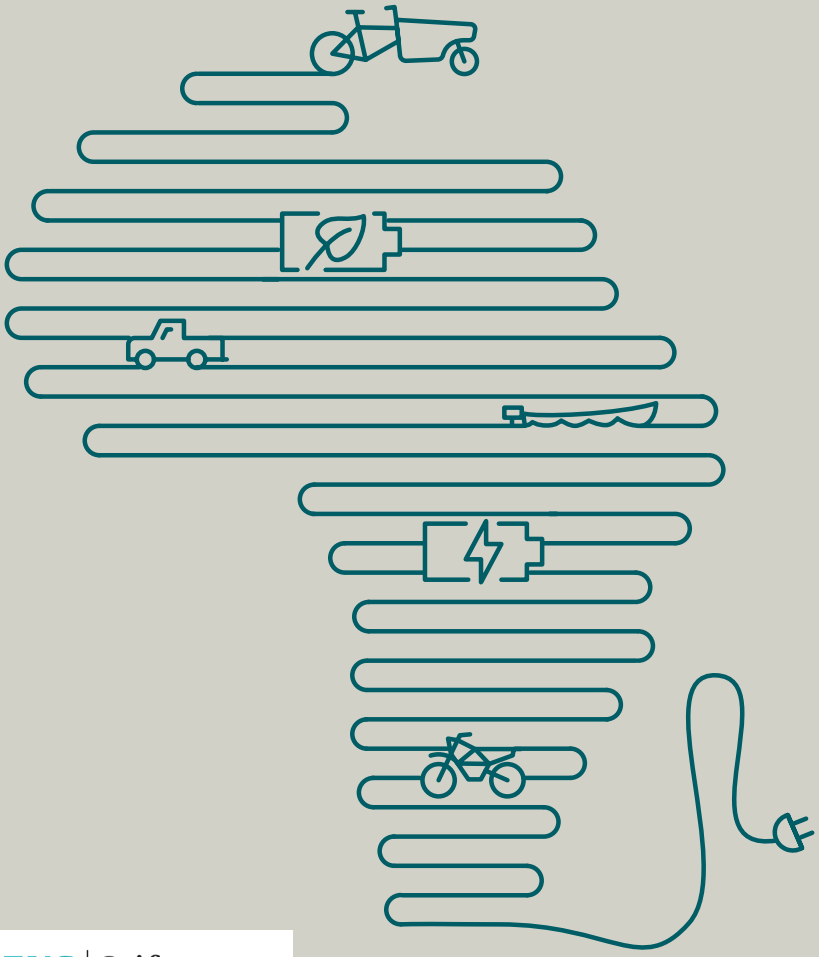

SIEMENS | Stiftung

E-Mobility Solutions for Rural Sub-Saharan Africa: Leveraging Economic, Social and Environmental Change

As follow-up of the "Spotlight on E-Mobility" Roundtable during the Lake Basin Innovation and Investment Week in Kisumu, Kenya

www.siemens-stiftung.org

Foreword by Rolf Huber

Looking at international debates on the potential of electric mobility for Africa, most people assume that the transition will start out in cities. Travelling throughout rural East Africa, I have met a number of innovative and impressive entrepreneurs who are convinced that rural areas with its people – creative and resilient problem solvers – will become the frontrunner to drive change.

With motorization rates on the rise in Sub-Saharan Africa (SSA), a number of countries have made first steps to ensure Africa will leapfrog to low emission technology, they are turning away from fossil based and often imported and expensive energy. In my opinion, East Africa is the dynamic heart of this new transition and has created a momentum that we wanted to capitalize on by launching our first roundtable on e-mobility within the 'Lake Basin Innovation and Investment Week 2019'. Gathering in the city of Kisumu, Kenya, at the shores of Lake Victoria, 130 political and industry leaders, catalyzers, start-ups and UN representatives discussed the potential of new technologies and e-mobility solutions for urban and rural settings. The outcome was fruitful and convinced us once again that the future lies in cross-sectoral cooperation and local solutions to provide access to basic services for rural communities. At the same time, this event offered a unique platform for start-ups to demonstrate the viability of their products and services by exhibiting their prototypes such as the first Kenyan produced e-cargo bike (anywhere. Berlin and WeTu, Kenya), solar bicycles (EURIST, Uganda),

an e-conversion of a 2-stroker motorcycle (Bodawerk, Uganda) and e-outboard engines for local fishermen. You could literally feel the energy and enthusiasm generated in each session.

In the weeks following the conference, we were surprised by the number of requests received asking for further information on the topic. We realized that the existing literature, particularly with a focus on Sub-Saharan Africa, is rather slim and the idea of a technical booklet that could fill this void was born. Thanks to the great input and support of our partners and the incredible amount of local knowledge provided by the participants, we were able to put together a small guide covering rural e-mobility solutions, new business model innovations and sustainable mobility concepts for urban areas.

In the last year, we have seen the synergies roundtable events such as Kisumu can generate and how continued exchange among sectors can create the starting point for tangible social change. We are on the path to a future that will be smarter in so many ways: smart mobility, smart charging, smart grid, and smart integration. We will continue working on further exchange formats and events to drive the momentum towards this striving new industry with its enormous potential for green jobs, inclusive economic growth and social development.

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Is Africa ready for an electric vehicle revolution?

Africa finds itself at a crossroads in terms of mobility – on the one hand, the continent still has one of the lowest motorization levels in the world; on the other hand, the continent is facing one of the fastest vehicle growth rates. Annual vehicle sales are increasing rapidly, at over 10% in most African countries compared to 4% in European countries.[1] A large proportion of vehicles are second-hand, only 1 in 10 vehicles imported into the region is new. This presents a unique opportunity for African countries to improve the emission of its vehicle fleet before motorization further takes off. Sub-Saharan Africa (SSA), in particular, is undergoing a mobility revolution spurred by rapid urbanization, rising population numbers, growing energy demand and economic growth. This comes at a time when most African countries are already grappling with mobility challenges in terms of congestion, inadequate infrastructure, air pollution, health issues and the fiscal burden high fuel prizes and subsidies place on the economy.[2] Vehicles powered by electricity and running on battery storage offer a fantastic solution to the above problems.

Box 1

Did you know that ...

... worldwide EV sales approached 2.3 million vehicles, with market penetration of 2.4% in 2019

... battery prices have fallen 87% from $1,100/kWh in 2010 to $156/kWh in 2019

... the number of EV models is rising, with 400+ new models expected by 2025

... 150,000 motorcycles in Kampala alone produce more than 450,000t of CO_2 annually

... a global shift to 90% battery electric motorcycles sales by 2030 could result in CO_2 emissions reductions of 11 billion tons between now and 2050

... traffic congestion in Nairobi alone is estimated to have an economic cost of approximately $ 18 million annually

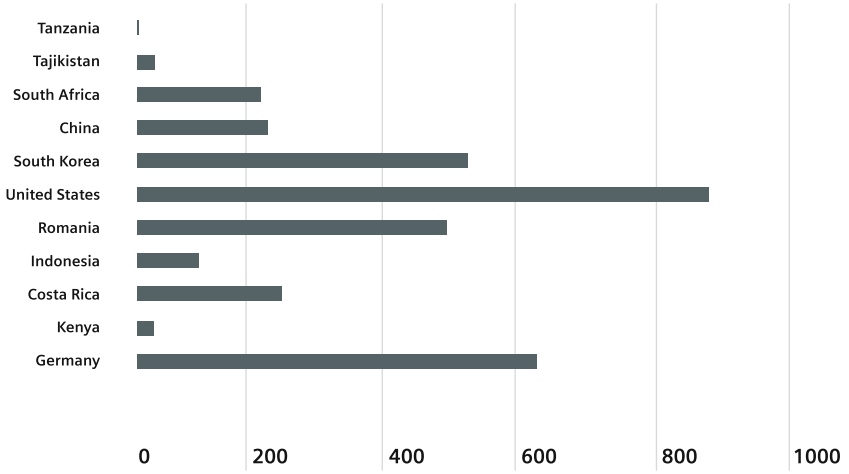


Figure 1: List of countries by vehicles per 1,000 inhabitants

Africa fits all criteria for an electric vehicle (EV) revolution: the continent has the richest renewable energy resources on the planet. Temperatures in the region are rarely below zero degrees and people travel an average distance of less than 80km daily with an average speed of 60 km/h, making EV solutions technically and economically the perfect fit. Africa also has one of the youngest technique-affine populations which could not only facilitate a fast shift to electric mobility, but more importantly, provide a workforce to develop own vehicle production capacities. Moreover, EVs have also gained attention as a strategy to decrease petroleum dependency and boost energy security in the context of increasing transport demand, which could be highly profitable for African countries' balance of trade and foreign exchange.[3] A number of Sub-Saharan African countries have already made significant steps in improving their overall vehicle fuel economy, enforcing vehicle standards and regulations such as the Climate Change Act in Kenya, or promoting non-motorized urban transport in Kigali, Rwanda. However, these efforts need to be significantly scaled up in order to stave off the growing burden of fuel dependency and discover an electricity storage solution to leverage Africa's abundant renewable energy resources.

Introduction to rural transport & mobility

With more than 60% of Sub-Saharan Africans living outside of urban areas, rural transportation and mobility are of utter importance. Roads represent a lifeline for economic and agricultural livelihood as well as a number of indirect benefits including access to healthcare, education, credit, political participation and social interaction.[4] Many Sub-Saharan African countries face major obstacles to rural access, such as the lack of all-season roads, poor road conditions and connectivity, as well as the reliability and affordability of transport services. Financial and technical constraints on national governments are often severe, which makes improving rural infrastructure and transport services challenging.[5] This has a direct impact on local communities as it increases transport costs, reduces accessibility to essential services (drinking water, education, health, finance) and limits social interaction. Enabling road access in rural areas would further help to boost farmers' income by providing market linkage to the nearest town or city, thus improving food security over the medium and long term.[6] The latter is a challenge at times when population

Box 2

Did you know that ...

... more than 60% of Sub-Saharan Africans are living outside of urban areas

... 80% of African urban dwellers do not own a motor vehicle

... more than 650 million people, walk, bike or use public transport

... SSA is lowest contributor to global emissions, putting out a total of 3.8% of all greenhouse gases

... there are 176,000 deaths per year in Africa due to air pollution which costs as much as 2.7% of the GDP

... Kenya will import a projected 730,000 motorcycles until 2022

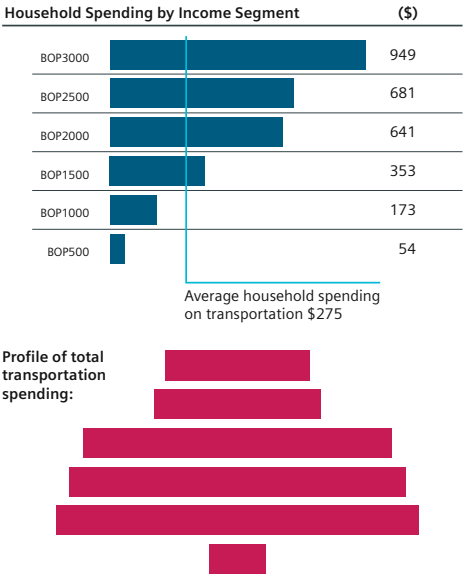


Figure 2: Case Study Uganda illustrating how transport expenditures increase as income rises

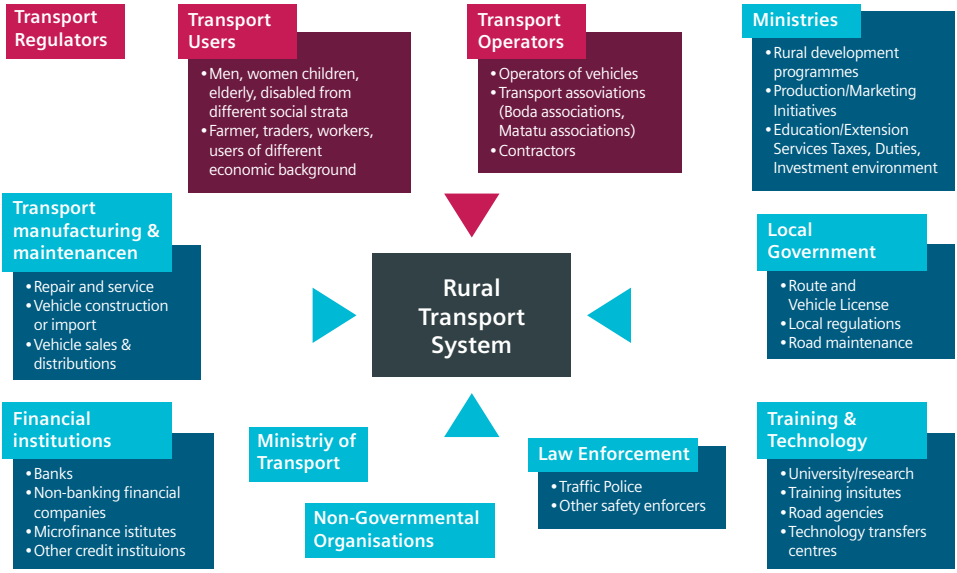


Figure 3: Stakeholders & factors influencing rural transport ecosystems in East Africa

growth and climate change converge to challenge food security, both globally and within the African continent. The initial 'first-mile' stages of crop movement, from farm collection to secondary roads, are the most expensive and pose the greatest obstacle to the development of agriculture in rural areas.[7] An efficient rural transport system using e-mobility solutions could essentially support local production, facilitate timely distribution of farm inputs and produce, reduce post-harvest losses and ensure a vibrant food system. Apart from a small minority who own motorcycles and cars (whose operating costs are very expensive since petrol prizes are as high as in Europe), most inhabitants of rural areas in Africa, more than 650 million people, walk, bike or use public transport in form of imported 2&3 wheelers.[8] The World Economic Forum calculates that the richest Sub-Saharan African households spend up to 70% of their household income on transport while the poorest income group typically spends more than 60% on food and less than 8% of their income on transport.[9] The lack of affordable mobility solution restricts economic improvement opportunities, strangles the markets and hinders people from accessing the jobs that will help them be more productive, increase their income and eventually escape poverty.[10] In order for EVs to seize the enormous socio-economic potential that improved transport in rural areas can unlock, it is crucial that future approaches shift from identifying communities as beneficiaries towards focusing on people as consumers and producers and on solutions that can make markets more efficient and competitive.

Who uses electric vehicles?

A customer profile

Floyd Owino
Student at Sori secondary school, spends 30KES ($0.30) for a e-bike ride to school; regularly rents e-bike from WeTu Hub at a daily rate of 300KES ($3)

"The means of transport I normally use to school is a motorcycle of which I pay the rider KES 30. I prefer using the ones that are electricity driven. There aren't many of them and using one of them to school feels unique and good. The electric bikes aren't noise polluting and you can't see any traces of smoke. Now that my father is constructing a home, instead of ferrying building materials to the building site using a wheelbarrow, we are able to use an electric cargo bike which saves time."

Goretty Akoth
Market trader selling groceries, daily income of 2000 KES ($20) with a profit margin of 500 KES ($5)

"When I first saw the electric bike, my feeling was wow! I had never seen something move so fast without fuel and I was happy that a cheaper option to transport groceries from the market and farms to my kiosk was being launched.Currently, my husband uses the electric cargo bike to transport water and goods from wholesale shops to retail shops. The usage of the e-bike has increased our daily earning and improved our way of life. He serves more customers on a daily basis and does not come home tired anymore. With the new income we have managed to set up a small B&B guesthouse."

George Omodi
Boda Boda Taxi Driver, 30 years with a family of four, owns bicycle, works 7hrs/day and travels 4km/day with a daily income of 800KES ($8) with profit margin of 500KES ($5)

"I first heard of electric mobility solutions from a friend who had seen a prototype of an electric cargo bike in Kisumu. So, when they finally reached my town Sori, I could not wait to use one since it looked so unique and I was instantly convinced it would be a really cost-effective means to support my young family as compared to fuel driven motorcycles that I had considered leasing on several occasions but failed to because of the high fuel costs.I see electric mobility as something that was made for people living in poverty like me and embraced it fully. So far, it has not disappointed. I have realised so many advantages while using it, I am able to go long distances and finish work early."

Daudi Kajese
Local fisherman in Sori at Lake Viktoria, daily income of 7,000KES ($68), daily spending of 5,000KES ($48), and a profit margin of 2,000KES ($20) at the end of the day

„As an entrepreneur, I am well observant on my daily spending. Just imagine that while using fuel-driven engines for fishing I had to spend at least KES 2000 on fuel alone. I knew that by substituting the fuel-driven engine for an electric outboard engine, my costs would definitely reduce by half since electricity is readily available almost everywhere nowadays and isn't so expensive. In fact, it's even cheaper in such a rural set up like Sori where we have a lot of people using solar energy for home usage. Fishing industry in Kenya has not always been a key area of interest for the government in Kenya and it's always been assumed to be a field of the illiterate ones in the society. So when I first heard of Electric mobility and introduction of e-outboard engines, I became very happy with the planned improvement and as for that reason I had to embrace the technology. So far so good because of the reduced spending on fuel."

The state of electric mobility in Kenya

Case Study

Over the last few years, Kenya and the horn of Africa region at large have started to feel the repercussions of climate change and its impact on human health, agricultural production and economic losses. The global transition to a low carbon economy has never been more urgent than it is today. Since the early 2010s, Kenya has been working diligently to position itself at the forefront of the energy transition race in East Africa. To that end, Kenya has enacted two transformative laws that directly affect its transition to a low-carbon economy: the Climate Change Act 2016 and the most recent Energy Act 2019. The initial motivation behind these policies was to reduce Greenhouse Gas (GHG) emissions by 30% by 2030, improving resilience to climate change and promoting low-carbon climate resilient development.[11]
Since the transport sector accounts for more than 13% of the country's total emissions, a nation-wide electrification of the vehicle fleet has been identified as priority mitigation action. However, the existing infrastructure for EVs in Kenya is still at an infant stage: only 350 EVs have been registered in the country (as per 2019). Kenya has currently 3.2 million vehicles with 2&3 wheelers presenting the largest share of the vehicle fleet and holding the highest rate of motorization, with 108,000 motor cycles new registered in 2018.[12]

	2015	2020	2030	2040	2050
Passenger car (PC) stock [-]	532,406	745,304	1,297,828	2,101,272	3,142,422
Inhabitants [in 1000]	46,050	53,115	67,245	81,375	95,505
Motorization rate [PC per 1000 inhabitants]	11.56	14.03	19.30	25.82	32.90

Figure 4: Projected increase of the motorization rate in Kenya

The country's vehicle market is dominated by second-hand vehicles imported from the UK or Japan. Two major Indian motorbike fabricators, TVS and Bajaj dominate the Kenyan 2-wheeler market with a market share of over 95%, making them the most important means of transport for the Kenyan population in both rural and urban areas.[13] Many of these internal combustion engine 2&3 wheelers are old and inefficient, emitting more amounts of particulate matter and black carbon than a passenger car. There is potentially quite a large addressable market for conversions as more and more of these motorcycles age. Given the government's objective to improve its policy framework, tax incentives have been introduced in the form of the Finance Bill 2019, reducing the excise duty for all EVs from 20% to 10%.[14] In 2017, the Kenyan Bureau of Standards began working on a revision of rules for registration of new imported vehicles. This re-standardization policy demands that new vehicles in Kenya will only be approved for use if they emit no carbon monoxide or other fine particulate matters into the environment Programme. In addition, Kenya has started to develop a policy on 2&3 wheelers use with the aim to shift to electric motorcycles with several pilots being carried out by Kenya Power, UN Environment and the Siemens Stiftung in Western Kenya.[15] The Kenyan government is further prepared and willing to support private sector initiatives such as Drive Electric, an EV consulting firm and Nopia Ride, an EV sharing firm, who have piloted the use of EVs in Nairobi.[16]

Given these developments, whether they are driven by large international companies or local start-ups, Kenya has demonstrated that it is indispensable to develop the necessary frameworks that integrate these new mobility solutions into their medium and long-term strategies and put in place the right conditions for the development and scalability of future technologies and business models.[17] With adequate sensitization and installation of charging infrastructure, electric mobility has great potential in Kenya.

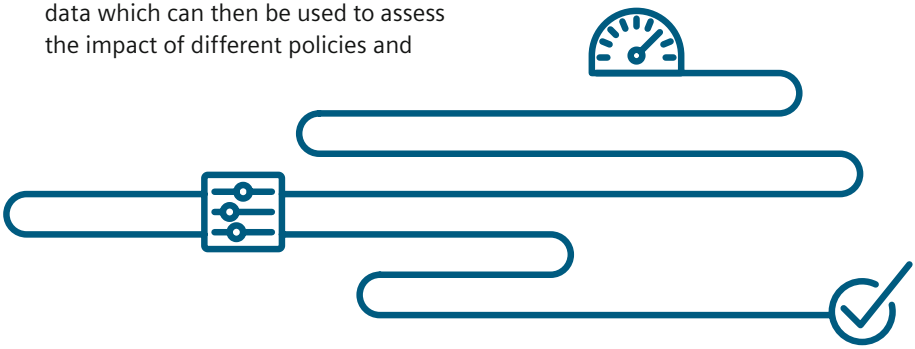
Martin Eshiwani
Director Road & Railway Transport, State Department of Transport, Kenya

"Electric mobility is prioritized in the Kenyan National Climate Change Action Plan (NCCAP 2018/2022) as Transport sector's Nationally Determined Contribution (NDC) target for emission reduction and the Government will provide incentives and work with stakeholders to encourage uptake."

Importance of emission quantification models and data collection

The effectiveness of any transport de-carbonization strategy depends on the availability of reliable data. The 'Advancing Transport Climate Strategies' (TraCS) project helps policymakers in developing countries and emerging economies to align their mobility and transport sector action plans with their climate plans, the so-called Nationally Determined Contributions (NDCs). These contributions are essential components of the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), and key to global efforts to limit global warming to 1.5-2.0 degree C above pre-industrialized levels.

TraCS focuses on fostering systems of collecting, evaluating and monitoring data which can then be used to assess the impact of different policies and measures in defining the next round of NDCs. Different emission quantification models, including the TrIGGER (Transport Inventory and Greenhouse Gas Emissions Reporting) tool are used in the project based on additionally collected data. TrIGGER is an open tool easily adaptable to any country's needs; it calculates transport total fuel consumption and estimates the corresponding tank-to-wheel emissions for CO_2, CH_4 and N_2O for a given country and year. Local emission factors for road transport are measured in grams of carbon dioxide equivalents (gCO_2e) per vehicle-km travelled and differ depending on vehicle type and size (e.g. cars, trucks, motorcycles), as well as the driving



patterns (e.g. free flow versus stop-and-go traffic) and some additional aspects. The higher the factor, the more work needs to go towards mobility shifts and fleet improvements in the respective country. When the specific emission factors are combined with average annual vehicle kilometers travelled per vehicle category, then transport emissions can easily be assessed and further analyzed. Kenya is one of the first countries in the entire region of East and Central Africa to develop country-specific road transport emission factors. An analysis of the mitigation potentials of several measures, covering passenger and freight transport, finds that the highest potential for emission reductions in the transport sector in Kenya lies in efficiency improvements of freight transport: 0.9 $MtCO_2e$ in 2030 (equivalent to an 11% reduction against the baseline) and up to around 3 Mt in 2050. The second largest potential is in electrification of road transport, including passenger cars, motorcycles and buses. Methodological coherence is very important as it provides for reduced uncertainty in the final results and comparability. Thus, TraCS encourages networking and exchange among national and international stakeholders in order to contribute to improving mutual understanding and harmonization of approaches.

Herman Kwoba
Project Officer, GIZ

"Kenya is one of the first countries in the entire region of East and Central Africa to develop country-specific road transport emission factors. An analysis of the mitigation potentials of several measures, covering passenger and freight transport, finds that the highest potential for emission reductions in the transport sector lies in efficiency improvements of freight transport."

With an academic background in Climate Change and experience working within Kenya's Ministry of Environment, Herman Kwoba is a member of the TraCS team based in Nairobi, Kenya.

E-mobility solutions in rural areas

In the framework of the Lake Basin Innovation and Investment Week (LBIIW) 2019, more than 130 guests discussed the opportunities, challenges and barriers for e-mobility solutions to take off in rural areas. It was overall agreed that EV technology has the potential to disrupt the African rural transport economy and that opportunities outweigh challenges.[18]

With the cost of renewable technology falling, new breakthroughs in electric batteries and with mobile technology making microfinancing options available to rural populations, East African start-ups are designing and experimenting with diverse business models for commercialization. This, however, requires holistic planning and multi-modal systems that involve complementary large- and small-scale transport modes operating to and from 'hubs' within villages, market centers and towns.[19]

Opportunities	Barriers
Africa's abundance of solar energy makes PV charging stations the preferred choice for rural EVs	Requires strong enabling policies, including tax incentives and subsidies
Zero-Emission mobility solution to fight Greenhouse Gas emissions and air pollution in urban centers	Competing priorities for limited government funding in Sub-Saharan Africa
Reduced Noise Pollution	High initial investment costs upfront compared to internal combustion engine vehicles
Employment opportunities & job creation	Unavailable investment capital for small-scale local businesses & entrepreneurs
Optimizing fleet mix by introducing smaller cheaper vehicles and focusing on 2&3 wheelers and light vehicles	Operating environment often challenging and disadvantageous with lack of enabling policies
Lower lifetime running costs than combustion engine vehicles	Current lack of charging infrastructure
More efficient than conventional vehicles; converting about 90% of the energy to motion[20]	Unfinished supply chains
Overcome fossil fuel scarcity and stop imported fuel subsidies	Lack of local technical skills & knowledge
Young technique-affine population interested in mobile and smart solutions	"Range anxiety" and EV limitations
Potential benefits of EV circular economy	Long recharging times and high costs for batteries

Technology

Internationally, the EV market is growing at exponential rates, with the global stock of EVs passing 5 million.[21] Every major automobile manufacturer now has hybrid and full plug-in EVs in commercial production. Africa has been increasingly targeted for manufacturing industries as significant proportions of raw material for global EV batteries can be sourced directly from the region. Further, EVs reduce the capital threshold for local manufacturing: an average internal combustion engine car has approximately 30,000 individual parts while an average battery powered electric car only has approximately 4,000 individual parts.[22] This will significantly lower logistics costs for parts shipping and warehousing and require less tooling and production line stations. It will also reduce manufacturing labor costs, thus, helping to make EVs more affordable. Technology remains very expensive and most parts are still imported from South East Asia with little customization to the African market demands. Widespread adoption of EV technology also requires building charging infrastructure. It is expected that future charging infrastructure will vary from existing gas station-based business models. The different possibilities currently being discussed include wired (conductive) and wireless charging points, private/home charging as well as swapping the vehicle's battery.[23] The key component of EV technology, however, is and remains the battery. Batteries make up a large share of the total cost of an EV and ultimately represent a key criterion for economic efficiency. The market has shifted towards lithium-ion (Li-ion) batteries which are mainly produced in Asia, with new technology trends such as silicon or lithium anodes, solid state cells or new cathode materials on the horizon.[24] Growing demand for batteries in Africa

Box 3

Did you know that ...

... an internal combustion engine of a motorbike has 267 Wh/km, 3l * 8.9kWh/l equals 27kwh/100km and a total of 12% efficiency

... based on field tests, electric engines of e-motorbikes have < 25 Wh/km per Person, 2.5 kwh/100km, and a total of >90% efficiency

... that costs per litre petrol are ± 1€ and costs per 100km are ± 3€

... costs per kwh are ± 0.25€ and costs per 100km are ±0.75€

... servicing and spare part costs of EVs are reduced to about 10% of original price level

... electric engines save C02 emissions of about 2.32 kgCO_2/Lge per km, per bike at 4.5l per day (loaded) and annually around 3.777 t CO_2 per bike and year

	2&3 wheelers	e-outboard engine	Light duty vehicles	Charging stations	Battery production
Market Outlook	E-Tricycle are increasingly prominent in African towns Last-mile goods transport is booming	Alone Lake Victoria hosts 50,000 fisher boats Eastern and Southern Africa counts hundreds of lakes; Lake Malawi, Lake Tana, Lake Tanganyika to name just a few	Buses/matatus are the number one inter-city transport Private vehicle fleets are booming	E-charging station will re-place petrol stations, huge potential in off-grid and on-grid being concurrent Charging an EV at home is possible with standard 120V or 240V AC power sockets in homes, offices or alternatively, high-power DC Fast Charger in public charging stations In Asia, motorbikes are being charged in less than 10 min	New Lithium Ion Batteries have a life-span of up to 20 years

and changing supply chains have increased the incentives for battery manufactures to build production plants in the region. Several young start-ups are piloting the local assembling and production of battery electric vehicles (BEVs). There is already a wide range of electric mobility technologies available: from electric 2 &3 wheelers to light duty vehicles and electric buses as well as more innovative technological solutions such as electric outboard engines and electric tractors (see above graphic for market outlook).

Box 4

Did you know that ...

... an electric car battery capacity is 24kWh with a power consumption of 0.2kWh per km

... a petrol vehicle engine capacity is 1500cc with a power consumption of 0.09L (0.819kWh) per km

... energy cost/km travelled are KES 4.00 for an electric car compared to KES 8.50 for a petrol vehicle

... tail pipe CO_2 emissions per km are zero for an electric car compared to 185.20gm/CO_2e for a petrol vehicle

... the average fuel economy for an electric car is 5km/kWh compared to 9.1km/kWh (12.68km/L) for a petrol vehicle

Business model innovations

The successful adaptation of e-mobility solutions requires innovative business models beyond the classic 'direct sales' business model. Circular and shared economy approaches offer changes especially in Bottom of Pyramid (BoP) markets where users have only limited cash for investments.

- Sharing economy is a broad umbrella term used for a number of economic models that have one thing in common: the joint use of goods and services through B2B or B2C variants.

- Circular economy is an economic system based on closed circles or loops in which raw materials, components and products lose their value as little as possible, keeping products and material in use and regenerating natural systems.[25]

Direct Sales

Direct sales are the conventional sales model in the vehicle industry. Due to high upfront costs in e-mobility, especially for batteries, it will be difficult to sell EVs directly at full price to the majority of customers in the African Market where cash income is limited. Direct sales might be restricted to large institutional fleets for e.g. delivery services, transport operators, tourism sector or municipalities.

PAYGO

The PAYGO model was first introduced to African markets for solar home systems, where households secured the system with a down payment of about 20% and paid a daily, weekly or monthly fee for an agreed amount of time before owning the application. In recent years, this model has been adapted to a variety of other market segments including the EV market. EV start-ups in Sub-Saharan Africa have made first attempts to use a PAYGO model, whereby they continue managing the batteries with a pay-per-use model.

Box 5

Taking mobility one step further:

Mobility-as-a-service solutions have already started to integrate various forms of transport services into a single mobility service accessible on demand. For the user, using a single application with a single payment channel to access a diverse menu of transport options can offer added value. For start-ups, EV companies and transport operators, mobility-as-a-service might be the road to a rapid scale-up and region-wide transition to zero-emission economy.

Business Models

	Production / Manufacturing	Capital expenditures (CAPEX)	Operational expenditures (OPAX)
Appliance	Retail ▶	100% covered by customer / buyer	100% covered by customer / buyer
Battery	Pay Go ▶	Down payment of up to 20% at beginning of contract, and daily fees for a year up to 100% owning the EV	100% of maintenance costs covered by customer
Charging Infrastructure	Pay per use ▶	0% for customer and 100% of cost burden of vehicle purchase, battery costs, and electricity prices on the company providing EVs	0% for customer, the owner takes care of the maintenance and the loading of the mobility solution

Pay-per-use

The pay-per-use business model has proven very successful for EVs in Sub-Saharan Africa as it removes the cost burden of vehicle purchase, battery costs, and electricity prices from the customer, placing a large share of the risks associated with EV technology, market evolution and infrastructure onto the providing company alone.[26] This business model is particularly popular with motorbike drivers in Kenya and Uganda who rent their motorbike on a daily basis.

Business Model Innovation

Introducing new technologies to frontier markets requires business model innovations that are able to envision a new future for the ecosystem as a whole. The following models represent an inspiring selection of innovative business models presented at the Roundtable in Kisumu in November 2019.

"Lack of awareness of available solutions and value proposition of electric mobility has been one of the largest hindrances for efficient uptake not only in emerging markets but in developed markets as well. In addition, new regulations need to be adopted to enable short-term uptake and to avoid creating bottlenecks for long-term uptake."

Opibus Ltd

Battery swapping & leasing

This business model is different from a business-as-usual model through a change of value proposition to swapping and leasing.[27] The battery remains property of the manufacturer and is exchanged between different vehicles. As a direct result, the upfront cost and the usage cost of the EVs have been significantly reduced. Nevertheless, in the nascent EV market, as there are not yet enough battery swapping stations outside of the city, the battery swapping model means that EV users are restricted to operating within a certain range from the swapping station.

E-Conversion of vehicles

To reduce the investment costs for EVs, a number of start-ups have specialized in the conversion of existing Bajaj and TVS motorbikes into e-bikes by exchanging the fuel tank and combustion engine with Li-ion batteries and an electric engine. Paying for the new engine and battery is possible either the classical way via the selling price (pay for equipment) or via a fixed rate dependent on use (pay-per-use). Targeted pay-off times are between 1-3 years for the customers, making it a profitable investment.

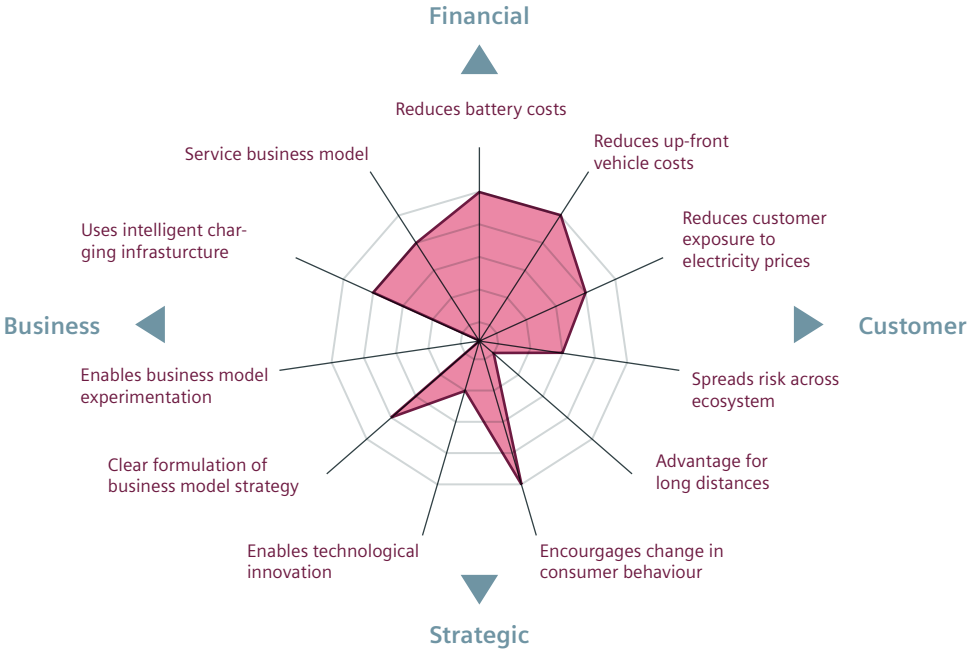


Figure 5: Framework analysis of e-mobility services through battery swapping

Spotlight

Circular Economy: Environmental issues of batteries

Driven by the ongoing transition to zero-emission economies, demand for batteries is expected to grow rapidly in the coming years. Batteries will be one of the key enablers for this transition given the important role they play in stabilizing the power grid and in the roll-out of clean mobility.[28] However, the extraction of lithium has significant environmental and social impacts, especially due to water pollution and depletion. Current levels of lithium collection in the EU are very low; the large volume of end-of-life batteries generated downstream worldwide prompts the need to manage these waste streams properly and recover valuable materials.[29] Although lithium's commercially valuable powder form, lithium carbonate, can be recovered from primary lithium batteries, this requires large commercial facilities where batteries undergo an energy-intensive, high-temperature melting-and-extraction process or chemical treatment.[30] One idea would be to hold EV producers accountable for the collection and recycling of spent lithium-ion batteries. However, as long as the costs of fully recycling a battery are higher than the value of the recovered materials, large-scale lithium recycling is a distant prospect. Siemens Stiftung in cooperation with its partner WeTu is piloting second-life solutions for used batteries and has set-up seven collection points for lead acid and lithium-ion batteries in the Lake Victoria region. The pilot focuses on the take-back and recycling of Li-ion batteries including pre-processing such as dismantling, sorting into chemistries, selling to recyclers (lead-acid) or exporting to Li-ion battery recyclers. As a Global LEAP Solar E-Waste Challenge winner, the project aims to establish value chains for all relevant materials and has identified a number of partners. WeTu is engaging with numerous Beach Management Units comprising of 4,700 fishermen who use about 5,000 WeTu fishing lanterns and even more lead acid batteries to power fishing bulbs. In addition, the project will test innovative incentive models for battery collection and will train sector workers on pre-processing. This pilot is a unique frontrunner as currently there are no e-waste management opportunities for lithium-ion products in the area.

Introducing WeTu Hubs

Siemens Stiftung and its not-for-profit enterprise, WE!Hub Victoria Ltd (WeTu), have established an incubation program for e-mobility solutions in rural Western Kenya along the shores of Lake Victoria.

To support e-mobility start-ups in testing their technologies, business models and applying their solutions, WeTu owns and operates 7 solar powered hubs. The WeTu Hubs are also solar driven charging stations with a capacity of a total of 150kWp providing electricity for a range of services such as electric vehicles. With WeMobility, WeTu offers a range of e-mobility solutions such as e-cargo bikes and e-boda bodas in their own operations but also partner with other local companies and organisations to provide solar energy for e-mobility appliances such as e-outboard boat engines. Boat owners spend up to $15-20 per day on petrol and oil for their diesel engines and lamps. By exchanging diesel engines for e-outboard engines, boat owners can contribute to a reduction in CO_2 emission while saving costs for expensive diesel and enabling them to re-invest.

The business vertical WePower provides renewable energy for e-mobility solutions and leasing services for solar lanterns for small-scale fishing. The product offers a price competitive alternative, which is easier to handle and environmentally sustainable. Competitive solutions on the market are mostly lead-acid batteries that need to be completed by cables and bulbs to serve as lanterns. Besides the regular loss of components, the lead-acid batteries drop their lightning capacity of max. 8h quickly to much shorter periods and end its lifecycle after approx. 2 to 3 months. In comparison, the WePower lithium-ion lantern's lightning capacity lasts up to 12h and has a life-cycle of approx. 2 years. The results are higher fishing yields per night, easier handling and a more sustainable product that is safely reintroduced into a circular economy by take-back systems at the WeTu Hubs. With

the third business vertical of WeWater, WeTu provides safe and clean drinking water 24/7. Expansion of water services are planned by further Water ATMs at central community sites and delivery services with e-mobility solutions, such as the e-cargo bike. WeTu's e-mobility services meet the mobility needs of rural communities and small-scale businesses in a sustainable, clean and environmentally friendly way. By offering collaborative "innovative work spaces" for e-mobility solutions at WeTu Hubs and an energy-autonomous charging infrastructure, this business model promotes rural development and the creation of new jobs. Applying a user-centric approach, hub partners are testing their products in the rural market and are able to meet customer demands focusing on a variety of occupational groups such as farmers, fishermen, as well as female market traders. WeTu's sharing business model promises to deliver cost-reductions in rural transport services and will improve local rural logistics and thus, impact the availability and affordability of products and services.

Sustainable transport through local conversion of motorbikes

an interview with Bodawerk

Bodawerk has been awarded the SET Award 2019. Could you tell us a bit more about how you started out and how your product has changed along the way?

After starting in 2018, we converted several motorcycles and prototyped different approaches around the electrification of a motorcycle. Our approach is to centrally own, manage, share and recycle the most expensive component of e-mobility: the Battery. One of the challenges we faced was sourcing lithium-ion cells, which pushed us into the Li-ion battery recycling. Every kilometer covered by our bikes, tractor and wheelchair so far, has been powered by batteries we have assembled using recycled laptop batteries. The demand we have encountered in the meantime exceeds by far our current production capacity.

Bodawerk decided to focus on the rather new business model of mobile energy storage (battery) swapping services.

What has been the local feedback?

Most Ugandans strive for ownership and start-ups are not typically advised to try to change consumer behavior but rather to fit in. However, if we look more closely at the Ugandan market, the basic costs of housing, food, healthcare and mobility cannot be covered by most salaries. Money is the most influential factor in decision making of the average buyer and has influenced our decision regarding business model. We have developed a solution specifically adapted to the local market and environment. Our sharing economy approach allows for significantly reducing the capital expenditures required and has the potential to transform markets. For example, fishermen working at night share their batteries with motorcycle taxi riders, who work during day time.

Producing locally while building capacity on the ground Bodawerk aims to introduce sustainable growth through

community involvement. Can you share with us some of your lessons learnt?

18 months ago, we started with a team of six people, now we are more than 30. As a company, we put a strong focus on people. Among the biggest challenges has definitely been to build on the existing skills and knowledge in terms of training and capacity building. Bodawerk invests heavily in the future of its employees making sure that they receive the best training with access to the best equipment. Youth participation is vital in effective development projects. We also strive to close the gender gap through ensuring gender diversity in enrolment.

Your vision is to become the main provider of e-mobility solutions for the African mobility and logistics sector. Do you think a market transformation is feasible in the Ugandan context?

In Kampala there are only an estimated 50,000 cars but more than 150,000 motorcycles. In the entire region, there are more than 3 million motorcycles. We do not think a market transformation is feasible, but rather inevitable. We strongly believe the 2-wheeler market will have completed a 95% transition to zero-carbon emission within the next 10 years.

Are you currently working on any new pilots?

For now, we focus on cutting the cost of logistics by 50% for our electric motorcycles and trailers. Additionally, we have ventured into the agricultural sector with a 2-wheel-tractor conversion which presents the largest employer and second biggest GDP contributor. Our e-tractor is basically a battery driven axle on wheels, that can be hooked up to threshing or milling machines, a trailer to aggregate and transport grains or equipped with a ripper, plough or tiller for field preparations.

What advice would you give to others starting out in the e-mobility sector in East Africa?

Make sure your product works, saves money or adds value and is payable in small increments.

Jakob Hornbach
CEO, Bodawerk

Jakob is a German Industrial Engineer and the CEO of Bodawerk international Ltd., a Uganda-based engineering and innovations company founded in 2017.

Technical Solutions

presented at Kisumu 2019

Company Name	**Opibus Ltd**
Product Name	**Electric Conversion Drivetrains, Electric Motorcycles and Energy Systems**
Technical Solution - In what ways is it innovative?	Electric Drivetrain converting existing ICE vehicles in local production with AC or DC charging units, reducing costs & resources First fully Kenyan built e-motorbike with swappable battery pack and portable charger Energy systems = locally assembled high-quality lithium-ion battery storage modules with a lifespan of 15-20 years
Capacity / Range (km, kwh, etc.)	Drivetrains: different models of 36,54 and 70 kWh; top speed 120km/h, power up to 220kW and torque up to 580Nm Motorbikes: 2.5kWh with a range from 70km; power up to 7kW, torque up to 220Nm with top speed of 80km/h Battery storage models: Units of 5 or 10kWh each; can be connected in parallel for larger systems
Price/ Maintenance costs for customer	Drivetrains: cost from $34,000 Motorbike: $1,900 Solar PV systems: depending on PV generation capacity and system size
Target group / market	Vehicles for tourism industry, public transportation, truck and utility vehicles; motorbike riders and fleet operators; commercial and industrial utility systems and off-grid residential / commercial actors for energy systems
Which mistake did you learn most from?	Since many of the components are not commonly imported, these procedures have been more time consuming and costly than initially assumed.
Website link	www.opibus.se

Company Name	**First African Bicycle Information Organization (FABIO) & European Institute for Sustainable Transport (EURIST) e.V.**
Product Name	**Solar Driven E-bike taxis**
Technical Solution - In what ways is it innovative?	E-Bike with a lithium-ion battery and a bottom Bracket Electric Motor; Charging of bicycles with normal plug or photovoltaic solar panels (if connected to lead batteries charging at night is also possible)
Capacity / Range (km, kwh, etc.)	40km; With 750 recharges per battery lifetime = 20,000km in total; carry load up to 100kg
Price/ Maintenance costs for customer	Initial Price E-Bike = $1000 Maintenance Costs $12 to $15 per bike in the beginning but reduced to $5 to $7
Target group / market	Bicycle taxi & cyclists
Which mistake did you learn most from?	Not using a variety of bicycles, engines and motors in order to compare different systems
Website link	www.eurist.info/ www.fabio.or.ug

Company Name	**EVUM Motors GmbH**
Product Name	**aCar**
Technical Solution - In what ways is it innovative?	The innovative aCar is designed to be simple, sustainable and versatile with only 600 components and a robust long lasting design and 48V; low repair costs & great affordability
Capacity / Range (km, kwh, etc.)	16,5 kWh make for 100km 33 kWh allow for the maximum range of 200km
Price/ Maintenance costs for customer	Buying price for the base model: $31,000 The total costs of ownership (TCO), considered 15.00km/a over 5 years sum up to ~ $23,000: ~30% below competitor level
Target group / market	In the Industry Sector: Factory transport, public institutions and local government In the Service Sector: Local transportation, construction and crafts and tourism In the Agriculture Sector: Horticulture and agriculture
Which mistake did you learn most from?	"One for all" doesn't mean complex and custom-fit for everyone, but a product that everyone can make great use of
Website link	https://evum-motors.com

Company Name	**BODAWERK**
Product Name	**Battery & Energy as-a-Service**
Technical Solution - In what ways is it innovative?	Swappable, combinable, shareable lithium-ion based battery. E-conversion reduces initial capital requirements by 90% while offering ca 50% savings on operational costs
Capacity / Range (km, kwh, etc.)	2.2kWh (E-Boda Top-Speed: 65km/h) Range depending on load: 1 passenger ~100km, 2 passenger ~60km, 1 passenger + 200kg of maize uphill ~30km
Price/ Maintenance costs for customer	Conversion ~ $200 Unlimited battery swaps & energy for ~ $2,50 / day
Target group / market	Motorcycle drivers
Website link	Bodawerk.com

Company Name	**ASOBO**
Product Name	**E-boarders**
Technical Solution - In what ways is it innovative?	Replacing inefficient, polluting and expensive outboard engines of fishermen with electric ones that are powered by renewable energy
Target group / market	Fishers of Omena on Lake Victoria
Which mistake did you learn most from?	The realization that innovative technology is only one part of the 'solution'. It's crucial to tailor and embed the technology in the needs of the customer and make it appropriate for the local context.

Company Name	**Solar E-Cycles Kenya**
Technical Solution - In what ways is it innovative?	Light, electric and solar-powered tricycles, essentially a solar-system on wheels. Providing users with affordable access to mobility and further productive use of the power generated on-board the tricycle
Capacity / Range (km, kwh, etc.)	60 to 100 km
Price/ Maintenance costs for customer	$1,500
Target group / market	Rural, off-grid communities
Which mistake did you learn most from?	Not setting up our operations within the communities we aspire to serve first
Website link	https://www.solar-e-cycles.com/

Company Name	**Anywhere.Berlin GmbH**
Product Name	**Steel Bird**
Technical Solution - In what ways is it innovative?	Off-road electric cargo bikes and cargo boda boda to deliver goods and services in rural areas where roads are bad or non-existent
Capacity / Range (km, kwh, etc.)	250 to 2000 watts – 4 kwh battery capacity – 80km range
Price/ Maintenance costs for customer	Price dependent on ramp quantity – currently around $2,000 dropping to region of $1,000 on 10k ramp
Target group / market	Rural and urban communities
Which mistake did you learn most from?	Believing that potholes are avoidable on a two wheeler was a wake-up call.
Website link	www.anywhere.berlin www.anywhere.africa

Policy drivers for urban transformations

In the context of Sub-Saharan Africa, most recent migration dynamics have started to blur the traditional boundaries of "rural" and "urban" – categories that no longer capture the spatial as well as occupational complexity of rural and urban livelihoods. Of course, low-density remote areas still exist in Sub-Saharan Africa but generally the improved access to information and communication technologies and to transportation networks as well as better educational standards foster the movement of people, blurring the limits of the old rural – urban divide.[31]

With this development come new challenges: Urban areas in most parts of Sub-Saharan Africa are faced with major obstacles in order to meet current and future needs of the populations. Mobility and energy will become the twin pillars of future urban transformations. The central task of urban mobility concepts is to encourage transport policies and investments that improve living and working conditions for urban residents by catering for their mobility needs in an environmentally-friendly and economically sustainable manner.

The United Nations Agency for Housing and Urban Development, UN-HABITAT, and the United Nations Environment Programme, UNEP, both promote policies and models to achieve sustainable urban transportation systems across the globe. The following interviews provide a better overview of their approaches towards sustainable urban mobility.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Accelerating transformational change towards sustainable urban mobility

an interview with UN Habitat

Building on UN HABITAT's Urban Electric Mobility Initiative, a new project has been launched as of January 1st 2020. SOLUTIONSplus is an EU-funded project with the aim to accelerate transformational change towards sustainable urban mobility. What are your hopes and expectations for this project?

SOLUTIONSplus is a global project which brings together 46 partners as well as 150 associated partners from Asia, Africa, Latin America and Europe. This project is unique in its approach of pooling different segments of the mobility chain: industry, research, local and national governments, public transport operators, city networks and associations.
How does the project work? First, demonstration actions testing innovative e-mobility technologies and services are locally implemented. Secondly, the potential for regional and international replication as well as scale-up is assessed. The core and distinctive characteristic of SOLUTIONSplus lies in the focus on the integration of different transport modes both at infrastructure level as well as by fostering digital integration through Mobility-as-a-Service. This way, e-mobility can really have a transformational impact on transport systems, beyond solely being a technological change.

Could you share with us some of the innovative solutions planned in the context of East Africa?

Two demonstration projects have just been launched in East Africa in January 2020. In Dar es Salaam, Tanzania, 60 electric 3-wheelers will be integrated with the existing Bus Rapid Transit (BRT) system. In Kigali, Rwanda, the project will have a systemic approach, integrating the planned BRT with the introduction of e-buses, in combination with electrified feeder services provided by 30 e-moto taxi and 100 shared e-bikes. Integration with public transport and first and last mile connectivity are the backbone of these pilots. To present an example of

physical integration, infrastructure in Dar es Salaam will be developed in a way that enables parking areas for 3-wheelers at or in close proximity to BRT stations, with solar-charging infrastructure. Safe pedestrian walkways will be provided to connect BRT passenger platforms and parking areas.

What factors need to be taken into consideration when thinking about scale-up?

Once the demonstration phase is achieved, potential to sustain the tested innovations will be further assessed. Successful concepts will be developed into feasibility studies and submitted to domestic, bilateral, multilateral or international financing institutions. As the success of urban e-mobility solutions critically depends on their integration within wider national urban mobility programmes,
SOLUTIONSplus partners will develop policy proposals and recommendations on these frameworks, e.g. fiscal and regulatory measures.

You mentioned Kigali's plan to become a green city. Could Rwanda's model be replicated in the context of Kenya?

Models as such cannot be replicated given local specificities of each area. However, city-to-city exchanges can be a valuable tool to share lessons learnt, identify common challenges and present ways to overcome these challenges. Kigali surely has a role to play in sharing its experiences with other cities in East Africa, particularly in regards to the introduction of different electric vehicle types and its mixed use development with a strong focus on public transport and the needs of pedestrians.

How can interested countries approach UN HABITAT for support of their planned e-mobility projects? Are there any upcoming calls for Sub-Saharan Africa?

A call for e-mobility innovators will be launched in the second half of 2021. Kenya, Mozambique, Zambia, South Africa, Cameroon and Nigeria have already been identified as replication countries. Businesses, local authorities and public transport providers in other cities are welcome to submit proposals to replicate the business models and demonstration actions of SOLUTIONSplus pilot cities.

Emilie Martin
Consultant UN-Habitat,
Urban Mobility Unit

As a UN-Habitat affiliated researcher from the Technical University of Berlin, Emilie follows the implementation of Solutions+ in East-African cities and researches impacts of e-mobility solutions in emerging contexts.

UNEP's Electric Mobility Initiative

an interview with David Rubia

The UN Environment Program (UNEP) estimates that traffic accounts for about a quarter of all energy-related carbon dioxide emissions to the atmosphere and further grows faster than any other emission sector. What can be done to combat this development?

A major global clean transport disruption is needed to shift to a cleaner and low-to-no emissions trajectory to achieve global targets, particularly the Paris Climate Agreement and agreements on air quality. In addition, urban spaces must be designed in a way that rely heavily on non-motorized transport (NMT) and invest in mass urban transport systems that link to NMT. The Electric Mobility Programme is a new global programme by UN Environment to foster the uptake of electric mobility. It targets the reduction of energy use, greenhouse gas and air pollutant emissions from the transport sector with a focus on transitional and developing countries. Together with regional partners, UN Environment supports the development of adequate policy packages, the set-up of pilot projects as well as strategies to finance the transformation towards electric mobility with the aim of regional replication and outreach.

How can governments put in place the right policies, demonstrate the viability and finally finance the transition to a cleaner transport sector?

In my opinion, governments need to identify policy gaps (regulatory, fiscal and local) and invest in policy impact assessments before developing the right policies to fill the gaps identified. In addition, new innovative financing mechanisms (such as green bonds) should be piloted and up-scaled for a clean transport sector and existing mechanism must be revised in order to set the scene for a nationwide transition. Addressing attitude change among communities, it is advisable to set up demonstration pilots where fleets are being tested either by private or public sector and the advantages of electric mobility can be experienced first-hand by the end user.

"Governments need to invest in renewable energy production and smart grid integration and develop the required IT infrastructure – all of which requires education, training and capacity building."

David Rubia
Programme Management
Officer Air Quality & Mobility Unit, UNEP

With a master's degree in Environmental Engineering, David has spent the last seven years working in sustainable development with a focus on climate change mitigation and air quality improvement in the transport sector. He is currently working on a global programme that is supporting the transition from internal combustion engine to electric mobility in developing and transitional countries.

You are coordinating UNEP's Electric Mobility Initiative which supports developing and transitional countries shift from internal combustion engine to electric mobility with a focus on electric 2&3 wheelers. Why did UNEP choose to focus on 2&3 wheelers as a starting point?

Transport experts from UNEP agree that two and three wheelers are the priority in moving to electric mobility. In many low and middle-income countries, 2&3 wheelers are the fastest growing transport mode, therefore, greatly impacting the climate and pollutant emissions in emerging cities. Electric 2&3 wheelers require less investment in charging infrastructure than electric cars or buses and can be combined with lower-cost renewable power charging appliances. In addition, 2&3 wheelers are primarily used as taxis and as such, a switch to electric mobility would reduce operating costs of these taxis, providing an economic incentive for this motorbike owners and taxi associations to support the transition to electric mobility.

In your opinion, what are the political prerequisites under which a mass-market shift to electric mobility might take place?

In order to facilitate a quicker uptake of electro-mobility, states should commit to mitigating climate change emissions and air pollution and empower government institutions with clear mandates. Kenya, for example, is one of the first countries to enact a national Climate Change Act that provides the legal framework to mandate climate resilient low carbon economic development. A multimodal and integrated policy approach can further minimize rebound effects, overcome split-incentives, and achieve a higher level of socio-economic benefits. This includes support for private sector (banks, manufacturers, service providers etc.), reduced tariffs for electric mobility charging as well as manufacturing incentives. Governments need to invest in renewable energy production and smart grid integration and develop the required IT infrastructure – all of which requires education, training and capacity building.

What fiscal incentives are needed for these policy changes to translate into actual actions?

Fiscal incentives for electric vehicles have strong market effects. Fiscal incentives if sufficiently high to offset cost differences between EV and conventional cars are the most important reason to buy an EV. In my opinion, policy changes translate only into actual actions if governments pursue dedicated EV policies such as tax incentives for low-carbon enterprises and low-carbon appliances and robust carbon pricing schemes with revenue used to promote low carbon economic development. It is also imperative to set up emission tracking methodologies and databases to better quantify mitigation and develop low emission financing mechanisms to better support electric mobility start-ups and local entrepreneurs.

Spotlight

Gender approach to urban mobility planning – the FLONE Initiative

Mobility and transport is an area of utmost importance for sustainable and gender-equal development, which has so far been neglected and downplayed in research and policy making both at the national and global levels. For the first time in history of policy making, both the Global South and North are immersed in urban planning trying to restructure urban governance in light of the Agenda 2030. However, there is still no systematic inclusion of women's needs in transport projects. While transport is often seen as gender neutral, women and men have different expectations, needs and constraints for using transport.[32] Since the majority of the global poor are women, thinking about gender in transport necessarily includes the implications of poverty for urban mobility. Urban mobility policies must work towards the creation of safe, sustainable and accessible public transportation spaces for women and vulnerable groups (especially young girls and boys, the LGBT communities and the elderly). In 2017, the debate about sexual harassment of women has caused an international outcry and led to increasing public attention on the restrictions of mobility women face in their daily movements.[33] In Nairobi alone, 76% of female operators (drivers and conductors) have either experienced or witnesses sexual harassment.[34] In order to address this challenge, the Flone Initiative (https://floneinitiative.org) initiated the Women in Transport (WIT) Program, a programme that seeks to attract, retain and promote women in the transportation industry by providing women with the skills and support necessary to realize a safe, sustainable and rewarding working environment that is free from violence.[35] The Flone Initiative has kick-started a number of campaigns to shed light on the situation of women in the Kenyan public transport system and to advocate for a gender approach to future urban mobility planning. The #MyDressMyChoice campaign, for instance, saw thousands of women protest the daily harassment and violence experienced in Kenya's public transport and led to public discussions on new legal reforms as well as a revised driving school curriculum and more civil society commitment to create safe public spaces. The Flone Initiative also started a crowd mapping platform called "Report it! Stop it!", where survivors of sexual violence can map out and report incidents. Reports made on this platform allow city authorities, civil societies and local governments to gain deeper insights and improve situational awareness of the issue. Providing gender sensitive and attractive transport services will only be successful if the context and mobility behavior of communities is better analyzed, understood and accounted for in urban transport design and planning. Involving all transport users, male and female, is the most important element to ensure thorough involvement, inclusion and monitoring of gender integration in urban transport.

Naomi Mwaura
Transport entrepreneur working to end sexual harassment on Kenyan public transit by advocating for a gender-balanced public transport workforce and training transit workers.

What's next?

By 2050, the number of people living in Sub-Saharan Africa is expected to double, accounting for more than half of the world's total population growth.[36] As demonstrated, without a shift to low or zero emission vehicles, the strong vehicle fleet growth will lead to a massive increase of air pollution, a massive increase of expenditures for oil imports and a massive increase of greenhouse gas emissions. Large-scale investment in renewable energy production is needed in order to develop the required infrastructure and smart-grid integration, training and capacity building for a clean energy future which could promote green growth across the African continent. Electrifying motorcycle taxis, minibuses and public transport in general will have one of the greatest impacts as these represent a higher volume of miles travelled. To keep pace with the growing demand and to address range-anxiety issues, adequate charging infrastructure is needed.

However, EV technology remains very expensive and most parts are still imported from South East Asia with little customization to the African market demands. Correspondingly, major barriers to large-scale investment in manufacturing business models include unfinished supply chains and missing local technical skills sets as well as infrastructure. There is also the environmental issue of battery manufacture and disposal, which has become more challenging in the region due to relatively informal waste management systems. Rapid EV adoption requires strong enabling policies, including tax incentives and subsidies, which is tricky given many competing priorities for limited government funding in Sub-Saharan Africa.
Against this background, successful

market penetration of electric vehicles may not only rely on the characteristics of the technology but more importantly on the business models available on the market. The innovative business models presented in this reader all started out in niche markets and have different expansion strategies and potential.

More research and capital resources will be needed to make EV market penetration sustainable. For this reason, Siemens Stiftung in cooperation with partners, stakeholders and research institutions has put research at the core of its priorities for 2020 with the aim to collect and analyze data to prove that e-mobility in rural Sub-Saharan Africa can positively impact livelihoods and can contribute to poverty reduction. Through a number of projects and studies, the Siemens Stiftung, financially supported by the German Federal Ministry for Economic Cooperation and Development (GIZ), will focus on data generation in the following areas: 1) environmental assessment of e-mobility solutions, 2) social and economic impact of e-mobility solutions, 3) analysis of business models, 4) training needs in regards to capacity building and education and lastly, 5) a study on the future of charging infrastructure.

In short, exciting times lie ahead of us and the future of transportation and mobility in Africa is packed with opportunity for innovators, entrepreneurs, governments and social jobs. The unique and inherent characteristics of geography, demography and economics in rural Sub-Saharan Africa will require all of us to come together and work in unison.

Appendix

Figure 1: List of countries by vehicles per 1,000 inhabitants › page 6
Calculations based on https://en.wikipedia.org/wiki/List_of_countries_by_vehicles_per_capita

Figure 2: Case Study Uganda illustrating how transport expenditures increase as income rises › page 7
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Figure 3: Stakeholders & factors influencing rural transport ecosystems in East Africa › page 8
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Figure 4: Projected increase of the motorization rate in Kenya › page 11
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Figure 5: Framework analysis of e-mobility services through battery swapping › page 21
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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. The foundation's international project work supports people in taking the initiative to responsibly address current challenges by working with partners on developing and implementing solutions. Technological and social innovation play a central role. The foundation's actions are impact-oriented and conducted in a transparent manner. Geographically, Siemens Stiftung focuses on regions of Africa and Latin America in addition to Germany and other European countries.

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