Electric Mobility In Uganda: Are We Ready?

MARCH 2021

This paper provides a snapshot of electric mobility developments in Uganda, East Africa, while illustrating potential benefits of a sustainable electric mobility system, through examples from cities around the world.
Acknowledgements

This work would not have been possible without the support of World Resources Institute (WRI), Shell Foundation and UK aid funded Cities and Infrastructure for Growth (CIG) Uganda. Each organization contributed to primary and secondary research, authorship and editing of this research document; a collaboration intended to further advance development of electric mobility in Uganda, as a means to making transportation more sustainable for cities.

WORLD RESOURCES INSTITUTE

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Shell Foundation (SF) is an independent UK-registered charity, founded by Shell in 2000, that creates and scales business solutions to enhance access to energy and sustainable mobility. We exist to serve the low-income communities most affected by these issues.

Shell Foundation believes that sustainable mobility lies at the heart of thriving societies, and is working to improve the ability to move people and goods in a way that is more affordable, inclusive and safer, with less impact on the climate.

CITIES AND INFRASTRUCTURE FOR GROWTH (CIG) UGANDA

Cities and Infrastructure for Growth (CIG) Uganda is a five-year innovative UK aid funded programme that provides demand-driven technical assistance to address constraints hindering urban development in the Jinja–Kampala–Entebbe corridor with particular emphasis on the Greater Kampala Metropolitan Area (GKMA).

CIG Uganda’s vision is to develop a productive and sustainable urban environment which supports Uganda’s economic development and makes Kampala ‘fit for purpose’ as the engine of national prosperity and growth.

CIG works in collaboration with government agencies and development partners to support urban infrastructure planning and development, and industrialization. The programme catalyses’ economic growth and jobs creation through unblocking the impediments to productive cities, and mobilising infrastructure investment. Key areas of support are Solid Waste Management; Industrial Parks development; Integrated Urban Planning and infrastructure Development in Kampala city and the GKMA; and ESIA for Kampala Jinja Expressway.
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1. Defining Sustainable Transportation

According to the World Bank initiative, Sustainable Mobility for All, sustainable mobility is defined as “essential, efficient, safe and green mobility”, and is a critical component in achieving the Sustainable Development Goals (SDGs), as seen in Figure 1, and addressing global challenges such as climate change, poverty reduction, air quality improvement, and job creation. Inherent in this definition is the need for sustainable mobility to be efficient, reducing the time spent commuting, and reducing traffic congestion and pollution. The key objectives of Sustainable Mobility for All include:

- **Essential** – Universal access across geographies and income groups.
- **Efficient** – Reduced time spent on transport, congestion levels and improved reliability.
- **Safety** – Reduced accidents and improved passenger security.
- **Green Mobility** – Reduced GHG emissions and pollution.

Figure 1: Sustainable Development Goals in relation to transportation

Source: https://sum4all.org/implementing-sdgs
In many countries around the world, including sub-Saharan Africa, low-density urban growth leads to decreasing access to urban services and increasing motorization which makes the provision of sustainable transport a complex challenge:

- In sub-Saharan Africa, an estimated 450 million people – more than 70% of the region’s rural population – are still unable to access jobs, education facilities and healthcare services due to inadequate transport.\(^2\)
- There are 128 million people in Africa living in large cities, which is over 10% of the entire population of the African continent. By 2050, this proportion is expected to double.\(^3\)
- Rapid population growth in Africa is paralleled by low-density urbanisation. Between 1990 and 2015, the urban footprint of cities in less-developed countries increased 3.5 times on average, whereas their densities declined at an annual rate of 2.1%.\(^4\)\(^5\) Sprawl tends to leave underserved communities with fewer accessible opportunities and fuels the purchase of polluting private vehicles for those who can afford it.
- Passenger and commercial vehicle motorization in African countries is low but growing. In Kenya, vehicle fleets are growing 12% annually, 80% of which are second-hand vehicles.\(^6\)
- Most African countries have weak policies regarding vehicle age restrictions for imports. Consequently, increasing motorization parallels decreasing fuel efficiencies.\(^7\)

**Land transport challenges**

Sub-Saharan Africa is at a critical urban growth juncture, with an opportunity to introduce green mobility technologies and policies that curb polluting motorization trends and improve safety and access for all.

- While globally, the transportation sector represents 14% of total greenhouse gas emission, land transport emissions in Africa, though lower than most regions, are among the fastest growing in the world.\(^8\) Hogarth et. al. (2015) estimates, between 2000 and 2012, transport fuel consumption in Africa increased by 82%, resulting in a transport emission increase of 88%, from 49 million tCO2 eq to 92 million tCO2 eq.\(^9\)
- Transportation is also a substantial driver of premature death. In 2016, there were an average of 26.6 road deaths per 100,000 residents in Africa—a roughly 2% increase from 2013 and 32% higher than the global average.\(^10\)
- Urban pedestrians are especially vulnerable. In Addis Ababa (Ethiopia), pedestrians accounted for 76% of road fatalities in 2018.\(^11\)

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• Tailpipe pollutants such as particulate matter, nitrogen oxides and carbon monoxide are a leading cause for cardiovascular and respiratory diseases in urban areas, especially among poor communities and children.\textsuperscript{12}

Effectively addressing these environmental and social issues means improving the way most people move and access services. In sub-Saharan African cities, this often means improvements to demand-responsive, privately-owned minibuses, sometimes referred to as ‘popular transit’ or ‘paratransit.’

• Paratransit accounts for 70 to 100\% of public transport services in most sub-Saharan African cities, and often constitute 40 to 50\% of travel modes.\textsuperscript{13}

• While these public transport services provide affordable rates and ubiquitous coverage for some, fares costs are untenable for the poorest of residents. In Kampala, low-income residents spend 25\% of their median household income on public transport.\textsuperscript{14}

• As such, walking is the only option for most low-income commuters, especially low-income women. A travel survey of 4,375 slum residents in Nairobi (Kenya) conducted by the University of California reveals that the percentage of low-income men and women who walk to work is 53\% and 67\%, respectively, compared with 36\% and 47\% of non-poor working men and women.\textsuperscript{15}

Electric Mobility as a Sustainable Mobility Solution

Electric mobility (e-mobility) plays an important role in achieving sustainable mobility, and electrification of transportation modes is growing around the world. In this paper, the authors define e-mobility as the movement of goods and people provided by electric vehicles that use energy stored in batteries to power the motor. The batteries are charged externally, using electricity.

At the global scale, electric vehicles (EVs) have the potential to mitigate greenhouse gas emissions and climate change, and improve public health, accessibility and economic development. For example:

• With the rapid electrification of transport sector globally, existing EVs of all vehicle types in 2019 collectively avoided 53 Mt CO2-equivalent (e.i., avoiding 0.6 million barrels of oil products daily).\textsuperscript{16}

• EVs reduce local, health-adverse pollutants. In 2015, transportation contributed 7\% to ambient pollution related morbidity in South Africa, roughly 1,400 deaths, and translated to US$ 1.5 billion in health-related damages.\textsuperscript{17}

• Poorly designed and aging vehicles are a major contributor to traffic fatalities for vehicle occupants, pedestrians and bicyclists.\textsuperscript{18} New EVs adhere to higher safety standards, saving lives and creating economic gains. World Bank estimates that halving traffic deaths could add 7 to 22\% to GDP per capita.\textsuperscript{19} Road injuries and fatalities cost Uganda up to US$ 1 billion in 2015, or 0.16\% of the nation’s GDP.\textsuperscript{20}


\textsuperscript{14} https://www.researchgate.net/publication/233264045_Matatu_A_Case_Study_of_the_Core_Segment_of_the_Public_Transport_Market_of_Kampala_Uganda


\textsuperscript{17} https://www.iea.org/reports/global-ev-outlook-2020.


\textsuperscript{20} https://www.thelancet.com/action/showPdf?pii=S2542-5196%2819%2930170-6
• EVs improve the affordability of services. In the next 1 to 3 years, the life-time cost of owning an electric urban bus will be lower than a conventional diesel equivalent, reducing operators’ maintenance and fuel costs with potential savings passed on to users.\textsuperscript{21}

• Research from the International Council on Clean Transportation (ICCT) on urban fleets in 20 cities—including 7 sub-Saharan African cities—shows that even with the existing electricity grids, battery electric buses have lower lifecycle GHG emissions than diesel buses, especially in cities that use renewable sources of energy.\textsuperscript{22}

• The construction and maintenance of the needed charging infrastructure for mass adoption of electric vehicles requires many technicians, creating quality jobs for men and women at a higher-than-average wage.

E-mobility alone cannot achieve a sustainable mobility vision, but it can be coupled with improvements in urban and transportation planning to ensure universal access and efficient operations:

• Data-driven route planning, combined with the use of EVs, can achieve significant steps towards sustainable mobility.

• Transport service reorganization necessary to enable mass electrification of vehicles, especially for paratransit operators, can also benefit service quality, safety and accessibility.\textsuperscript{23} The electrification process can entail route reallocation, new procurement contracts, and/or regulations mandating driver training and salaries, road safety improvements, route optimization and upgrades of stops and ramps.

• Public transport and logistics services can be further improved through mobile and web technologies that help users efficiently plan trips, pay cashless, hail safe and reliable transport, among other opportunities.

• E-mobility options can be offered in parallel to, and integrated with, other non-motorized transportation alternatives, such as bicycling and safe walking infrastructure. One global study in 2015\textsuperscript{24} estimates that doubling the use of bicycle users and electric bicycle users around the world by 2030, would reduce total urban transport energy consumption and CO\textsubscript{2} emissions by about 7%.

Major barriers remain for mass EV adoption. Latin America, for instance, is projected to need over 6,600 public slow charging stations and 3,300 public fast charging stations by 2025, with US$ 757 million in total infrastructure investment.\textsuperscript{25} Countries with low energy access and high carbon-intensive energy grids will face elevated barriers for EV adoption that are net-zero emission.\textsuperscript{26}

For all the potential impacts, a transition towards e-mobility will take time, and usually occurs through phased implementation of infrastructure upgrades and vehicle adoption, supported by evolving regulatory frameworks, and asset financing.

**Electric Vehicle Types**

Sustainable passenger transportation encompasses both non-motorized transport such as walking, bicycling, as well as motorized transport such as trains, buses, private cars, scooters, and motorcycles. The inverted pyramid (Figure 2) shows the transport modes from the most sustainable to the least sustainable.

\textsuperscript{22} https://theicct.org/sites/default/files/publications/Low-carbon-tech-pathways-soot-free-buses-megacities_ICCT-working-paper_31082017_VF.pdf
\textsuperscript{26} https://files.wri.org/e3fs-public/shifting-currents_o.pdf
Figure 2: Reverse traffic pyramid showing sustainability of transportation modes

Source: https://www.slideshare.net/ICLEI_Media/changing-course-in-urban-transport

There are a range of large and small transportation modes which are currently electrified and operating around the world. Electric Vehicles (EVs) can be categorized into four types based on propulsion and powertrain differences, as show below, and in Figure 3.

- hybrid electric vehicles (HEV),
- plug-in hybrid electric vehicles (PHEV),
- 100% electric or battery electric vehicles (BEV), and
- fuel cell electric vehicles (FCEV).

Figure 3: Overview of HEV, PHEV, BEV and FCEV electric vehicle types


Bicycles, Motorcycles, and Rickshaws (Two- and Three- Wheelers)

- Two- and three-wheelers are popular because of their maneuverability in congested urban areas, convenient first/last-mile connectivity and low costs, making these transport solutions affordable to low-income consumers.
- Two- and three-wheelers are increasingly dominant in developing and low-income economies, such as regions in Asia, Latin America and Caribbean, and sub-Saharan Africa, where rapid urbanization has created growing traffic congestion. These vehicles are also popular given their use as productive assets, i.e. motorcycle taxis. In some places e-motorcycles or e-rickshaws have achieved or are approaching cost parity with petrol-based vehicles of the same size, a significant factor enabling adoption.
• Two- and three- wheeler feature plug-in technology that can be charged at home, or through battery swapping programs where firms exchange fully charged batteries for used ones.
• Two- and three- wheelers also frequently transport goods, a trend that was amplified during the COVID-19 pandemic when movement of people was restricted by many city governments to prevent the spread of disease.

**Buses and Minibuses**

• Growing number of manufactures (e.g. Proterra and BYD) specialize in purpose-built battery electric vehicles (BEVs), such as buses. BEVs use overnight charging depots, which can be supplemented by overhead and fast charging stations, located at strategic points along the transportation route.
• About half a million of e-buses (more than 98% of global stocks) are operating in China. Shenzhen, China was the first city in the world to electrify its entire bus fleet (over 16,000 buses) in 2017.\(^{27}\)
• The number of e-buses in Europe, North America, South America and India have been increasing every year between 2015-2019. Today, outside of China, Santiago, the capital of Chile, has the largest operating e-bus fleet with more than 400 buses.\(^{28}\)
• Diesel buses with combustion engines can also be converted into electric buses, but this practice is less common beyond the research and development stage.
• Successful electrification of buses requires coordination across multiple government agencies, including physical planning, transportation, and electric utilities.
• In cities where public transport services are fragmented and privatized, electrification of public transportation across companies is difficult to coordinate (e.g. Cairo, Egypt, and Addis Ababa, Ethiopia).\(^{29} \)\(^{30}\) There are some recent pilot projects testing feasibility of electrification of fragmented public transport service operators in sub-Saharan African cities, although no findings have been released at the time of this research.

**Figure 4: New electric bus registration by country/region (excluding China), 2015-2019**

![Figure 4](https://www.iea.org/reports/global-ev-outlook-2020)

**Trains, LRTs, Metros and Cable Cars**

• Trains are the oldest form of electrified transport, using electricity provided through rails or overhead cables to power a motor. Originally designed with a steam engine fueled by coal, trains transitioned to electrification in the 1890s, and have widespread use across the world, including

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\(^{27}\) https://www.wri.org/blog/2018/04/how-did-shenzhen-china-build-world-s-largest-electric-bus-fleet
\(^{28}\) https://www.greencarcongress.com/2020/07/20200710-byd.html
narrow gauge and light rail transport services in cities such as Addis Ababa, Cairo, Nairobi and Kampala. Trains are used for both passenger and freight transportation.

- There is one known battery-operated monorail operated by BYD in Shenzhen, China. The tram is not available for public use but illustrates adaptability of battery-based rail transportation.31

**Private Cars**

- Electric passenger vehicles are the most typical and well-known electric vehicle type around the world (see Figure 5), with prominent manufacturers such as Tesla, BMW, BYD, Nissan and Toyota Prius, among others. Bloomberg NEF estimates that more than 50% of global passenger vehicles sold in 2040 will be electric, making up about 31% of all passenger vehicles on the road.32
- Based on total costs of ownership (i.e., including lifetime maintenance, fuel, battery costs, etc.), EVs will soon cost the same as their gasoline counterparts according to 2018 BNEF projection.33
- While electrifying private vehicles helps reduce global emissions, increased use of private vehicles does not necessarily improve equitable access to transit services across income groups.
- Single occupancy vehicles contribute to traffic congestion and consume more fuel per passenger, regardless of the vehicle engine type, and disproportionately benefit higher income urban residents, who can afford to own a car.
- Ride-hailing, bike-sharing and car-sharing models have emerged in some cities as a potential sustainable mobility solution, providing first/last-mile connectivity and transport options in areas not served by public and mass transportation.34

**Figure 5: Global electric car sales, 2015 - 2018**

![Global Electric Car Sales](https://www.iea.org/reports/global-ev-outlook-2020)


31 [https://www.railwaygazette.com/modes/byd-enters-urban-rail-market/43353.article](https://www.railwaygazette.com/modes/byd-enters-urban-rail-market/43353.article)
32 [https://about.bnef.com/electric-vehicle-outlook/](https://about.bnef.com/electric-vehicle-outlook/)
34 [https://www.ucsusa.org/resources/ride-hailing-problem-climate](https://www.ucsusa.org/resources/ride-hailing-problem-climate)
Figure 6: Electricity demand (TWh) across EV modes by region, 2018

2. Transportation and Electricity in Uganda

National Overview

Located in East Africa, Uganda has an estimated 41 million residents. With one of the world’s fastest population growth rates at 3% per annum, the country’s population is expected to reach 100 million by 2050. Today, 24% of Ugandans live in cities, but the country is rapidly urbanizing, with a 5.2% annual urban growth rate, a figure considerably higher than the global average rate of urban growth (of 1.6% between 2020 and 2025).

Transport

Uganda’s transport is dominated by road transport of which only about 30% constitutes a paved network. In 2018-2019 about 96% of freight cargo and passenger traffic was distributed by road.

• Major passenger transportation modes include cars and private taxis, 4-wheel drive vehicle (which can also carry light goods), mini-bus taxis, buses, trucks, and motorcycles.
• Public transport is dominated by 14-seater mini-buses (matatus) and motorcycle taxis (boda-bodas) which are largely self-regulated. They are typically imported second- or third-hand from neighboring East African countries, and have inefficient fuel combustion and immense emissions.
• Motorization rate in Uganda is very high. Nationwide, total number of registered vehicles range between 1.4 and 2 million (including motorcycles). The vehicle fleet in the country has nearly doubled, from 739,036 in 2012 to 1,355,090 in 2018.
• Due to motorcycles’ flexibility and accessibility, the number of motorcycles in Uganda has increased by 192 percent between 2010 and 2018, from 354,000 to over one million.

Combined with population growth and rapid urbanization, rise in motorization in Uganda is leading to many negative externalities:

• Traffic congestion and deteriorating road safety especially for vulnerable pedestrians and other users are major issues in the country. Although official road fatalities per available vehicles have been falling over the recent years, absolute road fatalities have been gradually increasing from 2,845 deaths to 3,500 deaths between 2014 and 2017.
• Locally, declining air quality is a major issue. Vehicle emissions represent significant source of pollutants (especially particulate matters) in Kampala as well as other growing cities in Uganda. Vehicle emissions standards, though existing on paper, are not properly enforced. Average CO₂ emissions have increased by 8% from 465 g/km in 2004 to 503 g/km in 2014—the latter of which is 75 percent higher than UNECE international standards.
• One study that compares different transport modes in Uganda found that given the same distance travelled and total number of passengers, buses are the least polluting in terms of carbon emissions: they are 3 times less polluting than mini-buses and 8 times less than boda-bodas. Private (saloon) cars would emit 18 times more than buses.

References:
33. https://www.fowode.org/publications/research/40
- Average fuel efficiency across Uganda is declining, from 12.52 L/100km in 2005 to 13.73 L/100km in 2014, as the average age of vehicles imported into the country increases.\textsuperscript{46} This is partly due to the fact that older vehicles cost less to purchase for the end user as a result of the Value Added Tax (VAT) policy and ineffective application of Environmental and Infrastructure Levies.\textsuperscript{47}

In order to address these urbanization and transport challenges, Uganda’s Third National Development Plan (2020/21 – 2024/25) calls for the development of “a seamless, safe, inclusive and sustainable multi-modal transport system.”\textsuperscript{48} As part of this agenda, the country aims to reduce road fatalities by about 10% from current rate of 3,689 deaths to 3,289. Uganda also aims to reduce average travel time from the baseline 4.1 min per road km to 3.5 min per km by 2025 within the Greater Kampala Metropolitan Area (GKMA).\textsuperscript{49}

**Electricity**

**Uganda’s electricity is mostly provided by clean energy sources.** In 2019, the country’s installed capacity includes: hydroelectric power (1004 MW), geothermal power (100 MW), solar photovoltaic (51 MW) and bagasse/ cogeneration (96 MW). Generation plants, distribution and transmission networks of Uganda is illustrated in Figure 8.

**There are seven primary electricity distribution companies operating in Uganda,** by geographic region. Umeme, the largest distribution company, has 97% of the distribution market, and other regional players include Ferdsult, West Nile Electricity Company, Bundibugyo Energy Cooperative, and Pader-Abim Energy Cooperative, among others. These distribution companies are independently operated and have been known to innovate in service delivery including pioneering the pre-paid metering system and integration of solar energy sources for consumers in rural areas.\textsuperscript{50}

Most of Uganda’s electricity supply comes from renewable energy sources, and production is increasing. Between 2018 and 2019, Uganda increased its generation capacity by about 35%, mainly due to the addition of a large hydroelectric generation plant (Figure 9). Today Ugandan consumers use approximately 65% of electricity produced in the country, and the increase in annual peak demand is modest compared to the growth of installed capacity. While electricity sales across all sectors have been increasing over the last few years, the majority of electricity in Uganda is consumed by the industrial sector, followed by domestic (residential) sector (Figure 10).

![Figure 9: Total electricity generation capacity of Uganda, 2014-2019](image-url)
A country’s electricity mix depends on available primary energy sources and the country’s technical, institutional, and financial capabilities. Uganda’s electricity generation mix is compared to other sub-Saharan African countries in Figure 12.

- Along with Uganda, Ethiopia and Democratic Republic of Congo rely on hydro power for 90-99% of their electricity generation.
- Kenya has the largest percentage of solar, wind and thermal in its mix.
- Ghana, Cote d’Ivoire and Nigeria have high gas percentages in its electricity generation mix, although Ghana has an almost equal split between gas and hydro power.
- About 89% of South Africa’s electricity is generated using coal, while it is also the only country in SSA that harnesses nuclear energy to produce electricity.

Source: Uganda (REA 2019) and other countries (IEA 2018)
Not all sources of electricity generation are equally clean.

According to lifecycle analysis conducted by the Intergovernmental Panel on Climate Change (IPCC), using coal to generate electricity is the most carbon intensive while sources with the least carbon intensity include nuclear, hydropower and other renewables such as wind, solar and thermal (Figure 13).\(^5\) Carbon intensity of electricity grids varies based on the energy source and transmission losses. Uganda’s electricity generation is the third least-carbon intensive among selected African countries (Figure 14). Because if this, Uganda has an opportunity to develop truly green transportation systems, through electrification of its transport sector.

**Figure 13: Carbon intensities of electricity generation technologies**

<table>
<thead>
<tr>
<th>Generation technology</th>
<th>Carbon Intensity (gCO(_2)e/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1001</td>
</tr>
<tr>
<td>Oil</td>
<td>840</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>469</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>309-1,050*</td>
</tr>
<tr>
<td>Nuclear</td>
<td>16</td>
</tr>
<tr>
<td>Hydropower</td>
<td>4</td>
</tr>
<tr>
<td>Other renewable</td>
<td>27</td>
</tr>
</tbody>
</table>

*Bioenergy carbon intensity varies by region and depends on biomass feedstock.


**Figure 14: Carbon intensity of electricity grid in select sub-Saharan African countries, 2017**

As seen in Figure 15, Uganda also has one of the lowest electricity access rates in sub-Saharan Africa, although this number has been increasing over the years. Uganda is one of the few countries in the region with excess installed generation capacity, partially due to: (a) Poor network reliability with many outages, (b) High initial cost of getting access to the distribution grid, and (c) High unit cost of electricity once grid access is secured.

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Figure 15: Electricity access rates in select sub-Saharan African countries

![Figure 15: Electricity access rates in select sub-Saharan African countries](https://link.springer.com/chapter/10.1007/978-3-030-11735-1_2)

Source: [https://link.springer.com/chapter/10.1007/978-3-030-11735-1_2](https://link.springer.com/chapter/10.1007/978-3-030-11735-1_2)

Given that Uganda has one of the lowest annual electricity generation quantities in the region (Figure 16), further analysis of energy needs in Uganda is required to understand where EVs fit in the general scheme of energy applications across the country. Other energy needs and priorities might take precedent over electrifying transportation, potentially leaving limited existing capacity for deployment of EVs in Uganda.

At the same time, the cost of electricity generation is constant, regardless of the number of users, causing a supply-and-demand mismatch due to low existing demand. This means the total electricity cost in Uganda becomes more expensive for end-users. Umeme, Uganda’s main power utility company, sees the emergence of e-mobility as an opportunity for increasing electricity demand, and has undergone preliminary conversations about investing in e-mobility infrastructure.

Furthermore, Uganda’s National Development Plan aims to increase access and consumption of clean energy and energy efficient technologies to support economic growth. To this aim, there is nearly 2,000 MW of electricity generation plants under construction across the country (Figure 17).

Figure 16: Electricity generation in select sub-Saharan African countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Electricity Generation (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda</td>
<td>4,384</td>
</tr>
<tr>
<td>Tanzania</td>
<td>7,230</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>10,059</td>
</tr>
<tr>
<td>Kenya</td>
<td>11,769</td>
</tr>
<tr>
<td>Democratic Republic of Congo</td>
<td>10,577</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>13,576</td>
</tr>
<tr>
<td>Ghana</td>
<td>12,262</td>
</tr>
<tr>
<td>Nigeria</td>
<td>36,277</td>
</tr>
<tr>
<td>South Africa</td>
<td>255,439</td>
</tr>
</tbody>
</table>

Sources: Uganda (REA 2019), other countries (IEA 2018 data)
Uganda was the first African country to sign the Partnership Plan for Nationally Determined Contributions (NDCs) as part of the Paris Agreement in 2018. Energy and transport sectors will play an integral role in meeting the committed NDCs.52

- The country is self-committed to working towards low-carbon development in order to reduce emissions and negative impacts of climate change.
- If followed through the committed policies and mitigation measures, about 22% reduction in national level GHG emissions can be achieved by 2030 compared to the business-as-usual scenario, resulting in 77.3 million tons of CO2 equivalent per year.53
- Policies to promote and deploy clean and more energy efficient fuels and vehicle technologies can potentially reduce about 2 million tons of CO2 equivalent per year—this is 24-34% less CO2 that would be produced by the year 2030, under current transportation modes and road infrastructure.
- Though Uganda’s per capita emissions contribution is miniscule (below the global average), setting ambitious NDC agenda to undertake the collective global problem is not only laudable; this path, if successful, can also bring reliable, accessible and sustainable energy and transport to improve the livelihoods of millions of Ugandan citizens.

Greater Kampala Metropolitan Region (GKMA)

Kampala is the capital city and the largest urban center of Uganda. More than 4 million residents, or about ten percent of the country’s population lives in the Greater Kampala Metropolitan Area (GKMA).54 It is a bustling economic heart with 70% of the nation’s manufacturing plants, contributing to more than one-third of Uganda’s GDP.55 Being the magnet for jobs, economic activities and livelihoods, GKMA, has nearly half of all vehicles registered in Uganda.

- In terms of modal shares, walking is the predominant mode in the GKMA. Almost 80% of total motorized trips is taken in boda-bodas and private cars, but matatus carry a significant 82% of total riders (Figure 18).
- Partly due to Kampala’s congestion, and partly due to their ability to provide flexible and efficient transport, the estimated number of motorcycles (boda-bodas) in the GKMA have almost tripled over the last 8 years, from 354,000 in 2010 to 1,034 million in 2018 and are expected to reach more than 3 million by 2050.56
- Boda bodas are prone to crashes, and the victims of road fatalities in GKMA are vulnerable pedestrians and cyclists (Figure 19).

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54 https://www.citypopulation.de/en/uganda/admin/central/012_kampala/
• Based on the Kampala Energy and Climate Profile, transport in the city contributes to a substantial share of local GHG emissions, and by 2030, it is projected to grow to one of the top two sectors (along with households).\textsuperscript{57}

Figure 18: Motorized modal split in Uganda’s GKMA, by percent of trips and population served

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>% Trips</th>
<th>% Persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private cars</td>
<td>37</td>
<td>9</td>
</tr>
<tr>
<td>Motorcycle taxis (Bodas)</td>
<td>42</td>
<td>9</td>
</tr>
<tr>
<td>Minibuses (Matatus)</td>
<td>21</td>
<td>82</td>
</tr>
</tbody>
</table>


Figure 19: Traffic related fatalities by mode in Uganda’s GKMA, 2017


The negative impacts of increased motorization in the GKMA have led to a rise of projects promoting sustainable transportation—for example reorganization and registration of informal paratransit services in Kampala, and pilot electrification of a locally manufactured bus in central business district (CBD). They are part of a concerted effort by municipal and national transportation authorities to support the movement of people, while reducing traffic congestion and improving air quality.

• **Commuter Railway:** Uganda Railway Corporation (URC) operate a commuter rail service in the Kampala Metropolitan Region, transporting about 2,000 people daily. The Kampala-Namanve route has been in operations since 2015, and after URC acquired management of additional meter-gauge rail, a Kampala-Portbell route was added in 2019. A third route between Kampala and Kyengera is currently underway, and URC has further expansion plans of commuter rail in the city.

• **Tondeka Metro bus project:** Tondeka Metro proposes to serve the GKMA with 980 commuter buses, procured from Indian and Ugandan manufacturers. Buses will operate with standard fares, under a scheduled timetable and utilize cashless payment systems.\textsuperscript{58}

• **Bus Rapid Transit (BRT) project:** A core project within the National Development Plan (NDP) since 2010, the Kampala BRT is expected to have 8 routes in the future, with a pilot

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\textsuperscript{58} https://tondeka.co.ug/
corridor originally planned for construction in 2011, but not yet constructed. The project has undergone a pre-feasibility study and preliminary station planning and design.

- **Increased bicycle lanes and protected pedestrian walkways**: Since approval of Uganda’s Non-Motorized Transport (NMT) policy in 2012, Kampala Capital City Authority (KCCA) has made efforts—such as demarcated bike lanes in CBD—to encourage safe cycling and walking. KCCA partners with UN-Habitat for a pilot bicycle-sharing scheme in Kampala. A series of car free days around the CBD is also being organized together with Uganda Sustainable Transport Network.

- **Namirembe Road-Luwum Street NMT corridor**: As the city’s NMT zone, this 2-km corridor involved the complete remodeling of a busy street that cuts through the center of Kampala. The planning began in 2011, and construction was completed in March 2020. It was opened when Kampala saw a surge in cycling and walking throughout the city, as a result of a ban on public transportation to mitigate the spread of COVID-19.

- **Kampala Institutional and Infrastructure Development Projects (KIIDP)**: They also entail design and construction of stormwater drainage channels, signalization of intersections, and construction of pedestrian crossings and protected footpaths, among others. One result is the Multi-Modal Urban Transport Master Plan, completed in 2012.

- **Bloomberg Philanthropies Initiative for Global Road Safety**: With support from the Bloomberg Philanthropies Initiative for Global Road Safety (BIGRS), KCCA has joined a global network of cities and national governments with access to global experts on road safety. Over the next six years, the initiative will provide support in areas such as data and surveillance, safer streets and safer mobility, and communication.

- **New Mobility Enterprises**: There is a growing number of new mobility enterprises operating in Kampala, leveraging advances in technology to offer app-based ridesharing, cashless payment, and trip planning services to urban residents. Several use EVs for service provision, while others provide safer, affordable last-mile connections and optimizing supply and demand of trips across modes and distances.

These initiatives, and others, are moving the city towards more sustainable mobility options, but these efforts needed to be implemented at scale, and coordinated across modes. Shifting toward EVs across different modes will be an important improvement to Uganda’s transportation ecosystem.

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61 https://www.kcca.go.ug/media/docs/KAMPALA%20NMT%20PROJECT.pdf
62 https://www.kcca.go.ug/kiidp
3. Understanding Electric Mobility

The EV ecosystem involves multiple industry sectors and a wide range of stakeholders, including vehicle users and owners, government regulators, private sector manufactures and transportation service providers.

We highlight four primary components of an e-mobility ecosystem in this section:

- Vehicles,
- Batteries,
- Charging Infrastructure, and
- Electricity Generation and Distribution.

In practice, these components are largely interconnected, cutting across energy, urban planning and engineering disciplines, with many overlapping stakeholders and spatial implications (Figure 20).

In geographies where the e-mobility industry is young, such as Uganda, e-mobility service providers are often dominated by technology and transportation startups and research-driven pilot projects, which typically do not have capacity or access to finance to provide e-mobility services at the scale required for widespread adoption. And e-mobility development can require top-down market actors (government, donors or large investors) who can offer incentives or subsidies to make the services affordable to low income population. Government can also play a role in enabling regulatory environment that makes it easy for small and large investors to develop the necessary infrastructure.

Figure 20: Interconnected landscape of electric mobility

Source: Adapted from “Mobility 2030: Transforming the Mobility Landscape”, KPMG
**Vehicles**

A thriving e-mobility ecosystem requires both an affordable and widespread supply of EVs and a strong demand for EV products and related services. Below are a range of measures that have been used increase EV supply and demand in cities around the world:

**Figure 21: Measures that increase EV supply**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean vehicle mandates, requiring compliance of vehicle emissions standards by manufacturers</td>
<td>Zero Emissions EV Program, California</td>
</tr>
<tr>
<td>For regions with vehicle manufacturing industries, local production and assembly of electric vehicles</td>
<td>BYD in Shenzhen, China; YMA Bicycles; Scooty's; and Marathon Motors, Addis Ababa, Ethiopia</td>
</tr>
<tr>
<td>For regions without vehicle manufacturing industries, local assembly of EVs using imported parts, and local vehicle maintenance</td>
<td>Campinas, Brazil</td>
</tr>
<tr>
<td>Subsidies and import tax/VAT waivers</td>
<td>New Energy Vehicle credit mandate, China</td>
</tr>
<tr>
<td>National-level e-mobility strategies or plans</td>
<td>Faster Adoption and Manufacture of Hybrid and Electric Vehicles, FAME III, India</td>
</tr>
<tr>
<td>Retrofit existing vehicles from combustion engines to electric motors</td>
<td>Opibus, Nairobi; Bodawerk, Uganda</td>
</tr>
</tbody>
</table>

**Figure 22: Measures that increase EV demand**

<table>
<thead>
<tr>
<th>Improve consumer knowledge</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Raise public awareness of e-mobility benefits</td>
<td>UYilo, South Africa; Nairobi, UNEP</td>
</tr>
<tr>
<td>Market EVs as modern, futuristic and eco-friendly</td>
<td></td>
</tr>
<tr>
<td>Implement pilot projects that are visible, giving residents experience</td>
<td></td>
</tr>
<tr>
<td><strong>Electrification of large fleets</strong></td>
<td></td>
</tr>
<tr>
<td>Transition government-owned or private sector vehicle fleets to electric vehicles</td>
<td>Transport for London; Ikea and Amazon</td>
</tr>
<tr>
<td>Legislation requiring transition of private sector transportation and/or freight fleets to electric vehicles</td>
<td></td>
</tr>
<tr>
<td><strong>Sharing EVs instead of purchasing them to increase affordability</strong></td>
<td></td>
</tr>
<tr>
<td>Vehicle leasing, sharing, pooling</td>
<td>Gura Ride, Kigali; CIVITAS and SEAP, Europe</td>
</tr>
<tr>
<td>E-hailing/ride-hailing</td>
<td>Caocao, global</td>
</tr>
<tr>
<td><strong>Provide enabling infrastructure early on</strong></td>
<td></td>
</tr>
<tr>
<td>Convenient and affordable access to charging</td>
<td></td>
</tr>
<tr>
<td>Use of interchangeable charging and battery infrastructure across manufacturers, and provision of manufacturer warranties for battery sharing</td>
<td></td>
</tr>
<tr>
<td>EV preferred access to parking and/or driving lanes</td>
<td></td>
</tr>
<tr>
<td><strong>End-user financial incentives</strong></td>
<td></td>
</tr>
<tr>
<td>Total cost of ownership marketing for fleet purchase</td>
<td>Cost and Emissions Appraisal Tool, WRI</td>
</tr>
<tr>
<td>Electricity tariff subsidies for EV charging</td>
<td></td>
</tr>
<tr>
<td>Tax credits/savings for EV purchase</td>
<td></td>
</tr>
<tr>
<td>Subsidies for EV purchase or for retrofit of combustion vehicles to EV</td>
<td></td>
</tr>
<tr>
<td>Waiving annual road or vehicle registration taxes</td>
<td></td>
</tr>
<tr>
<td>Providing parking fee discounts to EVs</td>
<td></td>
</tr>
<tr>
<td>Taxing combustion engine vehicles</td>
<td></td>
</tr>
<tr>
<td>Fuel tax (gas, diesel)</td>
<td></td>
</tr>
<tr>
<td>Emissions regulations, including national level emissions reduction targets and creation of low-emissions zones</td>
<td>LEZ in London, England</td>
</tr>
</tbody>
</table>
**Battery Production**

Battery production for EVs is energy intensive with a complex supply chain, including mining and smelting of raw materials. The ability to sustainably manufacture and use/reuse batteries in the future will have an impact on natural resource management and industrial development globally, and in Africa, which produces a significant percentage of raw materials used for battery production (Figure 23). 64

Today, many governments are creating policies that prohibit environmentally or socially destructive mining practices, while regulating disposal of batteries, incentivizing reuse and recycling. For example, European and Japanese markets have plans requiring second-life battery applications.65 And in China, which dominates global battery production, a new policy requires EV batteries produced after August 2018 to have unique IDs tracking use across the battery lifespan.66

**Figure 23: Global minerals production share from the Africa continent, 2018**

Source: IEA Africa Energy Outlook 2019

Over the last 5 years, rechargeable and portable lithium-ion batteries have gained popularity for use in EVs due to extended battery life and falling costs. In some markets EV batteries are expected to reach cost parity with incumbent options.67

**Figure 24: Measures that contribute for falling battery costs and extended life**

<table>
<thead>
<tr>
<th>Sourcing of materials for battery production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and Development on alternatives to the rare materials used in battery production, such as Cobalt.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Innovation in battery design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesla, for example, launched a new long-lasting million-mile battery in 2020.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Battery reuse and recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refurbishing and/or repurposing for second life, appropriate to batteries’ decreased performance.</td>
</tr>
<tr>
<td>▪ Energy storage for ISO, utilities and customers (China Tower, China)</td>
</tr>
<tr>
<td>▪ Renault powering elevators in multi-dwelling residential buildings</td>
</tr>
<tr>
<td>▪ Evgo, charging infrastructure provider, partners with BMW and Samsung to demonstrate second-life applications for EV charging in public settings.</td>
</tr>
<tr>
<td>Safe reuse/recycling of batteries components (GEM, China 2018 pilot project, and Gigafactory in Nevada).</td>
</tr>
</tbody>
</table>

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64 IEA Africa Energy Outlook
Charging Infrastructure

Hardware and supply of electricity required to charge electric vehicles differs based on vehicle and battery type. Large vehicles such as trucks and buses require charging terminals with high output voltage for maximum efficiency charging, with significant safety protocols. Batteries used to power smaller vehicles, such as two-wheelers require less power and output voltage for rapid charging (Figure 25).

Figure 25: Power capabilities by charging type

<table>
<thead>
<tr>
<th>Conventional plugs</th>
<th>Slow charging</th>
<th>Fast charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>Level</td>
<td>Level 1</td>
</tr>
<tr>
<td>Level</td>
<td>Power</td>
<td>Power</td>
</tr>
<tr>
<td>AC</td>
<td>3.7–22 kW</td>
<td>22–43.7 kW</td>
</tr>
<tr>
<td>Vehicle types</td>
<td>Vehicle types</td>
<td>Vehicle types</td>
</tr>
<tr>
<td>Two-wheeler, three-wheeler, private cars</td>
<td>Private cars</td>
<td>Private cars, Buses</td>
</tr>
</tbody>
</table>

Source: Authors’ compilation based on IEA 2019. Note the standards in the Figure might be different across geographies.

Because charging infrastructure is provided by both public and private sectors, socket design across stations isn’t universal. For example, Figure 26 shows different contemporary socket designs by manufacturing locations, such as CCS, CHAdeMO, CB/T. When planning charging infrastructure, standardization of plugs is a critical aspect, and to this end, some global best practices are:

- The Netherlands has pioneered interoperability standards for charging stations: Open Charge Point Protocol (OCPP) and the Open Clearing House Protocol (OCHP).[^68] [^69]
- Shared communications protocols and technology standards across industry entities such as electric vehicle supply equipment, charging point operators and distribution system operators, facilitates industry-wide compliance and enables smart charging options throughout a vehicle’s network, including EV wireless and cloud charging options.[^70]
- Advancements in Vehicle-to-Grid communications protocols allowing:
  - Smart Charging (V1G) during off-peak hours
  - Bi-directional charging (V2G), discharging energy stored in vehicles batteries back to the grid
  - Use of V1G & V2G strategies with renewable energy supply

Figure 26: Contemporary charging socket types for four-wheelers, by geography

Source: https://evcharging.enelx.com/eu/about/news/blog/552-ev-charging-connector-types

Provision of publicly accessible charging infrastructure must be considered by municipal governments, due to its impact on planning for public-right-of-way, parking, curb access, security

[^68]: https://www.openchargealliance.org/
[^69]: http://www.ochp.eu/
[^70]: https://saascharge.com/glossary/
and required connections to the electricity distribution grid. In some cities, governments and industry associations provide incentives to private sector for deployment and operation of charging infrastructure, as follows:

- $400 million in grants for development of EV charging infrastructure, as part of the 2009 American Recovery and Reinvestment Act (US).
- Funding of 88 pilot cities in China to install a minimum of one EV charger for every 8 EVs within the city center, with a focus of locating these along highways and major roads.\(^7\)\(^1\)
- Chinese New Infrastructure Plan that provides incentives for charging facility construction, and V2G and renewable energy integration.\(^7\)\(^2\)
- Mandate for new parking lots include a quota of parking spaces with EV charging points, dedicated to electric vehicles. (Beijing, Qingdao, Shanghai, Tianjin\(^7\)\(^3\))
- Globally, sustainability certifications such as USGBC LEED (US), BREEAM (UK) and Green Star (Australia, South Africa), require provision of EV charging stations to achieve certification points.
- Some governments offer incentive programs with discounted electricity rates when charging vehicles at home during evening and early morning hours (Time-of-Use Rate programs in United States cities).

**Figure 27:** Privately owned (left) and publicly accessible (right) EV chargers globally in 2019


**Electricity Generation and Distribution Networks**

While e-mobility eliminates tail pipe emissions from vehicles, the process of generating electricity to charge EVs can cause significant emissions, especially when that electricity is produced from fossil fuels. When EVs are charged using clean and renewable sources—such as wind, solar, pumped hydro, tidal action and geothermal—total EV emissions are dramatically reduced, gaining the full benefits of transportation electrification.

The most sustainable energy sources depend largely on local climate and topography conditions, among others. Countries around the world are improving their renewable energy portfolios to mitigate the rising global temperature due to carbon emissions. Some notable examples include:

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\(^7\)\(^1\) [https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf](https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf)
\(^7\)\(^3\) [https://www.d1ev.com/kol/117432](https://www.d1ev.com/kol/117432)
• Germany, with the highest energy prices in the EU (> .30 per Kw/h), places a surcharge on electricity consumers for consumption of non-renewable energy.74 Through a feed-in-tariff, government encourages photovoltaic panel installation, selling excess energy back to the National grid at a fixed, high price.

• Regions with high levels of solar radiation are increasingly investing in solar photovoltaic (PV) electricity generation. For example, Egypt provides 20% of national electricity consumption from renewable energy and plans to increase this to 42% by 2035 (14% wind, 25% solar, 2% hydro), predominantly through solar PV investments.

• Many East African countries, including Uganda, Kenya, and Ethiopia, provide over 90% of electricity from renewable sources, most commonly from hydroelectric power.

A key challenge with increasing the renewable energy mix in an electric grid is intermittency. There is a need to maintain power reliability during all times of day, and all days of the year, to support a reliable electric transportation system.

One common solution to this challenge is a hybrid source-fuel mix, using electricity generated from fossil fuels to meet base load demand, and renewable energy sources to supplement peak demands. Another solution is to provide sufficient energy storage, both at the location of generation and at points along the distribution network, or at distributed off-grid locations. Both traditional pumped-storage hydropower and lithium-ion batteries are used to provide electricity storage which can help maintain reliable power supply from renewables. In some regions, such as Gansu Province, China, retired EV batteries are used for electricity storage.75

Distributed Generation

As small-scale renewable energy generation options become more accessible, the distance between the location of energy generation and consumption gets smaller. For example, the increase in use of mini-grids for renewable energy generation, allowing prosumers to consume a portion of that electricity and sell the remainder back to the grid.76 In sub-Saharan Africa, mini-grids are most typical in rural areas with limited connections to the national grid, or by consumers who may have a grid connection but wish to avoid frequent and disruptive power outages.

Electric vehicles can also provide energy storage for consumers and utility companies through vehicle-to-grid integration (V2G). Some examples of this include:

• Pacific Gas and electricity (PG&E) in California, converted company-owned Toyota Prius to PHEVs for testing V2G supply at Google's campus. Xcel Energy, another US utility service provider, tested V2G technology with several converted hybrid city fleet cars in Boulder, Colorado, as part of its Smart Grid City project.77

• In London, a three-year V2G trial project with electric buses was recently launched, called Bus2Grid.78 79 The project uses 28 electric buses (BYD-ADL), with potential to expand. Using bi-directional chargers, each bus can provide up to 40 kW of power, which is up to 1.1 MW of power on demand.

Although V2G technology is promising, there are currently limitations to scaling, including managing battery degradation over time, updating regulations to allow V2G at scale, and developing business models that allow affordable pricing.

Distribution Network

74 https://energypost.eu/germany-2021-when-fixed-feed-in-tariffs-end-how-will-renewables-fare/
76 A consumer, either an individual or institution, at the same location of electricity generation is called a ‘prosumer.’
79 https://uk.motor1.com/tag/london/?utm_campaign=yahoo-feed
An inclusive, multi-modal e-mobility system requires a widespread and reliable electricity distribution network. To this end, development of “effective grid” or “smart grid” system through networking small power producers, can reduce dependence on a single energy source. Smart grids often provide compensation for small electricity producers who sell back to the grid, and use small-scale, bi-directional transmission equipment to allow consumer access.

In addition, since mass integration of EVs into the electricity grid can negatively affect low voltage electric distribution networks, when drawing power from the grid, managing voltage fluctuations at the point of the charging station is important to avoid infrastructure and equipment damage, including to the charging station and vehicle. Some best practices in voltage management include:

- Use of behind-the-meter batteries that store and time-shift energy.
- Household meters and appliances connected to a smart grid can allow automatic power conditioning and control of power consumption, coordinated with demand management and other electricity saving measures (e.g. Edison project, Denmark).
4. How Does Uganda Measure Up?

Uganda’s e-mobility ecosystem is nascent, diverse and actively evolving. Within East Africa, neighboring Kenya and Rwanda currently have more e-mobility initiatives (such as e-bike sharing programs and EV pilots), as well as polices to enable electrification of vehicles across modes. At the same time, the pace of interest in e-mobility is advancing quickly in Uganda. The country is home to the first electric bus manufactured on the African continent, paralleled only by South Africa and Ethiopia that assemble small quantities of electric cars. Such achievement is partially propelled by Kampala’s emerging reputation as a hub for entrepreneurship and startups within East Africa.  

At the time of this research, there are two known private sector companies, and one parastatal company, specializing in e-mobility services, as well as various academic and development initiatives interested in or actively engaged in e-mobility:

- **Zembo** introduced e-motorcycles to Uganda’s boda-boda sector in 2019, and as of March 2021 has deployed over 100 e-motorcycles serviced by 18 charging stations (including 3 powered purely by solar).  
- **Vehicle components are imported from China and assembled in Uganda. The e-motorcycles are then sold to boda-boda drivers on a lease-to-own basis whereby the swappable batteries are re-charged and owned by Zembo.**

- **Bodawerk** retrofits existing bodas’ petrol-driven power engines with electric ones. The lithium-ion battery packs are assembled and leased on a subscription-based model to boda drivers.

- **Kiira Motors** has built a limited number of electric private vehicles and solar-electric powered e-buses. Kiira Motors started in 2007 as a research project in Makerere University, Uganda, and the Kiira EV Project led to the establishment of Kiira Motors Corporation in 2011, owned jointly by the Government of Uganda (96%) and Makerere University (4%).

In addition to these companies, there are a small, but unknown, number of electric and hybrid bicycles, motorcycles and private vehicles, imported by individuals and vehicle dealerships throughout the city. Companies such as Ultimate Cycling Uganda and the non-governmental organization, FABIO, have also expressed plans to increase the number of e-bicycles imported and distributed in the country.

The demand for e-mobility in Uganda today is primarily constrained by a lack of infrastructure, supplier capacity, and companies specializing in e-mobility operating business models that are still in the discovery phase. Private enterprises must provide a wide range of e-mobility services (e.g., from the provision of battery chargers to the final assembly of a bike). This is partially due to the need for these early companies to offer highly integrated service models, which can be resource and capital intensive.

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Vehicle Supply, Batteries and Charging

Bicycles, motorcycles, and three-wheelers

Electric motorcycles are the most common EV mode seen on the streets of Kampala today, followed by electric bicycles and electric three-wheelers. This aligns with transportation mode share trends in Uganda, where use of boda-bodas as a transport service is on the rise, due to their low operational cost, increasing traffic congestion in cities, and limited service provision of public transportation.

- Two- and three-wheeler vehicles have smaller batteries which are cheaper to produce, yielding lower upfront costs for the end user when compared to four-wheel electric vehicles.
- Batteries for these small vehicles can be charged at home or with off-grid photovoltaic panels, within 3-4 hours. These batteries can also be locally produced by recycling and retrofitting existing batteries.
- The business models for market adoption of these vehicles are still evolving and being proven, by companies such as Zembo, through battery swap combined with lease-to-own models. Tugende, an asset financing company in Uganda has a new program giving preferential loan rates to people purchasing e-motorcycles.
- Research by TechSci estimates the two-wheeler market in Africa will reach US$9 Billion dollars in 2021.
- University of Michigan is partnering with Zembo to examine the impact of e-motorcycle adoption on greenhouse gas emissions reduction and air quality improvement in Kampala.

Buses, minibus taxis, and private cars

Currently, there is limited progress towards market entry of private cars, mini-bus taxis and buses in Uganda. The upfront cost to purchase an EV is still higher than combustion vehicles around the world, including in Uganda. Given the large number of second-hand vehicles imported into Uganda with combustion engines, estimated to exceed 600,000 vehicles per year by 2032, and the lack of purchasing incentives for EVs, market adoption for EVs will be slow.

Introduction of private EVs and e-buses requires accessible charging infrastructure. This infrastructure is expensive to construct, and successful implementation requires coordination across vehicles modes and manufacturers for design of charging stations as a shared resource. Without this, EV deployment in Uganda will be limited.

Similarly, it would be difficult to install suitable electric charging stations along streets and pavements in urban centers, due to indiscriminate practices of parking on streets and pavements, informal use of streets by vendors, and unregulated development that often encroaches on unused land and streetscapes. For these reasons, day-time charging is likely to be a major issue.

At the same time, there is a growing number of stakeholders addressing the need for policy incentives and publicly accessible charging infrastructure, which are key investments needed to unlock market opportunities.

- Kiira Motors has manufactured a small number of electric cars and buses in Uganda, including Africa’s first electric vehicle in 2011, and first solar electric bus in 2016. The Kayoola Solar vehicle is a fully electric city bus launched in May 2020. It can travel approximately 80km between recharges (for example Kampala–Entebbe–Kampala), and currently serves as an Executive City bus in Kampala for demonstration purposes.

87. Although it is difficult to estimate, at the time of this research there are likely fewer than 500 electric bicycles and motorcycles traveling in the streets of Uganda.
tun/
89. https://gotugende.com/
92. https://smart24tv.co.ug/2019/12/12/kayoola-electric-bus/
Government of Uganda plans to introduce a fleet of 980 buses in Kampala, through a partnership between India’s Ashok Leyland and Kiira Motors Corporation. This is the first phase of a project that will bring 3,000 buses to Uganda’s cities. There are no plans for electrification of the first 980 buses, but future project phases (after the first 980 buses) could utilize electric or hybrid engine technologies, a product that Ashok Leyland also manufactures in India. These plans are promising, but the project, registered as Tondeka Metro, is stalled due to lack of financial security.

Makerere University's Centre for Research in Transport Technologies (CRTT) is researching local battery production and recycling, with the goal of promoting industrial and economic growth in Uganda, while lowering the cost of EV production. Uganda is strategically located near mines producing essential ingredients for battery production such as lithium, cobalt, manganese, and graphite, yet there are no battery manufacturing plans on the continent of Africa.

One research project is exploring the financial and operational impacts of transitioning Uganda’s minibus taxis, the most widespread form of public transportation in Uganda, to electric vehicles. The study, run by the Emmett Interdisciplinary Program in Environment and Resources at Stanford University, plans to convert a small number of minibus taxis into electric vehicles, including design and provision of optimized charging infrastructure in Kampala and Nairobi.

### Investment Needed

#### Investment for EVs in Uganda

Electric two- and three-wheel vehicles that are dominating the streets of Kampala require less investment than larger EVs such as trains and buses. In Uganda, e-mobility companies for two- and three-wheelers and pilot projects are funded by a mix of grants, equity and results-based financing that supports startups in the early stages of market development. As part of their business model, some companies sell e-motorcycles at low profit margins and use battery charging services to generate the majority of its long-term profit margins.

Financing needs also increase as startups grow, making expansion of the e-mobility industry in Uganda difficult. Given limited infrastructure in the country, e-mobility startups are developing through vertically integrated models, which are incredibly capital intensive. The enterprises need to account for batteries, charging infrastructure, maintenance, and advertisements and advocacy—thereby requiring longer payback periods for large scale purchases (e.g. motorcycle chassis and lithium-ion batteries), and hindering their ability to achieve economy of scale. Often patient capital and venture funding have initially led the way for business model and technology development. However, to scale sustainably, the sector requires debt financing to support growing working capital needs along with matching infrastructure financing.

Financing of large vehicles such as e-buses is typically led by national or local government agencies, with support from development finance institutions (DFIs) and international banks, and often in collaboration with bus manufacturers. Some banks have emerged to specialize in funding e-buses in cities around the world, with lending rates varying widely across geographies, while other institutions play a strong role providing grants and in-kind technical support to regions interested in e-bus deployment (see Figure 29 for various funding sources).

Climate-focused financing such as the Clean Technology and Green Climate funds are also emerging as opportunities to finance e-mobility programs. These funds offer smaller amounts of money compared to traditional bank loans. Both climate funds, and some Development Bank financing, can

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require reporting of environmental and social impacts, which can be difficult to document for projects in the transportation sector.

**Figure 29: Funding sources for large-scale transportation investments, including e-buses**

<table>
<thead>
<tr>
<th>Funding Source</th>
<th>Example</th>
<th>Financial Products</th>
<th>What is Financed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilateral Development Banks</td>
<td>World Bank Inter-American-, African- and Asian Development Banks</td>
<td>Concessional loans, grants, guarantees, results-based financing</td>
<td>Bus and infrastructure acquisition and operations</td>
</tr>
<tr>
<td>Climate Finance (including for NDCs)</td>
<td>Clean Technology Fund, Green Climate Fund, Global Environmental Facility</td>
<td>Concessional loans, grants guarantee, equity</td>
<td>Incremental cost of low carbon investments</td>
</tr>
<tr>
<td>National Development Banks</td>
<td>China Development Bank, Bancoldex (Colombia), Development Bank of the Philippines</td>
<td>Loans to buyers, credit lines to manufacturers</td>
<td>Intermediary for co-financing, blending of governmental and commercial sources</td>
</tr>
<tr>
<td>Export-Import Banks</td>
<td>OECD list of official export credits agencies; Berne Union association</td>
<td>Loans, guarantees, and insurance to exporters</td>
<td>Supports exporters</td>
</tr>
<tr>
<td>Commercial Banks</td>
<td>Large banks (e.g. IDCBY, JPMorgan Chase, JPHLF, CICHY, BAC, ACGBY, CRARY, WFC)</td>
<td>Loans, lease financing, insurance</td>
<td>Supports exporters</td>
</tr>
<tr>
<td>Manufacturer Leasing</td>
<td>Scania, Proterra</td>
<td>Lease financing for bus, infrastructure or batteries</td>
<td>Largest volume of financing</td>
</tr>
<tr>
<td>Specialized Leasing Companies</td>
<td>Connect through manufacturers</td>
<td>Partial or full coverage of purchase cost</td>
<td></td>
</tr>
</tbody>
</table>

Source: 

Despite the growth potential of e-mobility in Uganda, the sector is hindered by a lack of funding for advancement of research, product development and service provision. This, coupled with limited demand for e-mobility services and products, makes it difficult for first movers to capture or grow the market. Elsewhere in sub-Saharan Africa, industry associations such as UYilo (South Africa) and the Association for Electric Mobility and Development in Africa (AMEDA, Kenya) serve as neutral associations that engage in knowledge provision, network building and advocacy for e-mobility friendly policies, although there are currently no such associations operating in Uganda.

**Electricity Infrastructure Investment in Uganda**

Uganda relies on low carbon-intensive, renewable energy generation (primarily hydropower) and is suitable for EV implementations. Uganda is also one of the top four off-grid (or mini-grid) markets in Africa, alongside Kenya, Tanzania, Senegal. However, limited energy access, high energy costs and power outages are principal barriers to transition, and large-scale EV fleets would place substantial pressure on the existing electricity grid. Moreover, efforts to provide electricity from renewable energy sources are often done in silos, uncoordinated with e-mobility investments, and more policy-level coordination is needed.

- The National Development Plan (NDP) 3 also offers a vision of a sustainable energy future, proposing increases in access and consumption of clean energy. The largest utility company, Umeme, is working with the Electricity Regulatory Authority (ERA) to achieve the following goals:
  - increase grid connection
  - increase electricity demand
  - improve reliability of supply

95 https://rmi.org/insight/energy-within-reach/
create more efficient service delivery

- In order to realize the vision from NDP3, deliberate and sustained investment in energy supply chain, from generation to transmission and distribution, is needed, including refurbishing aging infrastructure, improving distribution reliability, and extending grid to increase electricity access in remote areas. To deliver the power generated to all end users in Uganda, investment of up to USD 3 billion is required to upgrade infrastructure and operations, in the medium term. Different aspects of key investments needed to achieve universal electricity access are highlighted in Figure 30.

**Figure 30: Additional investment required in Uganda by 2025 to reach universal electricity access**

To absorb the current excess generation capacity and reduce the financial burden, the government is trying to attract further private sector investment. For example, the Uganda Renewable Energy Feed-in Tariff (REFIT) program encourages private sector participation in power generation from renewable energy technologies, through allowing feed-in-tariffs. This would be a positive alternative to the take-or-pay obligations in the Power Purchase Agreements (PPAs), which evidently, is putting additional strain on government finances in the absence of increases in end customer tariffs to recover the costs.

- Electricity Supply Industry (ESI) promotes energy efficient technologies and practices among consumers and service providers, through use of energy audits. These practices will contribute to lowering the cost of energy, allowing more Ugandans to afford a grid connection, and potentially increasing electricity demand. E-mobility enterprises can also play an important role in increasing Uganda’s electricity demand as the business model involves charging the batteries.

- At the city level, KCCA is interested in improving air quality and becoming climate smart. The city is therefore embracing e-mobility, most especially e-buses and e-motorbikes, and KCCA is willing to partner with Umeme and others to invest e-mobility infrastructure.

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5. **Looking Ahead**

Urbanization, coupled with increased consumption of natural resources and increased levels of GHG emissions, has led to a global urgency to mitigate climate change impacts. In this context, the potential contribution of e-mobility in combating climate change is significant. As the cost of renewable energy generation, storage, and energy efficient technologies falls, it becomes increasingly viable to transport people and goods using e-mobility, powered by renewable sources.

E-mobility can serve as a catalyst for transformative development in Uganda, but the sector is still nascent, and the level of adoption required for transformation and large-scale impact has yet to materialize. For mass adoption to happen, a multitude of measures and a concerted effort are required. This involves, among others, development of policies and environment that support e-mobility innovation, open and collaborative partnerships between public-, private- and research-sectors, and availability of appropriate technical and financial support for EV industry development (see Figure 31). These important steps are further elaborated below.

**Figure 31: Key steps in growing Uganda’s e-mobility system**

![Diagram showing key steps in growing Uganda’s e-mobility system]

**Enabling policies and regulations**

Regulatory frameworks can incentivize e-mobility research, product development and purchase. They can come in the form of incentive programs for companies and end-users, grants, or loosening policies to allow for innovation and exchange of ideas across the industry. Additional effort should be made to encourage stakeholder input, especially from the private sector, on e-mobility policy priorities and government-led e-mobility programs.

A sustainable e-mobility system should also have regulations supporting second life battery usage, and universal charging infrastructure standards in order to improve access to EVs and mitigate the negative impacts of e-waste. Policies that support training schemes for local assembly and maintenance of electric engines are also of paramount.
The connections between transportation, energy and land use planning are inextricably linked. Access to public charging stations along urban corridors must be coordinated with available public land, road easements and existing utility layouts.

Widespread access to EVs will not be achieved without expansion and improvements to the electricity distribution network in Uganda. The reliability of the grid and affordability of electricity access will be critical in facilitating a transition from combustion engine vehicles to electric vehicles.

**Funding support and capacity building**

Alongside long-term investments by government and donors in the supporting infrastructure to facilitate sector growth, short- and medium-term financial investments are the next important steps in building an e-mobility ecosystem in Uganda. This process is already well underway, and quickly evolving in the country.

More funding needs to be allocated to testing and piloting of EV programs, as well as other e-mobility applications (e.g. using e-bikes as part of mini-grid energy storage). De-risking for commercial viability of e-mobility enterprises and original equipment manufacturers (OEMs) can be achieved through the provision of risk mitigation and growth capitals at all phases of enterprise development (from ideation to scaling). Impact-based (i.e. social and environmental) monetarization and blended finance are also viable options. For instance, OEMs can use these funding mechanisms to enable early-stage e-mobility products. Similarly, transport startups can use them for reaching out to end-users (e.g. asset financing model practiced by Tugende).

Additionally, financing early-stage accelerator and incubator programs for e-mobility related enterprises as well as other ecosystem supports is critical—since they provide a venue for capacity building, mentorship, peer-learning and networking opportunities for the enterprises.

**Collaboration between actors to share learnings and research**

Formal and informal collaboration among different stakeholders—including regulators, policymakers, university and research centers, NGOs and early private sector investors—is essential for the sustainable EV ecosystem development in Uganda. An approach would be to establish platforms, forums, and coalitions to enable not only knowledge sharing but also to identify actionable initiatives to move forward Uganda’s emerging EV sector.

One direction Uganda can take is the exploration of partnerships with large OEMs such as Bajaj and TVS for the city’s e-motorcycle market. Another possible cross-sector collaboration in research and development is smart grid testing through public-private partnerships. Working together with international communities and universities can also provide opportunities for Uganda to learn from global EV deployment experiences—both successes and setbacks—and can then better tailor for relevant local contexts.

In terms of research agenda, an immediate ensuing step for the country is to identify of the unique regulatory, institutional and financial challenges for implementing e-mobility in Uganda, and to create a roadmap for implementation. This can entail study of environmental and economic impacts of transition to electric mobility, especially with respect to distribution grid improvements and charging infrastructure provision in Kampala and other strategic locations. Comprehensive analysis of funding gaps and needs for electrifying mobility in the region, especially in terms of infrastructure and fleet size will be necessary. This will be accompanied by feasible financing mechanisms over a designated duration. Finally, the role of end-of-life use of batteries for sustainability purposes and potentially unlocking addition capital should be researched and implemented.

Lastly, the role of government is essential in leading the way towards sustainable mobility, and creating an enabling environment for research, private sector growth and planning. Creation of policies which incentivize electrification of transportation in Uganda is one key step that the Government of Uganda can take, in addition to continuing to partner with private sector and research agencies to promote e-mobility among urban residents.
Conclusion

The purpose of this research is to encourage stakeholders across Uganda to leapfrog over the traditional path of transportation and design a future of sustainable mobility for residents. Given the country’s growing reputation as a hub for entrepreneurship and innovation, the country has the potential to solve its complex transportation challenges through clean and multi-modal mobility solutions, while providing jobs and growing local economies.

Such potential has been illustrated in the capital city of Kampala through initiatives such as the Kiira Motors Kayoola Solar Bus and applied research projects of testing electrification of privately-owned minibus taxis. The next steps of the transition will require a more concerted and risk tolerant effort to partner across private, public and research sectors in advancing the industry.

A key to unlocking this opportunity lies in equal investment of e-vehicles along with enabling EV infrastructure (charging stations, supportive transmission, and distribution networks). In Uganda (and throughout East Africa), a lack of infrastructure investment has created a barrier for deployment of four-wheelers and subsequently, e-buses, which can carry more passengers. It instead led to an unbalanced development of two- and three-wheeler vehicles given their ability to navigate through traffic and low cost. Their popularity, coupled with a lower total cost of ownership for boda-boda drivers enabled by e-motorcycle companies’ innovative business models and their partnerships with asset financing companies, has led to commercial models to electrification supported by relative investment interests compared to four-wheelers. Although e-bodas can increase access for the citizens and are especially well-suited for shorter first- and last-mile trips, passenger and pedestrian safety must be ensured with these modes.

While electrification of transportation is an important goal, there are other issues that must be addressed to achieve sustainable mobility in Uganda, including vehicle emissions standards, planning for attractive and vibrant mixed use communities, safe and affordable access to transportation for all residents, and provision of non-motorized transportation alternatives.

There is an opportunity for leaders in Uganda and across Africa to shape public policies, technology growth, and private sector investments to safeguard the next generation of sustainable transportation.

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