Prepared by: Kumbuso Joshua Nyoni (17th May 2022)

Title: Electric Mobility Needs in Sub-Saharan Africa

Context / Gap Analysis / Problem Statement

Zambian Context: Spurred by the economic boom at the turn of the millennium and the availability of affordable, though inefficient, second-hand vehicles from the developed world, the last decade saw a rapid increase in Zambia's motor vehicle (MV) population. As of 31 December 2020, the cumulative number of registered MVs in Zambia was 853,909 compared to 381,984 in 2011 [1]. Almost the entire fleet of MVs is internal combustion engine (ICE)-based, making transport the leading source of greenhouse gas (GHG) emissions, in addition to the toll it exerts on the aged road infrastructure.

African (&/or Global) Context: Facing climate change and associated issues such as humanitarian crises and growing socio-economic disparities, the global agendas uniformly recognize the urgent need to transition to sustainability. Development of low-carbon transportation in urban centers is positioned as a key element of this process, since the transportation sector is estimated by the Intergovernmental Panel on Climate Change (IPCC) to generate 23% of global energy-related greenhouse gas emissions. Consequently, promotion of public transportation and electric mobility is identified as a crucial point in the combat against climate change [13].

Governments' responses to climate change impacts are driving car manufacturers to accelerate the transition towards purely electric cars. When do you believe the economics of transport will tilt towards the mass deployment of electric cars in Zambia and the rest of Sub – Saharan Africa (SSA)?

Electric vehicles still remain as a pipeline dream for Zambia (& most of Sub-Saharan Africa) in the next decade. While this might be relevant post 2030, the region's focus must be more aligned to real problems facing society today such as low access to clean water and energy. With perceived cost reductions post 2030, mass deployment in Sub - Saharan Africa will be in the next 2 to 3 decades (*the next 10 years will mostly go towards attaining SDG7*). However, it is imperative to start planning today on how the EV diffusion will evolve and the nature of infrastructure development. To appreciate the dynamics in this niche industry, the questions below can help Zambia/Sub-Saharan Africa focus its attention in a timely manner by aligning the economy, market and technology trends owing to perceived cost reduction and economies of scale.

What's driving the EV market? Batteries keep getting better every year. This is not by default but by serious labor and financial investments. Battery average density keeps on rising at 4%-5% annually while charging speeds are also on the rise. For example, the Tesla supercharger 3 network can add about 120km of charge in just five minutes of charge for the Model 33. Apart from technology, policy makers are also lobbying for significant reduction of emissions in the automotive market. Another major concern for them are city policies, fuel economy regulations and quota systems. Several countries have put in place mechanisms to encourage adoption of electric vehicles through policy makers. Subsidies, for example, have encouraged purchase of battery electric vehicles. In 2016, countries like Norway, Korea, China, United States, France, UK and Japan offered national subsidies of USD 20,000, 16,550, 10,000, 8,750, 7,100, 6,200, and 5,500 for battery electric vehicles per vehicle respectively. With this effort, about 13 countries have announced their plans to eliminate the sale of internal combustion vehicles (ICV). This has led to rising policy pressure on manufacturers. This is enough to educate manufacturers on the future of ICV'S. Another contributor is the falling lithium-ion battery prices. From 2010 – 2019, lithium-ion battery packs prices dropped 87%. This has been attributed to discoveries of new manufacturing techniques, chemistries and introduction of simplified pack designs [6].

Are there Electric Vehicles in developing nations? The Kenyan government has set a goal of having 5% of all registered vehicles being EVs by 2025. Installation of charging stations in new government buildings is underway to achieve this vision. Kenya has severally experienced fuel challenges - for example, the increase of public transport costs by Ksh.15. This was as a result of increased fuel costs resulting from increased VAT. Private transport companies such as Eco-rent have, however, invested in EV's in Kenya. The company launched a digital application similar to Uber called NopeaRide. The organization uses only EV's and has also set up charging points for their vehicles. In South Africa, out of more than ten million cars, a thousand are EV's. Hyundai-Kona, a Nigerian-assembled EV has also put Africa on the EV map [6].

Are EV prospects promising for Sub-Saharan Africa? Technology advancements are exponential and endogenous. It is on this basis that the EV markets future is promising even in the Zambian context. The overwhelming support and interest from governments and other relevant institutions have also seen EVs market grow. Technological advancements will render the initial costs for EVs to be cheaper and as a result more affordable. Therefore, we could embark on planning for an EV future now by firstly endorsing hybrid vehicles through incentives with potential of retrofitting the existing country fleet (both private and public).

Leveraging potential: Increase in prices of gas and other fuel related commodities aligned to ICE mobility pose as one of the drivers to adopt e-mobility in Sub-Saharan Africa with majority of countries relying on imports to sustain their transport sector.

Notwithstanding the environmental benefits such as reduction in GHG emissions and cleaner air in urban cities such as Lusaka [2], electrification of minibuses and passenger cars offers an opportunity to standardize and improve the quality and safety of the public transport system, at the same time phasing out aged inefficient ICE vehicles. In addition, it would create new business opportunities in the EV value chain such as sales of batteries and operation of charging stations. Finally at country level, electric mobility would reduce the fiscal burden imposed by the importation of fuel.

Impact on existing grids: Electric mobility will alter the demand curve characteristics in both shape and magnitude. A typical change to the daily load characteristic would be an increase in night-time demand due to EV battery charging. A report by Rocky Mountain Institute shows that a 30-kWh EV battery stores as much electricity as the average U.S. residence consumes in a single day [3]. Vehicle to grid (V2G) technologies could provide ancillary services to the grid. Utilities will need to revise their grid codes and operate as flexible orchestration platforms bringing together network resources and ecosystem partners to balance the grid through decentralized, flexible units such as EVs.

New generation capacity will be required for the EV fleet, along with reinforcement of the distribution network to integrate charging infrastructure. However, this demand is slightly tapered by the overall well to wheel (WTW) efficiency of EVs which can be as high as 70% when supplied by renewable sources compared to petrol powered ICEs which range from 11-27% [4]. This entails that on average an EV passenger car needs as little as 25kWh against 80kWh for ICEs to travel 100km, even after accounting for the energy lost during charging and battery discharge [5]. Electrifying 10000 passenger cars each with a 30kWh battery, would add 300MWh energy demand to the grid.

Objectives & Research Contributions

The specific aims of this study are: (1) to document and categorize the potential of e-mobility in Sub-Saharan Africa (SSA); (2) to develop a selection process based on the documented capabilities in respective SSA regions; (3) to develop a systematic assessment process that can be applied anywhere in the region or globe. This will be achieved through:

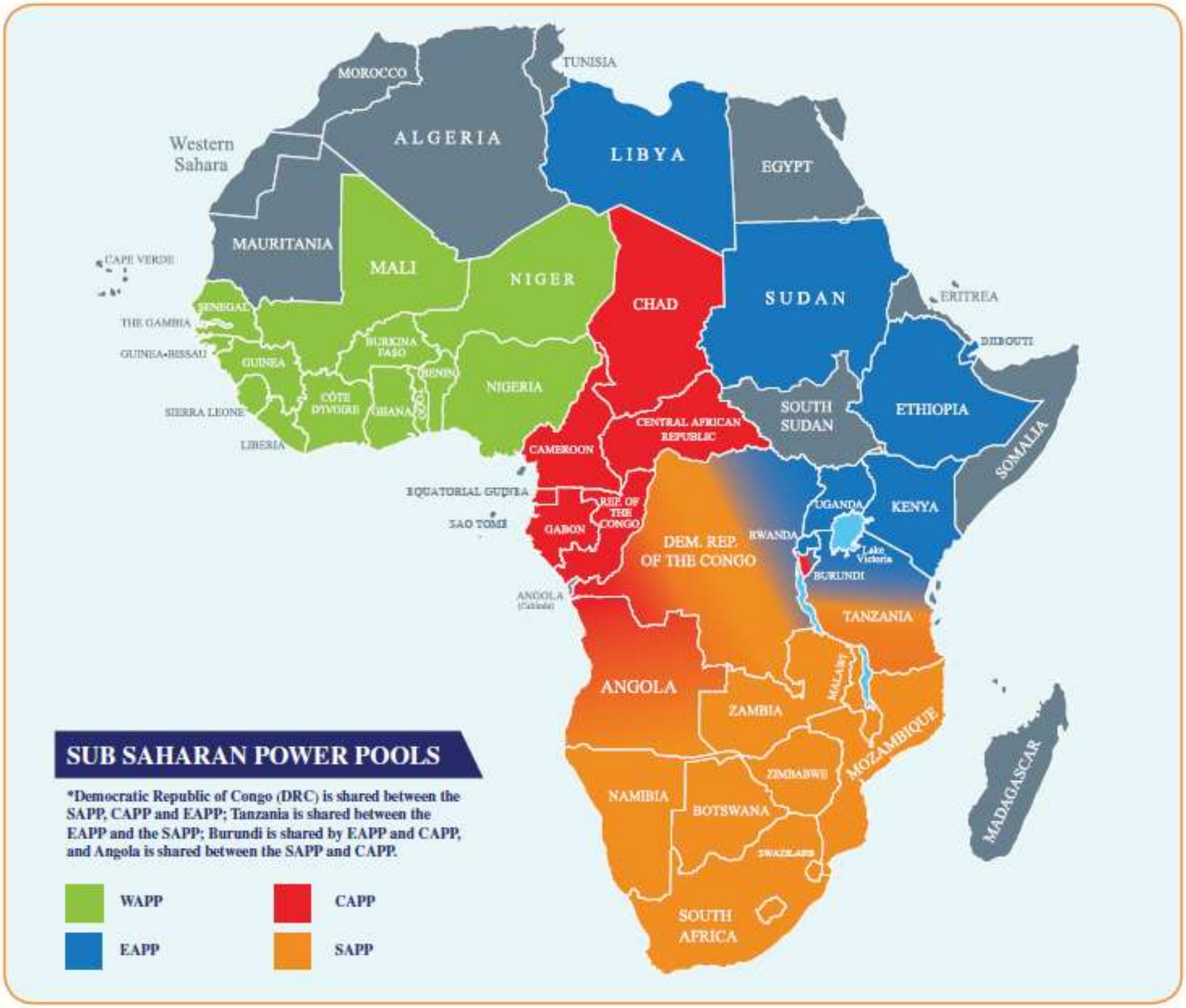
i. Review the existing policy/incentives on e-mobility and make policy recommendations for fast deployment in SSA.
ii. Review market potential of e-mobility in SSA (*linked with proposed policy recommendations and compare with do-nothing scenario on policy*).

iii. Key performance indicators for research considerations (*(i) economic benefit to public electric vehicle (PEV) owners/drivers, (ii) economic benefit to infrastructure owners/operators, and (iii) emissions and health effects of increasing growth of PEVs compared to internal combustion engine vehicles. These metrics could capture the expected benefits of investing in public charger infrastructure by geographic areas in SSA*)

iv. Development of a ranking and scoring methodology of SSA regions (&/or power pools, countries) using multi-criteria decision-making and the application of the same (*output shown in GIS map*). We could utilize the weighted sum method for ranking and scoring.

v. Development of a Q^2 methodology for e-mobility assessment. Q squared methodology entails using data from a variety of sources and qualitative and quantitative methods, it is possible to cover a wide range of issues and topics on e-mobility relatively efficiently.

vi. Application of the systematic assessment methodology on an actual SSA power pool, region or country. Propose a phased implementation approach at chosen case study (*i.e. starting with public transport, private etc.).* Assess the impact of e-mobility on a power pool/region/country case study in SSA (*refer to map below, case study to be chosen based on power pool with the most readily available data*).



Source: Africa Energy Portal [7]

vii. Discussion of the findings.

viii. Challenges, Recommendations and Next Steps

<u>Prospectus Research Tools</u>

a. QGIS/ARCGIS. Developing beautiful research maps
b. Osemosys & clickSAND. OSeMOSYS is an open source modelling system for long-run integrated assessment and energy planning. It has been employed to develop energy systems models from the scale of the globe, continents, countries, regions and villages. It can focuses on detailed power representations, or multi-resource (material, financial, all energy) systems.
c. FlexTool. The FlexTool is capable, on the one hand, of analyzing system operations using a time step that represents real-world challenges (an hour or less in the case of variable renewable energy, VRE) and, on the other hand, of carrying out least-cost optimization of the generation mix, as well as flexibility solutions with regard to grids, storage, the

demand side and sector coupling. The FlexTool, however, does not study the very short term (second/sub-second time scale); although this also is relevant for power system flexibility, it calls for another type of assessment.

d. Google Earth Pro.
e. The IEA Mobility Model [8]
f. E-Mobility toolbox [9]
g. NREL Transportation and Mobility Research [10]
h. ALTAIR e-mobility [11]

Lessons to be learned

Problems identified in California for the Installation of Public Charging Stations for Plug-in Electric Vehicles: Today, public electric vehicle (PEV) charging infrastructure is generally installed where there are significant numbers of consumers who have already purchased PEVs. This approach may initially seem logical, but it risks exacerbating environmental, transportation, and economic inequities as most current PEV owners are high-income, highly educated, and have off-street parking that can accommodate private charging equipment. The problem of charger access is magnified in areas with a higher number of multi-unit dwellings. Access to chargers is also worse in low-income and majority Black and Hispanic neighborhoods compared to high-income and majority White locations. If public charging infrastructure is consistently built based on past and present PEV ownership trends, and infrastructure availability is a major factor in choosing to purchase a PEV, then this creates a cycle that systematically excludes low-income communities of color. The current approach to identifying where to invest in public charging infrastructure fails to consider important factors like housing type, public transit availability, private charger availability, and commute patterns, which all play critical roles for achieving zero emissions mobility for all [12]. ***Lessons here could be embedded in the key parameters for ranking SSA regions/countries and in the market assessment***

Policy-level solutions and stakeholder constellations are established in the context of electric mobility (e-mobility) in Dares Salaam, Kigali, Kisumu and Nairobi: The study findings point out that in spite of the growing number of policies (specifically in Rwanda and Kenya) and on-the-ground developments, a set of financial and technical barriers persists. These include high upfront investment costs in vehicles and infrastructure, as well as perceived lack of competitiveness with fossil fuel vehicles that constrain the uptake of e-mobility initiatives. The study further indicates that transport operators and their representative associations are less recognized as major players in the transition, far behind new e-mobility players (start-ups) and public authorities [13].

References

1. The Road Transport Safety Agency. Annual Report 2020. [online]. Available at: https://www.rtsa.org.zm/wp-content/uploads/2021/09/2020-RTSA-Annual-Report-v5-FINAL-EDITED.pdf [Accessed on 17 May 2022]
2. Zambia Institute for Policy Analysis & Policy Research (ZIPAR). 2014. Working Paper no. 21. Used Motor Vehicle Imports and the Impact on Transportation in Zambia. [online]. Available at : https://www.zipar.org.zm/download/used-motor-vehicle-imports-and-the-impact-on-transportation-in-zambia/ [Accessed on 17 May 2022]
3. Chris Nelder, James Newcomb, and Garrett Fitzgerald, Electric Vehicles as Distributed Energy Resources (Rocky Mountain Institute, 2016), http://www.rmi.org/pdf_evs_as_DERs.
4. Julio A. Sanguesa, Vicente Torres-Sanz, Piedad Garrido, Francisco J. Martinez and Johann M. Marquez-Barja. A Review on Electric Vehicles: Technologies and Challenges. Smart Cities. 2021. 4. 372-404. [online]. Available at: https://doi.org/10.3390/smartcities4010022 [Accessed on 17 May 2022]
5. Fereidon Sioshansi. 2018. Impact of electric vehicles on electricity demand. Energypost. [online]. Available at: https://energypost.eu/the-impact-of-electric-vehicles-on-electricity-demand/ [Accessed on 17 May 2022]
6. https://www.renewablesinafrica.com/electric-vehicles-what-is-the-future/
7. https://africa-energy-portal.org/blogs/power-pools-enabling-ssas-transmission-corridors#:~:text=Sub%2DSaharan%20Africa's%20power%20pools,countries%20to%20offset%20peak%20demands.
8. https://www.iea.org/areas-of-work/programmes-and-partnerships/the-iea-mobility-model .
9. https://emobility.tools/
10. https://www.nrel.gov/transportation/data-tools.html
11. https://resources.altair.com/resfile_web_path/file-en/SIM_eGuide_Accelerating-eMobility_040821.pdf.
12. https://www.ucits.org/research-project/2022-29/
13. https://www.mdpi.com/2071-1050/13/4/1703