from the current governance structures due to the onset of a new constitution.

b) The data provided for the vehicle kilometres travelled is subjective to the approximations of the vehicle users.

c) There is limited information on the traffic conditions for rural Kenya.

d) Fuel consumption of the vehicles and engine boards used were based on the reported values from the operators. There are no real-world average fuel consumption rates for Kenya.

e) The default emission factors from IPCC were used for both road transport and fishing vessels

114 Weiss, M., Cloos, K.C., and Helmers, E., (2020). Energy efficiency trade-offs in small to large electric vehicles. Environmental Sciences Europe 32, 46. https://doi.org/10.1186/s12302-020-00307-8

6. Carbon Markets

There are two types of Carbon market mechanisms namely cap and trade schemes (or emissions trading systems, ETS) and baseline-and-credit mechanisms. Cap and trade schemes often operate in the compliance Carbon markets whereas baseline and credit mechanism is the core of voluntary Carbon markets (VCMs). Compliance markets are created and regulated by mandatory regional, national, and international carbon reduction regimes, such as the Kyoto Protocol and the European Union's Emissions Trading Scheme whereas Voluntary Carbon Markets involve buying and selling entities using emissions reduction credits relative to an agreed baseline. Examples of ETS globally are European Emissions Trading System (EU ETS), Korean Emissions Trading System (KETS), New Zealand Emissions Trading Scheme (NZ ETS), Regional Greenhouse Gas Initiative (RGGI) and Western Climate Initiative (WCI).

Relative to compliance Carbon markets, VCMs are much smaller. In 2018, Emissions Trade Schemes globally raised over USD 57 billion whereas global VCMs transacted Carbon credits worth USD191 million despite their low level.

6.1 Exploring Dynamics of Voluntary Carbon Markets

Voluntary markets operate outside the compliance Carbon market and operate within the conventional laws of supply and demand. Voluntary offset markets provide an opportunity for companies and individuals to purchase carbon offsets from project developers voluntarily to reduce carbon emissions. Carbon credits generated specifically for Carbon voluntary markets are known as Voluntary Emission Reductions (VERs). Notably, Certified Emission Reductions (CERs) from CDM projects can also be traded in a voluntary market. Voluntary trading provides a market for pre-compliance buyers who hope to buy carbon offsets at a lower price and buyers who buy with an intention of re-selling the carbon offsets.

The Carbon voluntary market has grown tremendously over a decade, valued at US$ 704 million in 2008 and US$ 4.8 billion in 2016 with 1,057,212,302 offsets transacted over the years. Certification is crucial in voluntary carbon markets because it increases the possibility of more sales compared to non-verified carbon credits. While VCMs have provided an avenue for sale of VERs, it has also been a victim of poor and uncertain Carbon pricing compared to its counterpart. In compliance markets, one metric ton of CO_2 emissions was sold at US$18.76 in EU ETS and US$ 20.62 in KETS[116]. VCMs carbon pricing in 2017, fluctuated between \$0.5/tCO_2e to more than \$50/tCO_2e with the average Carbon pricing for all VERs at \$3/tCO2e and over 17.3 MtCO_2e of offsets transacted at \$1.0/tCO_2e or less[117]. This is indicative of the market's failure to reach the forecasted prices of US$40/t$CO_2$e to US$80/tCO_2e range needed in 2020 in order to fight global climate change and its impacts[118].Carbon pricing volatility in VCMs is affected by six key factors namely; project type, project size, project standard/certification, co-benefits, age of offsets, and location. Buyers have shown preference to Carbon credits generated whilst the same projects provide benefits to the hosting communities. With additional co-benefits in a project, buyers often focus on which co-benefits are primary. These often include; community social benefits, improved livelihoods, biodiversity conservation, increased adaptation resilience, and employment/training. The geographical location of the buying entity's key operations, its headquarter, location of its customers or its suppliers may influence which projects they buy VERs from. Certification has been identified by many project developers to play a principal role in the pricing of carbon credits. While there exists an array of standards, an individual or a combined certification by these standards increases the chances of fetching above-average carbon pricing for different projects.

6.2 Standards and Certification

Standards are salient for marketing of Verified Emissions Reductions, a revolution that started in the early 2000s when compliance markets were being developed. With the surge of many companies attempting to become eco-friendly and develop green sustainable policies for corporate reputation, many sought to buy voluntarily carbon credits. However, the ecosystem was soon after flooded with many scandals that questioned the quality of the purchased offsets. Consequentially, different non-profit organizations came together to discuss necessary guidelines for offsets, a phenomenon that led to the establishment of the Verified Carbon Standards (VCS) and Gold Standard.

116 ICAP (2019). Emissions trading worldwide, status report 2019.
117 Hamrick, K. and Gallant, M., (2017). Unlocking potential: State of the voluntary carbon markets 2017. Forest Trends' Ecosystem Marketplace
118 World Bank and Ecofys. (2018). "State and Trends of Carbon Pricing 2018 (May)". Washington, DC.

Currently, many standards exist and certify Carbon-offsetting projects available including; Gold Standard, Clean Development Mechanism (CDM) certification, Climate Action Reserve, and American Carbon Registry, Voluntary Carbon Standard, the ISO-14064 standard and Carbon Farming Initiative (CFI). Standards differ in methodologies, project types/categories, and geographical focus. Despite such differences, all standards verify that legitimate offsets are being produced by ensuring that; project developers adhere to accounting methodology including standardized recording and reporting of additional benefits; ensure permanence and additionality of offsets and; prevent double counting and leakage. Permanence ensures that emissions are not delayed only to occur in the future. Project developers ought to ensure that offsets are not retired more than once and leakage is not occurring, hence leading to emissions reduced by project activities displaced to another geographic location.

Due to innovation and evolution in the sector, by 2016, 99% of the traded offsets were certified with 17% certified by Gold Standard; Clean Development Mechanism (CDM) and Climate Action Reserve each certifying 8%, 3% certified by American Carbon Registry certifying and majority of the transacted offsets[119]. Despite having many standards in the ecosystem, different standards specialize in certain geographical areas or project types such as the Carbon Farming Initiative (CFI) which only focuses on agroforestry projects in Australia and Plan Vivo that specializes in the prevention of ecosystem conversion or ecosystem degradation and improved land management. However, some of the diverse standards include the Gold standard and the Verified Carbon Standard.

Table 13: Standards, volume transacted, average price per $MtCO_2e$ and value of offsets sold in 2016[120]

Standard	Offsets ($MtCO_2e$)	Price per $MtCO_2e$(US$)	Value (US$) Millions
VCS	25	2.3	76
Gold Standard	10	4.6	46
VCS+CCB	8	3.9	30
CDM	5	1.6	8
Climate Action Reserve (CAR)	4.5	3	13
ISO 14064	2.5	0.4	1
American Carbon Registry	2	4.7	8
Plan Vivo	1	8	3
Carbon Farming Initiative	0.5	10.5	2

*The given values are based on 827 transactions representing 57.3 $MtCO_2e$ in 2016.

In 2017, Plan Vivo and Gold standards earned the highest prices in VCMs globally[121]. The Gold standard was ranked among the best due to its maintained steady growth as the second-largest independent crediting mechanism whereas fetching higher prices than its key competitor VCS. However, it is noteworthy that Environmental Finance global rankings, have ranked VCS as the best voluntary Carbon standard 5 years in a row since 2015 with Gold standard as a runner up over those years. This ranking is based on a survey with over 1000 respondents voting on the best standard based on efficiency and speed of transaction; reliability; innovation; quality of service provided and influence on the market and volume of credits transacted[122].

6.2.1 Verified Carbon Standards

Developed by Verra, Verified Carbon Standard (VCS) program ensures that Carbon offsets are real, measurable, and verifiable. Since its launch in 2016, it has grown to be the world's largest voluntary GHG program with over 1600 registered programs across 70 countries that have generated approximately 456 million[123] carbon credits[124]. After verification, VCS program issues Verified Carbon Units (VCUs) that can be used by project developers and are tradable GHG credits to individuals and companies aiming to offset or neutralize their emissions[125]. VCS is a diverse and dynamic program that has 15 sectorial focus, among them including Energy (renewable/non-renewable), Energy distribution, Energy demand, Manufacturing industries, Chemical industry, Construction, ***Transport***, and Mineral production[126]. VCS has become globally renowned for its six key principles in ensuring that quality assurance is guaranteed. VCS's six principles that projects ought to adhere to are***; additionality, real and measurable GHG reporting, conservative reporting, permanence, independent verification and unique numbering and transparency listing***[127] ***.***

VCS project cycle sets out four major steps in developing an individual project to generate quality assured GHG emission reductions and credits.

- ***Choosing a methodology***- This is selecting an existing VCS methodology or approved GHG program such as the Clean Development Mechanism (CDM). If a methodology for the proposed project does not exist, project developers can develop a new methodology suitable for the proposed project. Currently, the VCS program has a transport methodology for electric vehicle charging systems[128].

119 Hamrick, K. and Gallant, M. (2017). Unlocking potential: State of the voluntary carbon markets 2017. Forest Trends' Ecosystem Marketplace
120 Hamrick, K. and Gallant, M., (2017). Unlocking potential: State of the voluntary carbon markets 2017. Forest Trends' Ecosystem Marketplace
121 Economics, V., (2017). State and Trends of Carbon Pricing 2017.
122 Environmental Finance. Voluntary Carbon Markets Ranking (2014-2018)
123 Verra (2020). https://verra.org/
124 Ecosystem Marketplace. Financing Emissions Reductions for the Future State of the Voluntary Carbon Markets 2019.
125 Verra (2020). https://verra.org/project/vcs-program/
126 Verra(2020). https://verra.org/project/vcs-program/projects-and-jnr-programs/vcs-sectoral-scopes/
127 Verra (2020). https://verra.org/project/vcs-program/projects-and-jnr-programs/vcs-quality-assurance-principles/
128 Verra (2020).https://verra.org/wp-content/uploads/2018/09/VM0038-Methodology-for-Electric-Vehicle-Charging-Systems-v1.0-18-SEP-2018.pdf

- ***Validation of project description***- After a project is listed in the pipeline, project developers prepare project description in a VCS template upon which it is validated by a verification/ validation body (VVB). VVBs are qualified, independent and approved auditors tasked with assessing projects against the VCS Program rules and the requirements of the applied methodology. This is to ensure the integrity of the projects. Currently, they are over 20 active VVBs and projects ought to be verified by an auditor accredited by VCS and with a specialization in the proposed project's scope[129]. This process can be done before, during or after project design and implementation

- ***Verification of Emissions Reduction***- Project developers are responsible for monitoring, measuring and reporting of GHG emission reductions or removals. The GHG and co-benefits ought to be documented in a monitoring report in the VCS template and approved by VVB.

- ***Registration of projects and Issuance of VCUs-*** Project developers ought to open an account[130] with VCS registry operator[10] to be registered or request for issuance of VCUs. All information is publicly listed.

6.2.2 The Gold Standard

The Gold standard was established in 2003 by WWF and other international NGOs and functions as an offset standard focusing on environmental and social benefits[11]. This standard can be used as an add-on quality standard for CDM activities/projects. As of 2017, more than 550 registered projects had achieved emission reductions of about 78 million tCO_2eq[133] . The Gold Standard is not only keen on emission reduction and environmental integrity, but it also focuses on sustainable development to local communities. For a project to be certified, they must ensure that; they follow environmental and social safeguards; perform diverse local stakeholder consultation; have a gender-sensitive project design; achieve multiple contributions to Sustainable Development Goals (SDGs) and; receive civil society endorsement from the NGO supporter network. Gold standard certifies projects in the renewable energy sector, energy efficiency projects, waste management projects, water sector, and community-based projects. Notably, Gold certified energy efficient community-based projects fetched an average price of US$9.4, fuel-switching project US$11.4 and transport projects US$2.9.

Below is an 8-stage process of Gold Standard certification process as listed on the website[134].

1. Project Design

- ***Project planning and stakeholder consultation-*** This entails confirmation of the basic project design; assessment against Gold Standard safeguards; estimation of climate and sustainable development impacts and preparation of a Key Project Information. This further requires that one holds a gold standard stakeholder meeting, opens a registry account and pays the annual registry fee of ($1000)[135].

- ***Preliminary review by SustainCERT***- SustainCERT is a certification company launched by the gold standard to separate certification from the standard body and is in charge of preliminary review. At this stage the project developers ought to submit; a completed Stakeholder Consultation Report; Draft Project Design Document (PDD), including Safeguarding Principles Assessment, Estimation of climate and sustainable development impacts and Monitoring Plan; signed Gold Standard for the Global Goals (GS4GG) Cover Letter and; a signed Gold Standard Terms & Conditions. Project developers ought to pay a Preliminary Review Fee US$900.

2. Preliminary Design Approval

- Approval by SustainCERT at this stage results in the "***Gold Standard Project Listed***" and approves the project to kick-off.

3. Preliminary Design Review

- ***Third-Party Validation***- This is an Independent assessment conducted by an accredited validation and verification body (VVB) done through desk review and field visits to provide independent confirmation that the project is in line with the Gold Standard requirements.

129 Verra (2020). https://verra.org/project/vcs-program/validation-verification/
130 Verra(2020). https://registry.verra.org/
131 Verra(2020). https://verra.org/project/vcs-program/registry-system/
132 Nordic Initiative for Cooperative Approaches (NICA) (2019). Overview and comparison of existing carbon crediting schemes.
133 Nordic Initiative for Cooperative Approaches (NICA) (2019). Overview and comparison of existing carbon crediting schemes
134 The Gold Standard (2020). https://www.goldstandard.org/take-action/certify-project
135 The Gold Standard (2020). https://globalgoals.goldstandard.org/fees/

Project developers ought to identify, contract, and pay VVB[136] to carry out validation and provide a fully completed Project Design Document (PDD) and all relevant supporting documentation for VVB validation.

- ***Project Design Review by Sustaincert-*** SustainCERT reviews documentation and seeks clarifications and resolutions of corrective actions. Project developers must have received a positive validation opinion from VVB and ought to submit a VVB approved Project Design Document (PDD), all relevant supporting documentation and a VVB final validation report. The design review fee is set at US$1000.

3. Design Certification
At this stage, SustainCERT will certify that; safeguards are covered by the project design; the project has stakeholder inclusive design; there exists a robust monitoring plan and; estimated climate and sustainable development impacts. The status of the project will change from ***Gold Standard Project Listed*** to ***Gold Standard Design Certified.***

4. Project Monitoring
The project developer continually monitors the project according to the approved monitoring plan and engages with local stakeholders. They are also required to submit annual reports and prepare a monitoring report for verification to request issuance of impact statements and/or products.

5. Performance Review

- ***Third-Party Validation-***This is an independent assessment conducted by an accredited VVB through a desk review and a field visit and provides independent confirmation that the project is in line with the Gold Standard requirements. Project Developers (PDs) ought to identify, contract and pay VVB to carry out validation. A fully completed Project Design Document (PDD) and other relevant supporting documentation have to be provided for VVB validation.

- ***Performance Review by Sustaincert-*** SustainCERT reviews documentation and requests clarifications and resolutions of corrective actions where required.

The project must have a positive verification opinion from VVB. PDs to submit VVB approved monitoring report and all relevant supporting documentation including VVB Final Verification Report. The cost of the performance review is US$1000.

6. Performance Certification
SustainCERT certifies that a project has; adherence to safeguards; adherence to stakeholder inclusivity and; achieved climate and sustainable development impact.

Approval at this stage results in "***Certified Gold Standard Project***" status and Gold Standard issuance of certified products and/or impact statements.

6.2.3 Nationally Appropriate Mitigation Actions (NAMAs)

According to the United Nations Framework Convention on Climate Change (UNFCCC), Nationally Appropriate Mitigation Actions (NAMAs) are any initiatives that contribute to the reduction of greenhouse gases and prepared under the umbrella of the national government initiative[137]. This was established under Paragraph 1 (b) (ii) of the Bali Action Plan which called for NAMAs by developing country Parties in the context of sustainable development, supported and enabled by technology, financing, and capacity building, in a measurable, reportable and verifiable manner", committed and agreed upon by 114 countries in 2009 in Copenhagen[138]. NAMAs are diverse and can be implemented either as project-based mitigation actions to sectorial programmes within a designated industry or transformational policies. NAMAs can be financed domestically or seek international support on these 3 key areas; financing, technology transfer or capacity building. At the country level, some developing nations have highlighted in their Nationally Determined Contributions (NDCs) and/or INDCs conditional climate mitigation targets with solely domestic climate finance and international support. NAMA registry was established by UNFCCC in 2010 and became operational in 2013. The registry categorizes NAMAs into three categories;

i. NAMA seeking support for preparation

ii. NAMA seeking support for implementation

iii. NAMAs for recognition (NAMAs not seeking support)

136 The Gold Standard (2020). https://www.goldstandard.org/resources/approved-auditors
137 UNFCCC (2020). NAMAs. https://unfccc.int/topics/mitigation/workstreams/nationally-appropriate-mitigation-actions
138 ECOFYS. NAMA Database. http://www.nama-database.org/index.php/NAMAs

Additionally, the registry is a platform for developed countries to publish available support and resources that can be extended to the developing countries.

In the Past (2011-16), Kenya has registered 6 NAMAs on UNFCCC NAMA registry namely[139]; Transport NAMA on BRT, Rural household energy, Circular Economy Solid Waste Management Approach for Urban Areas, NAMA for the Dairy sector, Accelerated geothermal electricity development and Emission Reduction through Sustainable Solid Waste Management in Kenya. Notably, one of Kenya's NAMA portfolio is a transport sector project, Transport NAMA on BRT, which reportedly secured approximately €20 million[140] Globally, there are approximately 39 transport NAMAs. Table 14 below highlights some of the transport sector NAMAs in Africa and Globally[141]. Noteworthy, most of the highlighted projects lack information on their ability to secure funding for preparation or implementation.

Table 14: Example of existing NAMAs for transport sector[142]

Title	Country	Year of Initiative	Description
Transport NAMA on BRT	Kenya	2011	The objective of the transport NAMA is to reduce vehicle emissions, through Kenya's first Mass Rapid Transit System (MRT).
The rollout of electric private passenger vehicles	South Africa	2010	The NAMA aims to produce and use private passenger electric vehicles in South Africa, with the goal of a 10% penetration of electric private passenger vehicles by 2015. The objective is to decrease GHG emissions by 450 MtCO_2 equivalent from 2011 to 2050. The NAMA will help to demonstrate the feasibility and efficiency of electric vehicles, with the potential of making a considerable contribution to the sustainability of the sector and complementing other national climate change and transport initiatives.
Bus Rapid Transit in Kigali	Rwanda	2015	The NAMA is planned to be implemented through the design, construction, implementation, and operation of an efficient bus rapid transit (BRT) system for the city of Kigali.
Sustainable transport in Sri Lanka	Sri Lanka	2016	The transport NAMA for Sri Lanka focuses on the introduction and adoption of electric buses instead of conventionally fuelled buses in the planned Bus Rapid Transit (BRT) system on Galle Road in the Colombo Metropolitan Area (CMA).
Green Urban Mobility Solution for Zambian City Integrated Tramway	Zambia	2017	The NAMA aims to (i) to reduce GHG emissions arising through reduced vehicular traffic in Lusaka and Kitwe by introducing efficient tramway system as a means of public transport
E-mobility readiness plan	Chile	2010	The E-mobility Readiness Plan is designed to promote the introduction of grid-enabled electric vehicles in Chile on a large scale, leading to a target of 70,000 electric vehicles by the year 2020. The plan foresees the implementation of a set of activities to target barriers and provide incentives to achieve the overall target.
Production and application of hybrid and electric cars in Vietnam	Vietnam	2013	To reduce GHG emissions from the transport sector through the production and application of hybrid and electric cars in Vietnam, towards the target of the Vietnam Government that 6 million environmentally friendly vehicles will be in operation by 2020

Whilst post-2012 CDM from middle income countries such as Kenya are unable to trade in EU ETS, other international markets such the Korean trading scheme and New Zealand ETS purchase Carbon credits from Africa. The current CDM phase is viable till 2023, and the transition process under the Paris Agreement, from the Kyoto Protocol to Paris agreement, the rules are equivocal as to which projects will qualify for CDM, if the baseline remain the same and how the general transition will take place. Thus, making an investment in CDM is a great risk because it is indeterminate if the assets would access the same influential Carbon markets post 2023. Because of the increased uncertainty of the Carbon markets, there is a decline in the number of private sector players interested in selling Carbon credits coupled by the lengthy registration process. Consequentially, with consideration of a project's size, scale and timelines, many are considering alternative schemes and sources of funding.

In attracting the volunteer buyers, a project developer has to match the project characteristics with the interest and the needs of that buyer. It is agreeable that most of the voluntary buyers are often motivated by the uniqueness, the story and the additional benefits to the communities and their ecosystem such as conservation of wildlife in areas where such projects are developed.

139 ECOFYS. NAMA Database. http://www.nama-database.org/index.php/Kenya
140 ECOFYS. NAMA Database. http://www.nama-database.org/index.php/Transport_NAMA_on_BRT
141 ECOFYS. NAMA Database. http://www.nama-database.org/index.php/Category:Transport_NAMA
142 ECOFYS. NAMA Transport Database. http://www.nama-database.org/index.php/Category:Transport_NAMA

Article 6.2 of Paris Agreement[143]

Article 6 gives countries the option to generate and trade internationally transferred mitigation outcomes (ITMOs) through decentralized cooperative approaches under Article 6.2, participate in a UNFCCC-governed mechanism defined in Article 6.4 (the successor to the CDM), and collaborate through non-market approaches under Article 6.8.

Article 6.2 states that where engaging in ITMO transfers, parties shall "promote sustainable development and ensure environmental integrity and transparency, including in governance, and shall apply robust accounting to ensure, inter alia, the avoidance of double counting." However, the Paris Agreement does not specify how to ensure these requirements are met when parties engage in international transfers of mitigation outcomes, and states have different views on this.

It must be guaranteed that each transfer of MO is accompanied by a corresponding mitigation of GHG emissions that actually occurred. The second challenge is to ensure that the same MO is not counted twice and used simultaneously as an NDC compliance instrument by the party who issued the MO and the party who acquired the MO.

Under article 6.2, a state could then "import" MOs which correspond to a certain amount of unreleased greenhouse gases [GHGs]) generated on the territory of another state (through its domestic policies or a bilateral agreement) and use these "foreign" MOs to meet its mitigation pledge under the Paris Agreement. The rationale for allowing such international transfers is to help parties meet their NDCs in a cost-effective way. Acquiring MOs could enable them to benefit from the low-cost mitigation opportunities that may exist in other countries and that would facilitate the achievement of their targets

Role of Government (Article 6)[144]

A new challenge for transactions under Article 6 is the enhanced role expected from host country governments in the transactions themselves. As a result of host country's own NDC mitigation contribution, emission reductions are deemed become a national asset under the Paris Agreement. Though guidelines are still being worked on, it is foreseeable that host governments will play a significant role in overseeing and authorizing the export of mitigation outcomes to other countries. However, this will most likely impact the domestic process of issuing letters of authorization to the use of ITMOs pursuant to Article 6.2, as well as to activities implemented under Article 6.4, thus requiring greater capacity from national institutions and designated authorities. This is comparable to the situation under JI where governments had to issue emission reduction units (ERUs) but it is new in relation to the CDM. While under the CDM, project developers could claim the right to the credits as investors in a mitigation activity without substantial government participation, the fact that virtually all countries now have their own GHG targets under the PA, changes the situation considerably. By authorizing project developers to participate in mitigation activities and sell mitigation outcomes internationally, governments will have to exercise additional caution to not sign off on any transfers of emission reductions that the country will require to comply with its NDC commitments. This means having a very good understanding of the mitigation efforts needed for fulfilling the NDC, the costs of achieving those, and how this translates into specific mitigation interventions in order to avoid jeopardizing domestic mitigation targets due to over-selling ITMOs internationally. Additionally, governments will have a hands-on responsibility to track and record ITMOs, as well as to adjust their biennial transparency reporting for any exported mitigation outcomes.

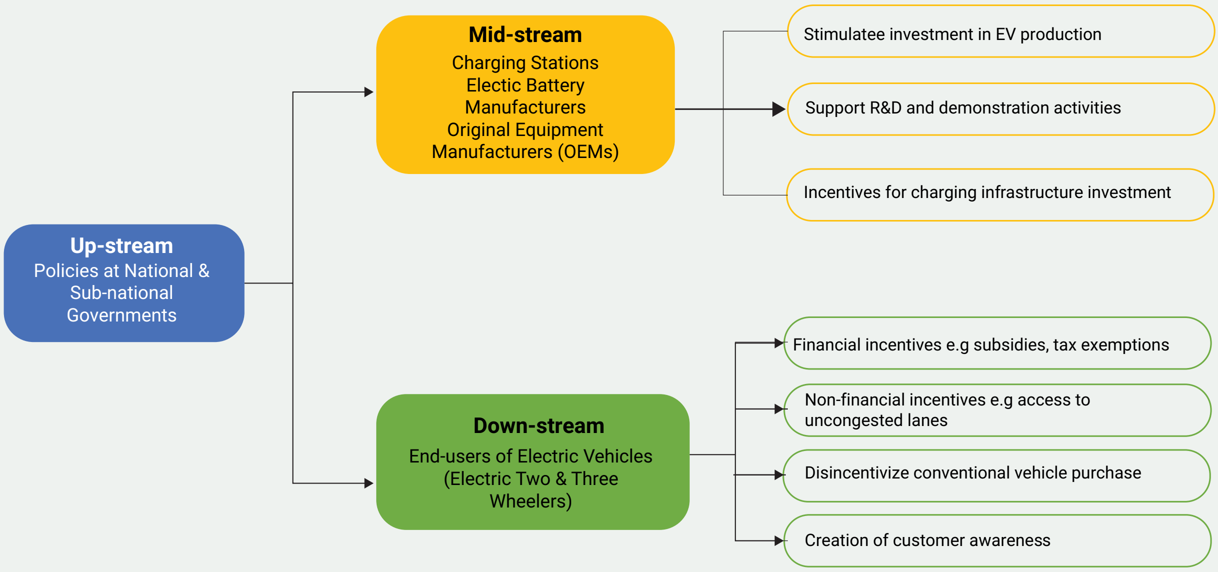
As governments are increasing their involvement in transactions, the contractual structures are diversifying. While under the CDM, contracts were concluded between mainly private buyers and sellers of carbon assets, complemented by a letter of approval (LoA) from governments involved, the Article 6 pilots indicate a potentially more diverse future contracting landscape. The emerging mitigation outcome purchase agreements ("MOPAs") seek to clarify the roles for governments and private entities in meeting and exceeding NDC targets, as well the sharing of the risk of the host country not achieving the NDC.

143 Circontrol Mobility and E-mobility (2019). Lessons from the Nordic experience in Electric Vehicle uptake. Retrieved from https://circontrol.com/lessons-from-the-nordic-experience-in-electric-vehicle-uptake/

144 UNFCCC.n.d. Paris Agreement: essential elements. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

7. Comparative Analysis of Countries with Developed E-Mobility Sector

Review of best practice across countries that are advanced in electric mobility reveal that governments play an important role in promoting the uptake of electric vehicles. Most success stories start with the government formulating policies that are geared towards creating an enabling environment for the manufacturing, importation and adoption of electric vehicles by consumers. For instance, the success in the introduction and uptake of electric vehicles in the Nordic region is attributed to the policy support that electric mobility received[145]. Figure 12 below shows how government interventions through policies can support the different actors in the electric mobility ecosystem.



Governments around the world are formulating plans to scale up efforts to reduce emissions by adopting low carbon technologies. This is in line with global agreements such as the Paris Agreement which seeks to promote a paradigm shift to low-emission and climate-resilient development[146]; and the Agenda 2030 which aims to promote sustainable cities and communities with a focus on air quality and sustainable transport systems[147]. This has indirectly pushed governments to come up with policies which will support the transition from fossil-based transport system to electric vehicles. Other countries, due to their over-reliance on imported oil, are being motivated by the need to reduce imports of crude oil and promote economic growth through local manufacturing of electric vehicles and batteries. China for example, aims to reduce $PM_{2.5}$ emissions in urban areas where the transport system is a major contributor, promote growth local of economies through supporting domestic manufacturing of e-vehicles and batteries[148] and; reduce imports of crude oil in the country[149]. Similar observations are made in India where the government aims to reduce crude oil imports, reduce carbon emissions and air pollution resulting from fossil-based transport system[150]. Rwanda through the vision 2030 for smart green e-mobility is promoting uptake of electric bikes[151]. Developed countries such as the United States, Norway, Denmark etc are driven by the need to provide energy security, low emissions and local economic growth[152,153].

145 United Nations. n.d.#Envision2030: 17 goals to transform the world for persons with disabilities. Retrieved from https://www.un.org/development/desa/disabilities/envision2030.html

146 Andrew Wong (2018). Restrictions in place to minimize foreign e-vehicle manufacturers from saturating the market in China. CNBC. Retrieved from https://www.cnbc.com/2018/04/18/tesla-could-benefit-from-the-cap-removal-on-ev-ventures-in-china.html

147 Hove, A and Sandalow, D. (2019). Electric Vehicle Charging in China and The United States. Retrieved from https://energypolicy.columbia.edu/sites/default/files/file-uploads/EV_ChargingChina-CGEP_Report_Final.pdf

148 NRDC. (2019). India Shifts Toward Electric Vehicles and Improved Mobility. Retrieved from https://www.nrdc.org/experts/anjali-jaiswal/india-shifts-toward-electric-vehicles-and-improved-mobility

149 CleanLeap. (2019). E-bikes to revolutionize mobility in Rwanda. Retrieved from https://cleanleap.com/e-bikes-revolutionize-mobility-rwanda

150 The Embassy of the Kingdom of the Netherlands in Norway. n.d. E-mobility in Norway. Retrieved from https://www.rvo.nl/sites/default/files/2019/04/E-Mobility%20in%20

151 Center for Global Energy Policy. (2019). Electric Vehicles Charging in China and United States. Retrieved from https://energypolicy.columbia.edu/sites/default/files/file-uploads/EV_ChargingChina-CGEP_Report_Final.pdf Norway%20 %20NL%20embassy%20Oslo.pdf

152 The Times of India (2019). Only Electric 2 wheelers maybe sold by 2025. Retrieved from https://timesofindia.indiatimes.com/india/only-electric-2-wheelers-may-be-sold-in-country-after-2025/articleshow/69451954.cms

153 Society of Indian Automobile Manufacturers (SIAM). n.d. Retrieved from http://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=14

To provide a clear understanding of how electric mobility for two wheelers in Kenya can be promoted, we zoom into India. India was chosen because of its high market for two-wheelers and the government has laid out a roadmap on how to electrify the three and the two-wheelers by 2025[154].

7.1 India case study on Electric Mobility

India is the world's largest market for two-wheelers. According to statistics from the body Society of Indian Automobile Manufacturers (SIAM), 17.4 million two-wheelers and 636,569 three wheelers were sold between 2019 and 2020[155]. The increased use of these has led to poor air quality, carbon dioxide emissions, over reliance on imports of crude oil to meet the country's energy demand for the transport system. It is estimated that two-thirds of the pollution in major cities in India is from the use of the two wheelers[156]. Compared to the four-wheel passenger vehicles the use of two- and three-wheelers in India is more polluting than four-wheeled passenger vehicles on a per-kilometre basis, especially if you consider PM emissions[157]. For instance, in the state of Andhra Pradesh 56.2% of the total pollution from the transport sector is from the use of the two-wheelers[158]. This is the highest proportion of emissions of all the other categories such as buses, trucks and the four-wheeler vehicles. As a result, India is moving towards electric vehicles to address these challenges, create jobs (through supporting local manufacturing of electric vehicles and batteries) and improve on mobility within the urban areas[159]. It is estimated that India could reduce fossil energy demand for road transport by 64 % and reduce carbon emissions by 37% by 2030 by pursuing a shared (usership sharing), electric and connected mobility future[160]. India, like other countries with well-developed electric mobility (e.g. Norway), understands that concerted effort at the national, state, and local government level and collaboration with the ministry agencies, public and private players in the sector is paramount in the realization of the goals in electric mobility in the country. This is demonstrated in the plans laid out to help in the realization of the full potential of electric mobility as discussed below.

According to the National Institution for Transforming India (NITI Aayog), India may be required to only sell electric three wheelers by 2023 and electric two-wheelers by year 2025[161]. This is in line with the country's programme on Faster Adoption and Manufacturing of Electric Vehicles (FAME). In 2012, the National Electric Mobility Mission Plan 2020 (NEMMP), was developed to provide a roadmap to adoption of electric mobility in India[162]. This led to the Faster Adoption and Manufacturing of Electric Vehicles (FAME) Scheme in India under the Department of Heavy Industry. The first phase for FAME was between 2015 -2018 and the second phase commenced in 2019[163] and will run for three years with a budget of USD 1.4 billion[164].The scheme aims to incentivize the upfront cost of acquiring the electric vehicles and support the continued use of the vehicles by developing the charging infrastructure[165]. Specifically, the government aims to grow electric mobility in the country through;

i. Demand incentives

ii. Establishment of a network for charging stations

iii. Promoting consumer awareness through information education and communication activities

The scheme covers vehicles under public transportation fleets; registered commercial vehicles for buses, four wheelers and three wheelers and privately-owned two-wheelers. Privately owned four wheelers are excluded from the scheme but an emphasis is placed on shared mobility for three wheelers and two-wheeler vehicles with the aim of reducing congestion in the urban areas.

154 Sharma.N., Chaudhry, K.K. and Rao.C. (2005). Vehicular Pollution Modelling in India.

155 Transport Policy Net. n.d. India: Motorcycles: Emissions. Retrieved from https://www.transportpolicy.net/standard/india-motorcycles-emissions/

156 Government of Andhra Pradesh. n.d. Pollution Control. Retrieved from https://www.aptransport.org/html/pollution-control.htm

157 NRCD. (2019). India Shifts Toward Electric Vehicles and Improved Mobility. Retrieved from https://www.nrdc.org/experts/anjali-jaiswal/india-shifts-toward-electric-vehicles-and-improved-mobility

158 Niti Aayog. (2017). India Leaps Ahead: Transformative Mobility Solutions For All Retrieved from http://niti.gov.in/writereaddata/files/document_publication/RMI_India_Report_web.pdf

159 The Economic Times (2017). Niti Aayog proposes two-wheelers sold in India after 2025 should be electric ones: Nitin Gadkari. Retrieved from economictimes.indiatimes.com/news/economy/policy/niti-aayog-proposes-two-wheelers-sold-in-india-after-2025-should-be-electric-ones-ni

160 The National Electric Mobility Mission Plan 2020(NEMMP) 2012. Retrieved from https://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf

161 The Economic Times. FAME II to fast track India's e-Mobility aspirations. Retrieved from https://auto.economictimes.indiatimes.com/autologue/fame-ii-to-fast-track-india-s-e-mobility-aspirations/3481

162 NRCD (2019). India Shifts Toward Electric Vehicles and Improved Mobility. Retrieved from https://www.nrdc.org/experts/anjali-jaiswal/india-shifts-toward-electric-vehicles-and-improved-mobility

163 Ministry of Housing and Urban Affairs (MoHUA) and Rocky Mountain Institute (RMI) (2019). Electric mobility policy framework. Retrieved from https://smartnet.niua.org/sites/default/files/resources/1-e-mobility-policy-framework.pdf.

164 Department of heavy industries. FAME II India Scheme. n.d. Retrieved from https://dhi.nic.in/UserView/index?mid=1378

Demand Incentives

Demand incentives will apply to the end-users through reduced cost of acquiring the electric vehicle (up-front cost). The Original Equipment Manufacturer (OME) will bear the initial burden of the reduced purchase price but will be reimbursed by the government upon provision of proof of sale[166]. For vehicles to be eligible under this scheme, they must be registered under The Central Motor Vehicles Rules, 1989 and under-go the Conformity of Production (COP) Test for eligibility parameters. The end-users can only purchase one vehicle per each category under the scheme[167]. Table 15 below shows the incentives of the three- wheelers and the two Wheelers.

Table 15: Incentives for the two and three-wheeler electric vehicles[168]

Category of vehicle	Type of vehicle	Demand incentive (INR*/ kWh battery capacity)	Cap on demand incentive (as % cost of vehicle)	Maximum number of vehicles to be supported	Approx. battery size (kWh)	Maximum ex-factory price to avail incentive (INR)
Three Wheelers (3W) including registered e-rickshaws	EV	10,000	20%	500,000	5 kWh	500,000 (USD 6,606)
Two Wheelers (2W)	EV	10,000	20%	1,000,000	2 kWh	150,000 (USD 1,981)

*INR-Indian Rupee

Provision of demand incentives is a practice observed in the leading countries in electric mobility. For example, since early 1990s Norway has formulated policies that aim to incentivize the purchase (financial incentives) and use of electric vehicles (non-financial incentives). Financial incentive included exemption from import taxes on electric vehicles, exemption of the 25% VAT on purchase of electric vehicles, the 50% rule which ensures that counties and municipalities can only charge up to 50 % of the cost for fossil fuel cars on ferries, toll roads and public parking. Non-financial incentives include access to non-congested lanes and access to free parking[169]. China provided subsidies to consumers to lower the upfront cost of the electric vehicles. These subsidies were paid to manufacturers which greatly attracted more manufacturers to venture into the electric vehicle business[170]. Another incentive that was attractive to consumers is the reduced time in acquiring a license plate for electric vehicles as compared to conventional vehicles (acquiring a license plate for a conventional vehicle can take years). This trend is also observed in the United States where the federal government gives a tax credit of between USD 2,500 to USD 7,500 per electric vehicle depending on battery size, for the first 200,000 electric vehicles sold by manufacturers[171]. A new law in Netherlands, that came to effect in January 2020, introduced free-interest loans for purchasing electric bikes, a leasing scheme (where employees can lease a bike at an affordable fee from the employer) and get reimbursed for millage covered for business trips[172]. This is meant to encourage people to use electric bikes to work.

In addition to incentives, the government can use restrictions to promote uptake of electric vehicles. For example, in China petrol-fuelled motorcycles are not allowed in cities[173]. This has seen the rise in the use of electric bikes, and they are gradually displacing use of other forms of transport such as buses, taxi and bicycles. India aims to phase out the fossil-based two-wheelers by 2030. This will force people to take up electric vehicles as the means of transport[174].

166 Department of heavy industries. FAME II India Scheme. n.d. Retrieved from https://dhi.nic.in/UserView/index?mid=1378
167 Department for Heavy Industries (2019). Operation Guidelines for Delivery of Demand Incentives under FAME India Phase II
168 ibid
169 Norsk. n.d. Norwegian EV policy. Retrieved from https://elbil.no/english/norwegian-ev-policy/
170 Ou, S., Lin, Z., Wu, Z., Zheng, J., Lyu, R., Przesmitzki, S. and He, X. (2017). A Study of China's Explosive Growth in the Plug-in Electric Vehicle Market. Retrieved from https://info.ornl.gov/sites/publications/files/Pub72210.pdf.
171 Electric Vehicles: Tax Credits and Other Incentives," US Department of Energy, Retrieved from https://energy.gov/eere/electricvehicles/electric-vehicles-tax-creditsand-other-incentives;
172 Ebiketips. Netherlands expecting even greater e-bike boom as tax breaks and incentives kick in for 2020.Retrieved from https://ebiketips.road.cc/content/news/netherlands-expecting-even-greater-e-bike-boom-as-tax-breaks-and-incentives-kick-in-for
173 Stefan Bakker (2018). Electric Two-Wheelers, Sustainable Mobility and the City. Open Access.
174 The Times of India. Only Electric 2 wheelers maybe sold by 2025. Retrieved from https://timesofindia.indiatimes.com/india/only-electric-2-wheelers-may-be-sold-in-country-after-2025/articleshow/69451954.cms

Establishment of a network for charging stations

Provision of demand incentives without a charging infrastructure will not result in adoption of the electric vehicles by end-users. Availability of a well-established charging network is a key requirement for accelerating the adoption of electric vehicles[175]. FAME II has included plans for development of the charging infrastructure in India with a focus on establishing public charging stations. This will be achieved through partnerships with the different stakeholders in the sector such as the government agencies, Public Sector Enterprises (PSEs). The infrastructure must be established under the Ministry of Power notification on 'Charging Infrastructure for Electrical Vehicles- Guidelines and Standards' established in 2018 and will be amended from time to time. By early 2020, The Indian Ministry of Heavy Industries and Public Enterprises had approved the construction of 2,636 charging stations in 62 cities across 24 states and union under FAME II[176]. Out of these, 1,633 charging stations are fast-charging stations, and 1,003 are slow charging stations[177].

Other options for charging in other countries include home charging and innovative technologies such as battery swapping. Home charging is a viable option in developed countries where electricity access, capacity and quality (reliability) is assured. However, it should be noted that public charging stations are still desirable even in developed countries to cater for long distance trips or when the need to charge arises when away from your home[178]. Countries such as Norway started a scheme in 2015 to develop fast charging stations every 50 km on the main roads[179]. A key feature to incorporate on the public charging station is to ensure that they are fast charging technologies. This will reduce congestion in the stations and inconveniences caused by having to wait for long for the batteries to be fully charged.

Promoting consumer awareness

To ensure uptake of electric vehicles by end-users relevant, timely, and clear information about the electric vehicles must be provided. Under FAME II an Information, Education and Communication (IEC) program will be developed for creation of public awareness about the scheme. Under the electric vehicle guidebook for Indian states, states can adopt these three strategies (See Table 15 below) for creation of awareness for electric vehicles.

Table 16: Strategies for public awareness creation[180]

Strategy	Actions
Mass communication	Organize a general public outreach campaign
	Display consistent EV-related signage
	Develop public websites as a tool to propagate information
	Collaborate with the central government on national-level campaigns
	Highlight the electric vehicle fleet using labels
	Encourage promising stakeholders through awards and recognition
	Fund market research
Personal communication	Showcase ride-and-drive events
	Create targeted outreach campaigns
	Identify regions for electric vehicle demonstrations
	Introduce awareness activities for auto dealers
	Promote electric mobility in tourist destinations
Education and skill training	Develop an electric mobility vocational training program
	Introduce advanced degree and certificate programs
	Introduce electric mobility for children and youth
	Introduce EV driving schools

175 McKinsey and Company (2017). The future of mobility in India: Challenges & opportunities for the auto component industry

176 Article on PV Magazine (2020). Indian companies to partner on EV charging infrastructure. Retrieved from https://www.pv-magazine.com/2020/01/31/indian-companies-to-partner-on-ev-charging-infrastructure/

177 MERCOM (2020). 2,636 EV Charging Stations Approved Across 24 States under FAME II Program. Retrieved from https://mercomindia.com/2636-charging-stations-approved-across-states-fame-ii-program

178 Norwegian EV policy. Retrieved from https://elbil.no/english/norwegian-ev-policy/

179 EVS30 Symposium Stuttgart, Germany, October 9 - 11, 2017. Charging infrastructure experiences in Norway – the worlds most advanced EV market. Retrieved from https://elbil.no/wp-content/uploads/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf

180 Council on Clean Transportation (2019). Electric Vehicle Guidebook for Indian States.

7.2 Conclusion

Electric two-wheelers have been promoted to reduce carbon emissions, improve air quality, and for easy accessibility of urban areas. It's apparent that government involvement is key in the growth of the sector through creation of an enabling environment. Incentives from the government for instance, play an important role in reducing the cost of acquiring the two-wheelers and the three wheelers. For a private actor aiming to promote uptake of electric vehicles in rural areas, two options can be explored based on case study discussed above:

- How to partner with the government and;
- The financial and non-financial incentives (without government involvement) they can provide to encourage the consumers to switch to electric vehicles especially where government policies and regulations are non-existent.

The push and pull theories have often been used in most context to explain how market transformation occurs. The technology-push occurs when there is discovery of a new innovative product. The demand-pull on the other hand is driven by the societal needs and hence products are designed to address these specific needs. However, the two theories are not as linear as they appear but rather other factors interact at the market level that influences technology uptake. Factors affecting choice of technology are not limited to performance measures but also other factors such as the prevailing socio-political cultural norms, rules and preferences come into play. For example, the existing legal structures in a sector have the capacity to promote or hinder the development and adoption of new technologies. Bringing this to e-mobility, it is evident that the drive is mostly technology-push, as demand remain quite low among end-users. There is need to develop and implement policies and strategies that would combine both the technology-push and the demand-pull as is evident in the countries leading in uptake of e-vehicles. A private firm aiming to promote e-vehicles in Kenya can first explore the option of forming partnership with the government. The government will be in a position to formulate and implement policies that are favourable for uptake of e-vehicles. For example, in India the government has set a target for the year the fossil fuel bikes will be phased out.

The next option is to investigate what are some of the activities that the private firm can implement for the demand side to increase demand and promote continued use of the e-bikes. For example, in India the government caters for part of the up-front cost of the bike making the bikes affordable. The private actor can at the beginning of the project pay for a certain percentage of the initial cost of acquiring the bike. This will attract, especially the new users of the bike. As they grow the market, and the end-users start to appreciate the benefits of e-bikes, they can withdraw the incentives. Another option would be to enable them to acquire the bikes by providing low interest loans or no interest loans. This can be done through the motorcycle association, where the members can be enable to switch to electric bikes through loans. Gradually the private firm can lobby for tax exemptions for importing electric bikes. This will contribute to reduced upfront cost of the bike. Acquiring the electric vehicle is not enough but the charging infrastructure has to be in place for the continued use of the electric vehicles. Since most of the rural areas may not be electrified and electricity maybe unreliable, the private firm can invest in innovative charging infrastructure such as battery swapping. Once the upfront cost and charging infrastructure is provided, then the last step would be to create awareness among the motorcycle users. Having quality products without creation of awareness will not result to the desired outcome. The awareness creation can be concentrated on the target region. Some of the approaches to awareness creation include roadshows, meeting with the end-users for demonstrations and County events such as trade fairs where the technology is show cased.

8. Conclusions and Recommendations

The need for Africa to invest in electric mobility is driven by a myriad of accruing benefits. Rapid urbanisation and continued economic growth within SSA lend the region to a continued uptake of motorized transport for both urban and rural applications. E-mobility provides an opportunity to allow sustainable growth for the transport sector. The following recommendations will allow the growth of the sector at its nascent stage.

8.1 Policies, Regulations and Institutional Framework

Presently, the policy measures governing e-Mobility are limited to Standards for EVs instituted by KEBS and a reduction in excise duty for EVs with a capacity of 10 persons or more. The standards set-up need to extend to the installation of charging infrastructure and licensing of distribution channels so as to cover the entire value chain. Two-wheelers and three-wheelers require less intensive charging infrastructure networks when compared to higher capacity vehicles. Tax exemptions applied to this vehicle segment will go a long way in encouraging the uptake of vehicles which can initially be adopted even without an extensive network. The tax incentives on the demand side can extend to tax holidays for companies and institutions to electrify their fleets. The latter will encourage the set-up of more charging infrastructure beyond domestic households and malls. KPLC is piloting an initiative together with the UN e-Mobility Programme to electrify a portion of their Kisumu operating fleet. The operation will be keenly monitored and compared to the remaining portion of the conventional fleet to assess the cost savings and other benefits which may be used to inform more corporations. Such initiatives should be built upon especially as a public awareness drive to inform the general population on electric mobility. Part of the programme will also allow KPLC to allow consumer behaviour and structure appropriate tariffs to allow for charging.

Tax incentives and subsidies offered to the supply side should also encourage the set-up of local manufacturing and assembling plants. At present, the conventional two-wheeler and three-wheeler local assembling has increased due to an increased enabling environment as presented in the National Automotive Policy. A few of the policies supporting the set-up on plants include incentives on depending on the levels of vehicle breakdown. The level of incentivization will depend on local value added; degree of technology transfer; improvement in level of expertise; level of foreign exchange earnings; strengthening of manufacturing value chain; developing linkages within the industry and investment in Research and Development (R&D). An additional incentive that was reported during the KIIs is a reduction in tariffs fees for industries

Importation of EVs still encounter different challenges. There is no provision for prototype registration, under KRA and NTSA. All imported EVs are marked as Nissan Leafs while NTSA has no drop-down menu for EVs to separate them by vehicle type and segment. First course of action is to develop a prototype registration for the different vehicle segments. This requires institutional coordination between NTSA, Ministry of Transport and KRA. Though there is goodwill to see the growth of the sector, the efforts at present are fragmented in each department.

8.2 Charging Infrastructure: The Accelerator

Current discussions indicate that EV development and building charging infrastructure is a chicken and egg situation. One group proposes that an increase in number of EVs will automatically lead to the need to develop a good network of charging infrastructure while the other group posits that a well-developed charging infrastructure could play a significant role in increasing the uptake of EVs. The bottom line however, is that a well-established charging network is key in accelerating the adoption of electric vehicles.

Different countries have taken different approaches in building charging networks. In China for instance the central government is heavily involved with and they set targets as well as provide financing. In the US, most state governments are in charge of driving the process. In India, under the FAME II the they have plans of establishing public charging stations through public private partnerships under the 2018. Charging Infrastructure for Electric Vehicle-Guidelines and Standards 2018. One common trend that can be observed is presence of home charging which will remain a complimentary approach for charging EVs. This however is mostly viable in developed countries where electricity access, capacity and quality (reliability) is assured.

Kenya, which is at nascent stages, does not have stipulations by the government on charging infrastructure in the country thus it remains open to both private and public investments. Opportunities exist for the private sector to come in but there's lack of incentives to undertake the same. Among other things, the government will need to come up with guidelines and standards on the development of charging infrastructure. A key feature to incorporate on the public charging station is to ensure that they are fast charging technologies. This will reduce congestion in the stations and inconveniences caused by having to wait for long for the batteries to be fully charged.

For E2Ws and out board engines, battery swap stations present a promising approach despite past failures when it comes to charging.

To successfully implement this however, there will be value in developing standards for batteries to allow for interoperability between brands. These include but are not limited to: (i) dimensional standards (e.g. shape, size, form); (ii) voltage standards and (iii) quality control (e.g. ISO certification). Key questions to be answered when setting up the station will be on ownership and the initial investment. In the case of Siemens Stiftung and WE TU battery swap stations can be set-up in the existing hubs with little modifications on the existing infrastructure. This can be complemented by the existing mobile money platform that can allow ease of payment. Elaborate Battery Management Systems will be key in tracking of the batteries to avoid loss and also ensure their shelf life is maintained. Additional consideration to be made while setting up would be on existing ownership structure for both boats and motorcycles. Discussions with stakeholders reveal that at least 50% bodabodas are not operated by their owners. In most instances they pay a daily rental fee to the real owners.

8.2.1 Increasing energy demand and E2Ws in rural Kenya

The energy generation mix in Kenya is dominated by renewable sources of energy (geothermal, hydro, solar and wind) resulting in low emission rates. Adoption of electric mobility will result in a better transport sector in terms of carbon emissions. Various pathways can however be explored to meet the anticipated energy demands with increased use of EVs in the country. Both the grid and off-grid solutions will be key in meeting this demand. Minigrids have the advantage of reliability but suffer from lack of demand. Electric motorbikes and boat engines have been highlighted as viable options for demand stimulation for these distributed sources. In their paper[181], June, Aggrey and Jay evaluates the potential of electric engine boats as crucial anchor loads. From the study, they find that boat charging can contribute to at least 17% more consumption per day resulting in substantial technical as well as financial value to minigrid system. Charging of electric motorbikes and outboard engines for boats around the lake will thus create demand for energy at the various hubs currently operated by WE TU along the lake region.

8.2.2 Battery Selection for E2Ws

Technological advancement has led to development of better batteries (lithium ion, nickel metal hydrides) with higher energy density hence reducing the overall weight on the motorcycle. While Kenya recently developed a waste management strategy, the specific components on e-waste are shallow and pass the responsibility to the user to ensure safe disposal. With the anticipated growth in the number of EVs, the government will need to provide sufficient guidelines in the disposal of used battery packs. Batteries from EVs can still find use in varied applications such as energy storage for solar systems. Collaborations between organizations between will be key to create a central pool for battery recycling.

Key considerations will need to be made on energy density which in return affects range which was a cited concern among both *bodaboda* and boat operators. This should be coupled by a good battery management system that can quickly provide details on level of charge and general condition of the battery. Other factors to evaluated when deciding on the battery types to be used for e-mobility include:

- Battery life versus its cost
- Battery chemistry
- Charging properties
- Recycling infrastructure

8.3 Greenhouse Gas Abatement and Carbon Trading

GHG modelling was carried out for the geographical region of Homa Bay, Siaya and Migori counties for conventional two-wheelers, three-wheelers and outboard engine motors. The total abatement potential (tank to wheel) of shifting from ICE motorcycles to a partially electrified fleet was estimated as 5,383,959 tCO_2e for the period of 2019 – 2049. The partial electrified fleet assumed penetration rates of 0%, 10%, 25%, 50% for the year 2019, 2029, 2039 and 2049. The well to tank emissions from charging the EVs specifically from charging through the grid was estimated at 6,068,715 tCO_2e. These emissions are expected to decrease as Kenya's electricity mix continues to phase out fossil fuels for renewable energy to power the grid.

From our assessment the trading of carbon credits, post the Paris Agreement introduces a few complexities that were not present during the Kyoto Protocol and trading through CDM. Under the Paris Agreement each country that ratified the treaty is required to actively aim to reduce their Nationally Determined Contributions which are considered national assets. Host country governments in the transactions themselves are envisioned to play a large role in overseeing and authorizing the export of mitigation outcomes to other countries.

181 Lukuyu, J., Muhebwa, A., & Taneja, J. (2020, June). Fish and Chips: Converting Fishing Boats for Electric Mobility to Serve as Minigrid Anchor Loads. In Proceedings of the Eleventh ACM International Conference on Future Energy Systems (pp. 208-219).

This enhanced role will likely also impact the domestic process of issuing letters of authorization to the use of ITMOs pursuant to Article 6.2, as well as to activities implemented under Article 6.4, thus requiring greater capacity from national institutions and designated authorities.

Similarly, voluntary carbon market as a means to align themselves with the foreseeable changes will are already offering certification for projects noted to have host country authorization for trade. The latter is noted to fetch higher prices. It is highly recommended that project developers seek host government certifications before setting out to trade.

Annex 1 KII INFORMANT LIST

Name	Organisation	Position / Role
Francis Romano	Drive electric	CEO
Samson Ondiek	KPLC	Chief Officer, Corporate Planning
John Kidenda	PowerGen	Director of Software and Analytics
Vivian Vendeirinho	Rve.Sol	Founder and Chair of Board
Thilo Gabriel	AHK	Project Manager
Valerie Leisten	AHK	Senior Project Manager
Erika Lovin	Crossboundary	Senior Associate
Lee Okombe	Ministry of Energy	Assistant Technical Officer
Anthony Mburu	(Formerly) Tesla	(formerly) Energy Business Development Lead
Jay Tenaj	Energy for Growth Hub	Research Fellow
David Rubia	UNEP	Programme Officer, Air Quality and Mobility Unit
Emilie Martin	Urban Electric Mobility Initiative / UN Habitat	Project Consultant
Tim Cowman	Carbon Africa	Director
Mathias Krey	Perspective Climate Group	Managing Director
Jakob Hornbach	Bodawerk	CEO & CFO
Filip Gardler	Opibus	Founder & CEO
Laurens Friso	Asobo	Co-Founder & CEO
Mathias Ehrenwirth	Technical University of Ingolstadt	Head of Building Energy Systems

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ABOUT SIEMENS STIFTUNG

While this document has been prepared in good faith and based on international best As a nonprofit foundation, Siemens Stiftung promotes sustainable social development, which is crucially dependent on access to basic services, high-quality education, and an understanding of culture. To this effect, the Foundation's project work supports people in taking the initiative to responsibly address current challenges. Together with partners, Siemens Stiftung develops and implements solutions and programs to support this effort, with technological and social innovation playing a central role. The actions of Siemens Stiftung are impact-oriented and conducted in a transparent manner. www.siemens-stiftung.org

WORKING AREA: BASIC SERVICES

Secure access to basic services is indispensable for people to lead independent and dignified lives. Our goal is to reduce existential deficits in basic services and strengthen necessary social structures. With our international *empowering people. Network*, we bring innovators and social entrepreneurs together and foster the combination of technical and entrepreneurial concepts. This allows us to promote the spread of suitable solutions, maintain a platform for knowledge transfer, and enable networking of development collaboration organizations. Locally-operating projects are run together with partners and implement innovative as well as proven solutions. Additionally, we impart the necessary knowledge to ensure that self-supporting structures can contribute to a permanent improvement in basic services.