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THE POTENTIAL FOR MINIBUS ELECTRIFICATION IN THREE AFRICAN CITIES: CAIRO, NAIROBI, AND CAPE TOWN.

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EXECUTIVE SUMMARY

This study evaluates the potential for minibus electrification in African cities as a means of promoting cleaner public transport, improving air quality, and addressing the climate crisis in an equitable way. Minibus systems are the main form of motorized transport for most residents and are likely to continue dominating public transport service provision in Africa, in the short and medium term. Since most minibuses run on diesel and are often poorly maintained, African cities risk being locked into public transport systems that exacerbate air pollution, increase the public health burden because of respiratory illnesses, and contribute to the climate crisis through vehicular emissions.

Drawing on twenty-one interviews with key actors working on EVs and bringing in a comparative perspective, this study analyzes the overall policy environment for minibus electrification in Cairo, Nairobi, and Cape Town. The findings reveal that although vehicle electrification is actively under discussion with growing government pilots and private actor activity, **more focus is needed on the public transport modes used by most people rather than private motorization.** We also found that, despite their ubiquity, minibuses are relatively neglected as a focus of potential electrification. The viability of minibus electrification must be **supported by stable energy supply, with increasing renewable energy share** if minibus electrification is to **contribute towards climate mitigation. New and more sources of finance** are needed to cover up front investment in charging infrastructure and new vehicles. Tax relief **is insufficient to make e-buses price competitive.** Minibus operations are often complex and there is a need for more **deliberate support for formalization to enable access to EV technologies along with cross-sectoral collaboration** to design the most appropriate solutions that address African cities' unique realities.

Recommendations:

African governments should **review counterproductive policies** on low density suburban developments, secondhand vehicle imports, low quality fuel standards and persisting use of highly polluting energy sources when renewables are available and cost effective in the long-term.

African governments should **stabilize and clean the energy supply as well as encourage innovative off-grid charging** solutions such as solar rooftop charging stations, to complement grid supply.

African governments should **develop EV targets, standards and enabling policies to govern the E-bus value chain including minibuses** to secure safety, sustainability and maximize socio-economic benefits of vehicle electrification.

Minibus stakeholders across the value chain need to be part of processes of **co-design in E-bus solutions. More pilots should be encouraged** for learning and awareness. Electrification requires cross-sectoral collaboration, overcoming vested interests and unlocking investments and value, across the entire value chain.

Innovative finance and investment must be encouraged to overcome the up- front costs of the electric vehicle transition and to encourage inclusive and equitable share of benefits of electrification. Tax Incentives are unlikely to suffice.

1.0: AN OVERVIEW OF MINIBUS SYSTEMS AND VEHICLE ELECTRIFICATION IN AFRICA

1.1 INTRODUCTION

Emissions from transport are a strong contributor to urban ambient air pollution and global climate crisis. Fortunately, cities have several available tools and approaches that can help reduce transport emissions. They can work to reduce trips with mixed land-use, compact growth, and infrastructures for remote work. Modal shift away from personal cars and towards public transport and non-motorized modes is also widely recognized as critical. Finally, providing incentives and infrastructure to reduce emissions through electrification of remaining motorized modes is key. Working towards all these strategies at once and in a complementary way is a challenge, even more so for cities that are facing high urbanization rates as in the case of most parts of Africa.

This report examines the potential for electrification of the dominant transport mode in most African cities- the minibus.

We ask:

Under what conditions can electric vehicles be leveraged to improve health and reduce emissions in the minibus sector?

What are the challenges and opportunities to electrification of minibus systems in African cities?

Currently, focus is on cleaner fuels, better vehicles, or replacement of minibus systems by bigger, cleaner buses or mass transit like Bus Rapid Transit. All of these are valuable avenues to explore. However, given the likelihood that minibus systems will continue to dominate African public transport soon, this project explores the potential for minibus electrification as an additional viable policy option.

The viability of minibus electrification depends on several factors and hence is likely to vary from place to place. To explore this variation across context, we turn to three very different African cities: Cairo, Cape Town, and Nairobi. We explore and compare their emerging transport electrification landscapes including environmental, energy and transport policies, regulations, standards, incentives, and targets. Finally, we conduct a Strength, Weakness, Opportunities and Threat (SWOT) analysis for each case study. From this analysis, we extract some overall insights and recommendations for further work.

1.2 BACKGROUND TO THE PROBLEM

While a growing number of studies are starting to look at the bottom up and top down movement towards EVs in African cities, the focus is often on personal cars, motorcycles and formal bus systems (Galuszka et al 2021). Much less attention is given to minibus systems, sometimes called paratransit or informal or popular transit, that are used by the large majority of residents and critical to public transport in most African cities.

In most African cities, the majority of people use minibus systems as their main mode of motorized transit, and these minibuses represent about 30% of the vehicles on the streets. Minibuses are essential for mobility and generating access in the city (Campbell et al. 2019, Peralta-Quiros 2019) and are the core of public transit systems. These systems are not without flaws but a strong case can be made for their upgrading in order to respond to equity, public health, and climate imperatives (Jennings and Behrens, 2017, Hegazy et al. 2019, Klopp and Cavoli 2019, Schalekamp & Behrens 2013, Schalekamp and Klopp 2018)

Improving minibus service can help retain transit users in the system and de-incentivize purchase of old and polluting private cars. Many minibuses are often second-hand and poorly maintained, rely on dirty fuels and contribute to a growing and serious air pollution problem in African cities. This problem disproportionately impacts workers in the minibus sector, the walking poor and transit passengers, and hence constitutes major, yet under-addressed, social and environmental justice problems (Ngo et al. 2015). Overall, petroleum and diesel reliance and related emissions from transportation impact African urban society in highly unequal ways.

Most approaches to addressing these equity, health and emissions problems involve either a narrow focus on cleaner fuels and emissions controls, or replacement of minibuses by bigger, cleaner buses or full BRT systems. However, even in the European context with strong environmental regulations, this strategy is not working adequately and high transportation emissions remain a problem (European Environmental Agency 2019). While progress no doubt is being made more incrementally through these fuel, emissions, and public transport improvement efforts it is important to explore whether a possibility exists to move more directly into electrification of vehicles while expanding clean renewable energy sources in Africa, with a particular focus on minibuses for equity, health and climate reasons.

Diverse public transport improvements are urgent. African cities appear to be following global trends by privileging personal car-centric development that induces more car use among those who can afford it. Motorization rates are increasing but still low compared to other world regions; yet transportation related air pollution in African cities is already a serious concern (Abera et al. 2021, Ngo et al. 2015) and crash rates per capita are among the highest of any region making death by vehicle a top killer of African youth (WHO, 2018, Kazeem 2019). A number of reasons explain this problematic pattern. While the majority of people walk and take shared mobility, road infrastructure is built around personal cars, neglecting proper NMT and public transit infrastructure (Klopp 2012). In addition, an unregulated, global vehicle recycling industry means that the vehicles on African streets including those used for bus services are on average very old, less safe and do not have the best technologies for ensuring reduced emissions (UNEP 2020). Improving these minibus services is critical to the overall goals of making cities liveable and healthy and retaining current transit users in the public transport system (Klopp & Cavoli, 2019; Kumar et al., 2021). Thus, it is important to ask whether EV technologies can assist in this goal of overall improvement of public transport in African cities or at least level the playing field with cars as we see EV adoption of personal vehicles accelerate on the continent.

1.3 THE AFRICAN EV OUTLOOK

While the number of electric vehicles (EVs) worldwide is still small (7.2 million in 2019) it is growing rapidly, and a raft of new initiatives around public transport prioritization and vehicle electrification are underway that are likely to lead to an expansion of EV use (IEA, 2020). In 2019, an estimated 425 000 e-buses were in operation globally, 99 percent of which were operating in China and South America with the major EV bus manufacturers being BYD, Yutong, Zhongtong, and Solaris Bus. The EV bus sector has achieved a compound annual growth of 100 percent since 2013, driven largely by exponential growth in China. The prices of EVs are decreasing due to decreased component costs due to technology developments and it is expected that EVs will reach price parity with diesel vehicles by 2030, at which point the battery will only account for eight percent of the vehicle price. This will make EV buses and minibuses increasingly popular as a way to decrease GHG emissions and address air pollution (GreenCape, 2020, Montmasson-Clair, Dane, and Moshikaro, 2020). Indeed, in African cities we see electric vehicles, primarily passenger cars, tuk tuks and motorcycles as well as formal buses already on the ground and being tested on a small-scale (Galuszka et al., 2021).

Currently, Africa accounts for very few of the world's new vehicle sales and use but is a major destination for old and used vehicles. In many African countries 80-90% of the vehicles are imported from the US, Japan and Europe, and many use dirty fuels including diesel with high sulphur (Roychowdhury 2018, Kinney et al. 2011, Safari and Labib 2008). As electrification picks up in these parts of the world with growing bans in Europe and the US on internal combustion engines (ICE), their older and end-of-life vehicles are likely to be exported to Africa; by staying in use, these vehicles will contribute to net greenhouse gas emissions as well as creating serious public health problems in African cities. In addition to importing used vehicles, many of these African countries also import petroleum to fuel their vehicles, leading to concerns around energy security, foreign exchange,

fuel quality (including sulfur content) and price fluctuation. Overall, as Europe, Japan and the United States improve their transport emissions, a growing concern exists that Africa will absorb both old vehicles and dirty fuels into their public transport systems, severely impacting those who work in and use these systems (BBC 2016, DW 2018).

1.4 METHODOLOGY

Given that much is in flux and in progress in the EV policy arena, we conducted a total of twenty-one interviews with key actors working on EVs and public transport across the three cities to get the status of the sector and reforms, concerns and as well as perceived opportunities. These interviews with policy makers and private sector actors in both EV companies and green finance as well as the transport sector help give a better sense of not just what is happening currently but what is being planned around electrification of public transport and the perceived challenges in all three cities. Next, we developed the three case studies focussed on existing transport electrification policies, programs and regulations including taxes and tariffs. We explore how far private sector efforts and investments have progressed across Cairo, Cape Town and Nairobi and how different policies, laws, regulations, costs, and politics are impacting the prospects of minibus electrification. We conclude with some recommendations for each city and extract some general insights for the way forward.

2.0: THE CASE STUDY CITIES: CAIRO, NAIROBI, AND CAPE TOWN

2.1 CAIRO, EGYPT

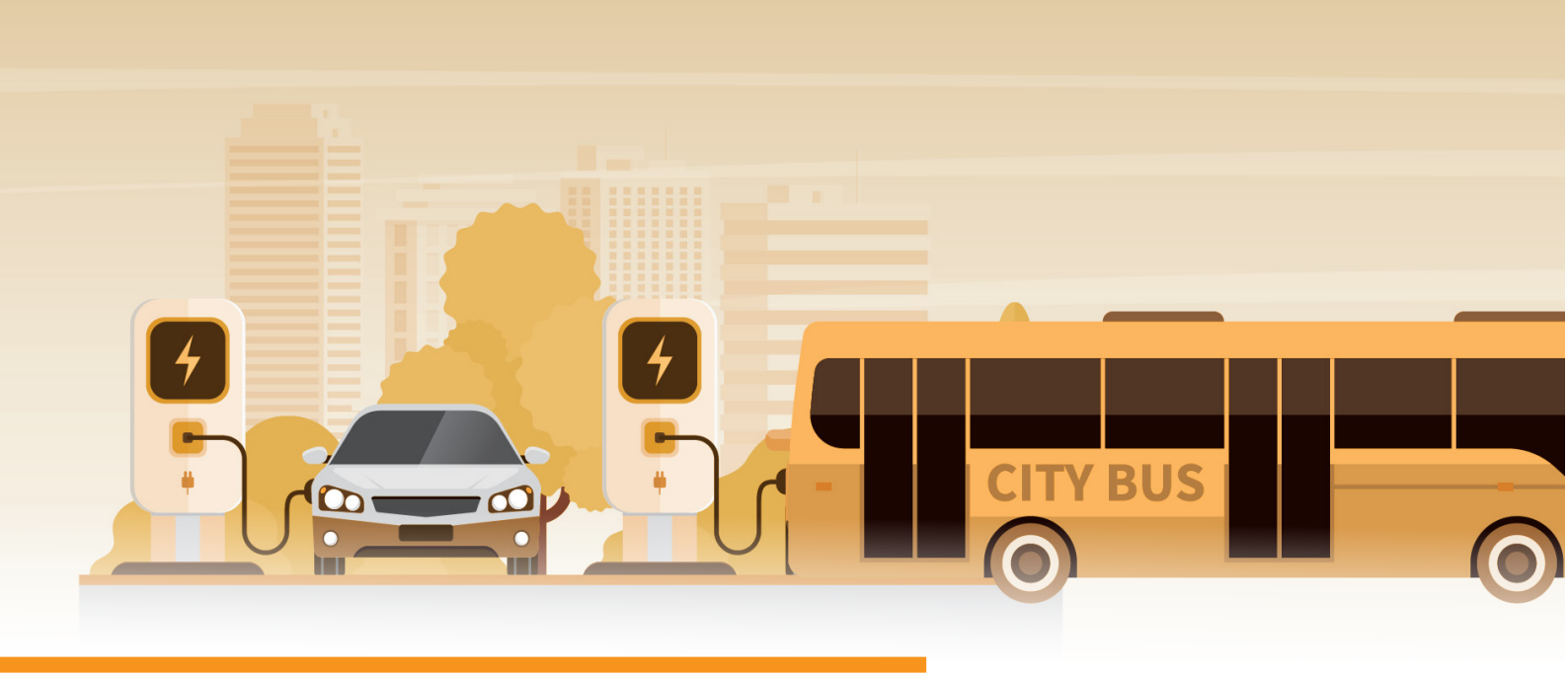
The Greater Cairo Region (GCR), which includes the Cairo, Giza and Qalubeya governorate, is the most populous urban agglomeration in Africa with more than 20 million inhabitants in 2018. Cairo has a rail-based transit system and public bus operators which provide services. The Cairo Transport Authority licenses private companies to operate on their behalf. These modes together constitute formal public transport service provision. New private market entrants provide shared ride-hail like paratransit services accessible through smartphones. Paratransit services are provided by a large sector comprising 7-seater vans, 14-seater microbuses, and 29-seater midi-vans. Total travel trips likely to be between 40 – 45 million daily trips, including Active Travel. (Transport for Cairo and Integrated Transport Planning 2021) Of these, around 63% of trips are made by mass transportation, with paratransit trips accounting for 63% of those trips while covering every neighborhood within the urban agglomeration (The Centre for Environment and Development for the Arab Region (CEDARE) 2018).

Paratransit services cover the entire urban agglomeration and are spread over hundreds of routes originating from an estimated 228 terminals. The average paratransit service is 10-15 km long, takes around 15-25 minutes and stops 5-15 times, while formal bus services operated or licensed by the Cairo Transport Authority (CTA) tend to average 20-30 km distance, last 50-65 minutes and stop 30-40 times. Paratransit services can be categorized as shorter, more direct, and much more frequent than formal services. (Transport for Cairo and Integrated Transport Planning, 2021)

The exact number of paratransit vehicles is impossible to calculate. Estimates for the number of paratransit in vehicles thus commonly assume 60'000-100'000 vehicles. According to CAPMAS, in 2019 there were 159'000 buses in Egypt, out of which 129'000 vehicles are private, touristic or travel buses. These categories include all different kinds of inter-city and intra-city paratransit services but exclude 7-seater vans registered as private cars. Estimates for the number of paratransit in vehicles thus commonly assume 60'000-100'000 vehicles. (CAPMAS, 2019)

Public transport is widely regarded as unattractive in Egypt, particularly compared to private cars. Private motorization grew by 90% between 2008 and 2018 at an annual growth rate of 7%, triple the annual population growth rate of the same period. Traffic congestion in GCR has severe impacts on the economy and quality of life and was estimated to cost 3.6 percent of Egypt's national GDP in 2014. (World Bank, 2014)

> **~63% of trips are made by mass transportation,** with paratransit trips accounting for 63% of those trips



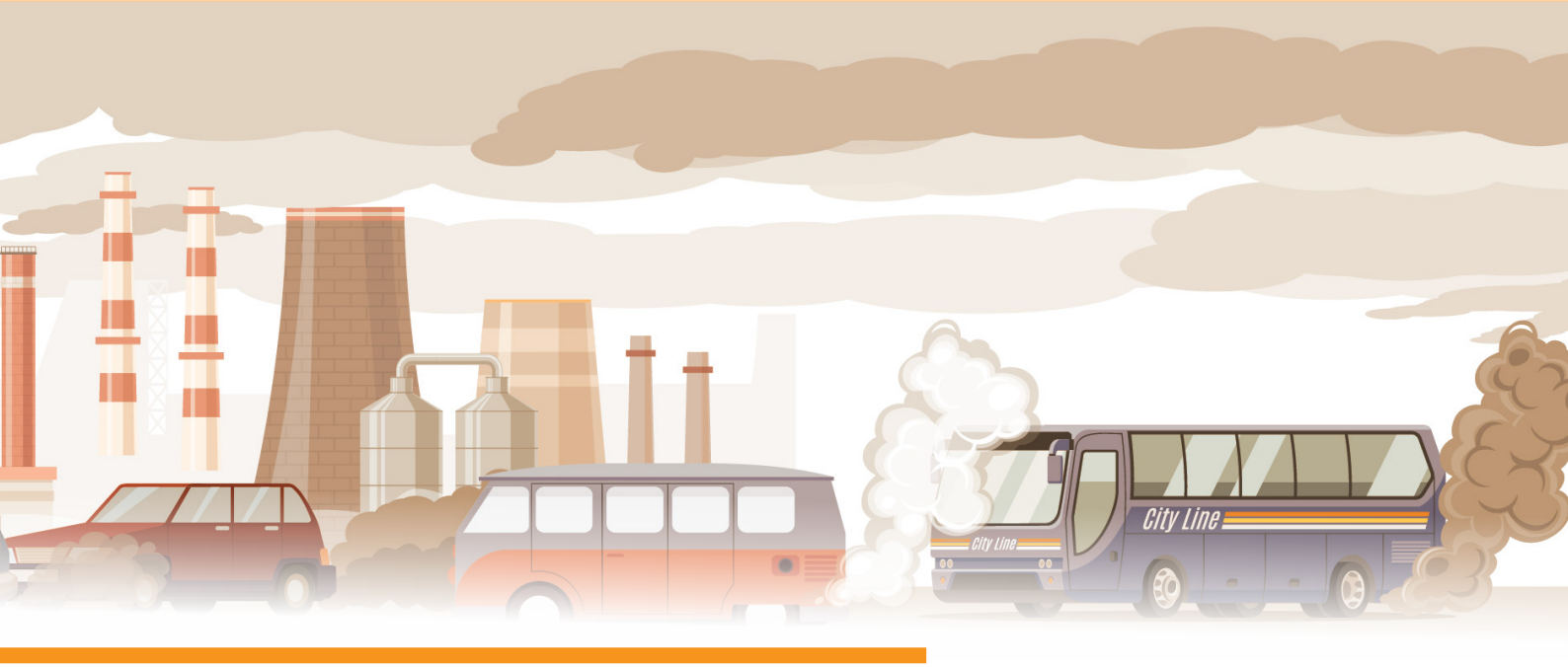
2.1.1 ELECTRIC VEHICLES AND INFRASTRUCTURE

As of 2021, there are an estimated 300 Electric Vehicles (EV) in Egypt, according to industry associations. In Cairo in 2019, the Cairo Transport Authority (CTA) launched a two-vehicle pilot with two Foton Battery Electric Buses (BEBs), while private bus operator Mwasalat Misr launched a single vehicle pilot with a Shanghai Wanxiang BEB. Two charging network operators Revolta and Infinity E started operations in Egypt. Revolta Egypt launched in 2018 with an investment of USD 3.4 million for construction of an EV-Charging Network (EV-CN) reaching up-to 87 stations with Level-2 50kW chargers sourced from OEM-supplier ABB in mid-2020. It also imported new and second-hand private electric vehicles. The company seems to have ceased operations during the onset of the COVID-19 pandemic and to have exited the Egyptian market since. Infinity E, an Egyptian company operating in the renewable energy and electricity distribution space, secured an investment from the EBRD, dedicating USD 20 million to launch a network of EV's, and had constructed and operated ~130 by 2020.12 10 EV-CN OEM's ABB, Schneider Electric and Siemens all have offices in Egypt. Schneider Electric was contracted to construct 60 charging stations in the New Administrative Capital (NAC).

The World Bank recently started to finance a USD 200 million for the "Greater Cairo Air Pollution Management and Climate Change Project", which includes an investment in 100 E-buses and their related activities to be operated by the Cairo Transport Authority (CTA). The World Bank is also financing a study on the appropriate strategy to scale up Electric Urban Bus adoption nationwide. This project includes a focus on efficient and clean mobile cooling solutions, indicating a concern with implementing EV technology in the hot and dry Egyptian environment.

Egypt produces cars and heavy commercial vehicles. Production peaked at 116,700 vehicles in 2010, dropped to 40,000 vehicles during 2013-2017 and has been increasing since, reaching around 69,000 vehicles in 2018. Total sales are volatile, but increasing to 168,000 cars, 26500 buses and 37000 trucks in 2020.

Public policy aims at tripling the share of locally manufactured components to 46% by 2030. Different public bodies are working in parallel to launch Egyptian manufacturing of EV's, including the Ministry of Public Business Sector (MoPBS) which aims to assemble tricycle and passenger car EVs in the state-owned El Nasr Automotive Manufacturing Company, or the Arab Organization for Industrialization (AOI, affiliated to Ministry of Military Production (MoMP) which aims to assemble electric buses. All manufacturing attempts are through partnerships with different Chinese EV-vendors.



2.1.2 AIR POLLUTION

Air quality is a serious issue, with the transport sector estimated to contribute around 26% of PM2.5 emissions in the GCR. (Heger, Wheeler, and Meisner 2019) Diesel is of very low quality, with the Sulfur content more than 100 times the international standards, exceeding 5000 ppm. (The Centre for Environment and Development for the Arab Region (CEDARE), 2019) GHG emissions from transport are rising the fastest and follow the electricity generation sector as the second-largest GHG emissions contributor nationally, with 15% of the total. (MoE and EEAA, 2018).

The air quality issues associated with low quality diesel are especially hazardous considering the high actual urbanisation rate of Egypt. Recent research using remote sensing revealed 93% of the population to reside within dense urban areas. (SWAC and OECD 2018) The paratransit industry, which dominates urban mobility service provision, directly emits dirty emissions within these urban areas. Moreover, it has been estimated that despite current investments in improving refinery quality and production expansion, diesel fuel quality will remain at 100 times (5000 ppm) the desired target quality of 50 ppm. (The Centre for Environment and Development for the Arab Region (CEDARE), 2019).

Some air quality actions focus on converting vehicles to run on compressed natural gas (CNG), which reduces NOx and PM by 90% and 77% respectively compared to Diesel, but only cuts CO2 emissions by 11%. (Pecqueur, et al. 2008). The GoE is pushing the conversion of private vehicles and public buses to CNG through "The National Program for Vehicle Retrofitting and Replacement". Early 2021 it announced a new 7.1bn EGP (~450m USD) financing package providing subsidies of 20-25% of the total cost of up to 65k EGP (~4k USD) per vehicle for private cars and microbuses.

The program, which is managed by the Ministry of Trade and Industry, originally planned to target retrofitting 250'000 vehicles by 2023. The Ministry of Petroleum and Mineral Resources recently announced plans to expand the scope further, targeting the replacement of an additional 200'000 vehicles. These targets include an estimated 15'000 microbus conversions. Such conversions started in the 1990's with 320, 000 vehicles already sporting dual-fuel engines.

A government-sponsored trade exhibition early January 2021 showcased private car, taxi, microbus, bus, and freight models. Microbus vehicle importers and local assemblers have intended to shift their strategies to include dual-fuel models. The program also includes a 1.2 billion EGP plan to retrofit 2000 Cairo Transport Authority (CTA) and 300 Alexandria Public Transport Authority (APTA) buses to operate on CNG instead of diesel. This corresponds to more than half the fleet in Cairo.

2.1.3 CLIMATE POLICY FRAMEWORKS

Currently, Egypt does not have strong climate legislation. The first assessment of current GHG emissions includes the Sustainable Transport Project (STP) and the expansion of the Cairo Metro as transport climate actions (MoE and EEAA, 2018). Both projects aim at the replacement of minibus systems by bigger, cleaner bus or rail and target a reduction of the equivalent of ~1.12 Mt CO2 every year. This corresponds to less than one years' growth of transport related GHG emissions. (Attari, et al. 2020) The transport sector emissions will accordingly continue to rise. The Egyptian Nationally Determined Contribution (INDC) (Arab Republic of Egypt, 2015) does not mention any quantifiable targets for the transport sector. High-level GHG mitigation measures for the passenger transport sectors include increasing the share of railways, bus, and shared microbus services for passengers.

> **Sustainable Transport Project (STP)** and the expansion of the **Cairo Metro** as transport climate actions aim at the replacement of **minibus systems by bigger, cleaner bus or rail and target a reduction of the equivalent of ~1.12 Mt CO2 every year.**

2.1.4 ENERGY SECTOR

The 2035 Integrated Sustainable Energy Strategy (ISES2035) targets the reduction of Transport sector primary energy use by 23% compared to the baseline year of 2010, the highest sectoral decrease. However, Egypt's National Plan for Energy Efficiency (2018 - 2020), which operationalizes the ISES2035 discusses neither E-mobility nor climate finance as a source of funding.

Generation capacity in Egypt is high and increasing. Historically dominated by the state, private producers are increasing and have invested billions of dollars into renewable energy projects such as the 1.44Gw solar-feed-in tariff Benban solar park and wind projects on the Gulf of Suez.

In parallel, several high-capacity and high-efficiency combined cycle Gas turbine power plants providing 14.4Gw were commissioned by the GoE and entered service. By 2020, this led to an overcapacity of productive capacity of around 83%. This large reserve margin lends itself to position Egypt to rely more heavily on renewables (which can be volatile) while maintaining capacity to be an exporter of surplus power.

Production relies heavily on fossil fuels, with 90% of productive capacity in 2020. Clean energy sources accounted for 10%, out of which 5.7% are renewables and 4.3% hydroelectricity (Slater, 2020). Egypt has a high potential for renewable energy generation. The GoE has set a target share of 35% of electricity to be produced from clean energy sources (30% renewables and 5% hydroelectricity) by 2030. The remaining 65% are to be 27% from fossil fuels, 29% from coal and 9% from nuclear power, diversifying the generation base (MoP, 2014). Notable is the addition of coal, which was used starting in the mid 2010's.

Transmission capacity has been lagging generation capacity and necessitated massive investments. Since 2015, such investments led to a reduction in blackouts and in energy losses due to the weaknesses in the network. Interconnections with North Africa (via Libya) and Asia (via Jordan and Saudi) and with Sudan are expected to allow for the export of surplus electricity. National level transmission capacity does not necessarily translate at the local level. The E-bus pilot in Alexandria for instance faced implementation challenges where the cost of upgrading the power supply grid was significantly higher than planned. (World Bank 2019).

Energy Experts agree that using Egypt's surplus of electricity in road transport electrification is the most viable and sustainable of all available options (Interview by Hegazy, A. and Mohgazi. A., July 28, 2020). Another suggests that despite the short-term economic benefits from expanding Egypt's electrical energy export activities, their fixed costs to install transmission lines are very high, especially in the Mediterranean, and the future of international demand is uncertain (Interview by Hegazy, A. and Hegazy. M., August 20, 2020). On the other hand, road transport electrification is a manageable and sustainable demand channel that has numerous benefits on Egypt's economy and the quality of life in Egypt's dense urban areas.

2.1.5 FINANCIAL SECTOR

At the macro-level, Egypt can access international sources of public and private capital. DFI investments in E-mobility are increasing, as shown with the World Bank Loan and EBRD investments. The Egyptian Financial Regulatory Authority developed Green Bond guidelines that are meant to allow projects to tap into international sources of green climate finance. (Financial Regulatory Authority of Egypt, 2014) These were used to finance the 6th of October Electric Monorail project as a clean transport project, the first such issuance of Green Bonds in the Arab World. At the micro-level, the National Program for Vehicle Retrofitting and Replacement relies heavily on local banks to provide financing and on the Ministry of Finance to provide subsidies covering part of the capital expenditure. However, the focus on the engine retrofit and replacement program and the support for expansion of the natural gas transport and refueling infrastructure locks capital into the CNG route, making the e-mobility conversion less attractive for the private sector.

The Cairo case reveals important movements towards reducing emissions through transport projects, including efforts towards electrification where some finance and support are available for conversions, especially of public buses. However, these efforts still fall short of what is needed to address the pressing problems of air pollution and climate change, and some policy actions, like low density suburban developments induce more emissions. Most of the efforts to reduce transport emissions, whether in the public or private sector, tend to focus on mass transit leaving out microbuses except for the subsidies for conversion to dual fuel use with CNG. Electrification efforts tend to involve large buses, with limited forays into private vehicles. Thus, the electrification of minibuses as another alternative to CNG conversion remains relatively unexplored. Nevertheless, with unprecedented investments in solar energy production and an electric grid with relatively low (and improving) GHG-emissions per kWh of electricity produced, an ecosystem is emerging that is potentially conducive for electrification of the existing public transport industry including microbuses. A stronger and more coherent transport decarbonisation strategy is needed, one that is inclusive of microbuses given their importance, including for lower density developments in the region.

2.2 NAIROBI, KENYA

Studies indicate that 70% of residents in Nairobi make use of public transport everyday which consists of commuter rail and minibuses called matatus. Matatus dominate the public transport sector with a modal share of 40% of all trips, while Non-Motorized Transport has a large modal share of 48% (Williams, et al., 2015). Matatus use diesel engines, and many are in poor condition exacerbating the air pollution problem which is serious (Waweru, 2020). High levels of PM2.5 in Nairobi, much of it linked to transport, point to the need to reduce emissions in the transport sector to safeguard air quality and address aspects of social equity in Nairobi.

2.2.1 ELECTRIC VEHICLES AND INFRASTRUCTURE

In 2020, Kenya had 190 EVs registered with motorcycles representing a majority at 118; the rest are shared among 28 station wagons, 22 three wheelers and 21 forklifts, followed by one registered wheel tractor (SDOT, 2020). According to the Association for Electric Mobility and Development in Africa (AEMDA), Kenya has 18 e-mobility companies indicating a fast-growing interest and market for EVs in the country. 88% of these businesses focus on two and three-wheelers, followed by four-wheelers and larger vehicles. The Report also says that companies are providing a range of services, with battery swapping and charging stations taking a lead (AEMDA, 2021).

Currently, there are no registered e-buses in Kenya, but this might soon change. OpiBus, has launched an e-bus pilot seeking to retrofit existing minibuses with electric drivetrains (OpiBus, 2021). This indicates growing interest and opportunity to invest in e-buses to support Kenya's mass transit, air pollution and climate plans, as an environmentally friendly alternative to current buses that run primarily on imported diesel. Investing in e-buses could in the long run realize several socio-economic benefits. The potential reduction in air pollution will provide public health benefits such as reducing the number of deaths because of outdoor air pollution and the attendant public health burden occasioned by poor air quality. As the e-mobility sector grows, creation of jobs across the value chain has the potential to improve livelihoods for numerous Kenyans by providing additional revenue streams.

There are 21 electric vehicle standards developed by the Kenya Bureau of Standards (KEBS,2020) that cover the safety, operation, and test procedures of three different classes of electric vehicles namely, road vehicles, motorcycles, and hybrid vehicles. A government report on EV standards recognizes the need to develop more standards on the safety, operation, performance and test procedures for motorcycles and hybrid electric vehicles. (Unpublished, 2020). Existing EV standards involve testing procedures that have been developed in Europe, US, and Japan. These testing procedures are applicable to electric vehicles that use European, American, or Japanese technology. Other

standards to be developed are those on standards on charging stations and procurement and disposal of batteries. It is worth noting that there is an ongoing process to simplify the language adopted in the standards, to allow for greater public participation (GIZ,TraCS, 2021).

A determinant for a successful e-bus system in Nairobi is the buy-in from key stakeholders. There is commendable effort led by the State Department of Transport (SDoT) supported by the Advancing Transport Climate Strategies (GIZ, TraCS, 2021) program to convene dialogues with government and non-government stakeholders to discuss the EV agenda in general, and how to create an enabling environment for their uptake. Several of our interviewees including those in government, mentioned that the presence of several agencies with interdependent, and in some instances overlapping functions on transport, can prove to be a challenge when coordinating activities related to EVs. It is worth noting that, key transport agencies view minibus electrification as a low priority because of the plans to phase out matatus particularly within the Central Business District. Even within SDoT, minibus electrification remains largely unexplored during the EV discussions.

Interviews conducted with key transport operators and transport workers union, reveal that the industry is yet to engage deeply with the subject of minibus electrification. Their responses indicate that e-buses are largely a welcome idea, particularly regarding addressing environmental and social concerns. Transport operators who spend almost 10 hours a day in congestion are some of the most vulnerable groups to respiratory health complications as a result of air pollution (Ngo, et al, 2015). To compound the situation, they often cannot afford proper health care to manage these conditions. E-buses have the potential to significantly reduce vehicular emissions.

Transport operators generally question the financial viability of deploying e-buses because of the high cost of purchasing the buses or paying for a retrofitted one (Interview by Klopp, J. and Odhiambo, E. July 28, 2020). Affordability of EVs in general was mentioned by all our interviewees across different sectors. Transport operators are also concerned as to whether deployment of e- buses will cause job loss within the sector. It is important for EV stakeholders to discuss the impact of e- bus deployment across the value chain. Mechanics and spare part vendors may be some of the biggest losers as their livelihoods capitalize on repair of ICEs. Fuel operators will also record significantly reduced revenues if there is large scale deployment of e-buses.

Lastly, a key concern reiterated in the interviews across sectors, including transport operators, is the viability of e-buses in the Nairobi context (Interview by Klopp, J. and Odhiambo, E., July 28, 2020). This is owing to the heavy-duty cycle that matatus currently undertake which can range from continuous usage of 8-12 hours daily. The questions posed are whether the batteries will have the range to run for these long hours, will the life of the batteries last given these long operating hours, coupled with heavy unpredictable traffic, and is there a potential revenue loss occasioned by the time taken charging the battery within the 8-12-hour cycle.

2.2.2 CLIMATE POLICY FRAMEWORKS

In Kenya, the Climate Change Act refers to the National Climate Change Action Plan (NCCAP) as the document mandated to prescribe measures for enhancing energy conservation, efficiency and use of renewable energy in transport. The NCCAP details sectoral climate action goals. It emphasizes the need to invest in sustainable public transit systems and mentions electrification of the Standard Gauge Railway as a decarbonization strategy. These goals have culminated in detailed action plans contained in the Transport Sector Annual Climate Change Reports which explicitly mention plans for an e-bus pilot of 150 hybrid buses. Additionally, Kenya's updated Nationally Determined Contributions Communication under the Paris Climate Agreement emphasizes investment in low-carbon efficient transportation systems, as a means of supporting climate mitigation actions (NCAAP, 2018).

> Kenya's updated Nationally Determined Contributions Communication under the Paris Climate Agreement emphasizes investment in **low-carbon efficient transportation systems,** as a means of supporting climate mitigation actions.

2.2.3 AIR POLLUTION

The Air quality regulations provide for annual emission inspection and reduction measures for public service vehicles by the National Transport and Safety Authority. Current statistics indicate that vehicle inspection is limited to only 260,000 annually, out of the present 2.5 million vehicles in the country and corruption remains a problem with some vehicles passing inspection regardless of actual emissions status. Some of the proposed recommendations include allocation of more resources for inspection manpower, modernization of inspection centres, and public awareness on vehicle inspection and maintenance. Nairobi's air quality routinely breaches limits set by the World Health Organisation (WHO); an annual average of 17 micrograms per cubic metre of the deadly PM2.5 has been measured, which is more than 70% the WHO recommended limit (Sensors Africa, 2019).

Data collected in 2020 confirms that PM2.5 levels in Nairobi are frequently at dangerous levels (Interviews conducted with Open Seneca by Odhiambo, 2020) and this is backed by growing scientific literature (De Souza 2020). If more data on the number of matatus that do not meet emission standards is collected and publicized, there may be a strong environmental and public health case for the shift to e-buses. E-buses running on clean electricity have the potential to promote better air quality in Nairobi especially because Kenya's source of energy is mostly renewable. At a sub-national level, Nairobi has initiatives focusing on monitoring air quality and has finalized an Air Quality Action Plan (2019-2023). The Plan seeks to create an evidence base for policy interventions and enforcement related to air quality management. Such initiatives provide impetus towards actions that seek to improve air quality.

> Current statistics indicate that vehicle inspection is limited to only **260,000 annually, out of the present 2.5 million vehicles** in the country

2.2.4 ENERGY SECTOR

Kenya is a global leader in renewables having recently ranked fifth as conducive for investments opportunities in clean energy (Business Daily, 2019). As per the Kenya National Energy Efficiency and Conservation Strategy (2020), the share of renewable energy to the grid was at a commendable 87%. This portfolio implies that investing in EVs will have a significant positive impact in reducing GHGs and improving air quality, since the source of electricity is almost 100% renewable. There is excess energy production, and Kenya Power, the utility company, has expressed intention to invest in EV charging infrastructure as a means of increasing its revenues from commercial electricity consumption (Business Daily, 2021). Power generator KenGen, has also expressed a similar interest in investing in EV charging infrastructure (KenGen, 2020).

Both electricity and diesel prices in Kenya are considered high, with the burden being pushed to consumers. Electricity costs, whether for household or commercial use, have often been under scrutiny for being too expensive and discouraging for businesses (Daily Nation, 2021). Kenya Power and KenGen could thus potentially increase revenues through electrification of public transport operations. Minibuses, Bus Rapid Transit lines and Light Rails, offer higher volumes of revenues compared to private vehicles. The uptake of EVs for private use will take much longer compared to an incentivized mass transit system, mainly because of affordability and preference which will be discussed in the next section on finance. Additionally, if the EV agenda from the onset is largely focused on private vehicles, it can exacerbate social and environmental injustice given that lower income residents tend to use public transport and walk and hence are more exposed to pollutants than those in cars, especially low emissions vehicles. Benefits still accrue more generally from cleaner cars but passengers and workers in public transport would not get the same benefits. Further, private EVs will only be accessible by a select few because of affordability.

In terms of policy, the Energy Act (2019) advocates for renewable energy investments in transport systems. Section 102 (3) of the Act mandates the Ministry of Energy to develop a national strategy to tap into these opportunities. In this regard, The Kenya National Energy Efficiency and Conservation Strategy (2020) mentions a target to increase the share of EVs by having them constitute 5% of all imported cars annually by 2025. It emphasizes that incentives such as lower import duty for EVs, lower vehicle road taxes, incorporating charging stations in public buildings and new estates, and public awareness on e-mobility will support the uptake of EVs.

2.2.5 FINANCE SECTOR

Affordability of EVs is the greatest concern shared by all interviewees across all sectors. The high costs of purchasing an e-bus, whether new, second-hand, or retrofitted, is still out of reach for transport operators without subsidies, incentives, and support from the government. The Finance Act (2019) halved the excise duty from 20% to 10% of EVs carrying more than 10 persons meaning that e-buses fall under this category. Investors have also been allowed to import electric golf vehicles and sightseeing buses with a motor capacity of 72V/6.2 kW that are designed to carry more than ten persons, as well as other vehicles of any capacity propelled by an electric motor.

However, these tax incentives are still far from making e-buses affordable (Interview by Odhiambo and Kipkoech, January 11, 2021). For example, according to Isuzu Buses and Microbuses (2021) the starting cost of a retrofitted e-bus is $45,000 translating to 4.5 million Kenya shillings which is more than double the cost of purchasing a new ICE bus. The high costs of EV are partly attributed to the taxation model used by KRA which does not cater to EVs. Ongoing stakeholder consultation by the State Department of Transport in Kenya (2020) recommends that KRA should develop an EV template based on the vehicle technology, power, range, weight, and carbon dioxide emissions. Taking into consideration that the matatu industry is run by private entrepreneurs, many at times struggling to break even, it makes little financial sense now to invest in an e-bus and efforts are needed to subsidize these costs (Interview by Kipkoech, D. and Odhiambo, E. January 11, 2020).

Apart from tax relief, there are other avenues that can mitigate the high upfront cost of EVs. Globally, there is increasing interest in channelling climate finance investment towards decarbonizing transport. The International Finance Corporation estimates that the investment potential for airports, seaports, railways, rapid light rail, roads, and overall transport efficiency by 2020 will be about $11 billion (IFC, 2020). The Climate Finance Unit at Treasury has signalled interest in the EV agenda and suggested zero rating taxes for all e-mobility projects and leveraging financing from the Green Climate Fund to support uptake of EVs (ASM, 2020).

Our interviews revealed that local e-mobility entrepreneurs are struggling to attract financing for their projects especially from banks. One stated that, "banks seem to have little understanding of climate finance in general, and how EVs are a means of meeting climate action targets" (Interview by Odhiambo, E. and Kipkoech, D. January 11, 2021). The Landscape of Climate Finance in Kenya Report (2021) indicates that there is a need to scale-up investment in transport. It highlights that, in 2016, despite the transport being responsible for 11% of the country's emissions, no climate finance has been tracked in the low-carbon transport sector through The Integrated Financial Management Information System in 2017/18, and no investments have been tracked in electric vehicles or the development or supporting infrastructures in 2018. These statistics indicate, more green finance is needed to support the EV agenda. Revenues from road tolls from cars running on fossil fuels is an example of innovative finance sources to support the uptake of EVs.

Encouraging local manufacture and assembly is also a viable strategy to boost uptake of EVs, while mitigating costs. It is also an opportunity to build local capacity and skills. while creating jobs in the sector. Encouragingly, the National Youth Service (2020) has unveiled locally assembled e- 3 wheelers and handcarts, and such initiatives should continue to be supported by local policies that create an enabling environment for manufacturing.

With electricity available from renewable energy, growing institutional frameworks and incentives for electrification as well as clear targets for EVs, the Nairobi case shows strong potential for minibus electrification to gain hold as a viable policy option for equitable transport decarbonisation. However, deep concerns about viability, affordability and possible job loss exist within the matatus sector. Finance to support the transition and public investment for charging infrastructure is imperative to enable a potential transition. Additionally, continuous investment in building local capacity to assemble and eventually manufacture EVs will allow for maximization of socio-economic benefits from the EV transition. Overall, despite the dominance of the matatu as a public transport mode, a great deal of EV attention tends to focus on personal vehicles and larger buses. A pilot involving a matatu cooperative and the start-up Opibus, is underway, and may offer early learnings for minibus electrification.

2.3 CAPE TOWN, SOUTH AFRICA

Minibus-taxi services dominate the public transport sector of the City of Cape Town municipal area. The 2013 Household Travel Survey, although outdated, found that 54,1 percent of Cape Town households used minibus-taxis as their preferred mode of travel (National Household Travel Survey, 2014). Since 2013, Cape Town has experienced a severe degradation of passenger rail resulting in an increase in minibus-taxi and conventional bus travel (Morilly and Behrens, 2021; Competition Commission, 2021). The City of Cape Town is characterised by low-density urban sprawl with most minibus-taxi users living between 10 to 20 kms from work opportunities.

The business model of most minibus-taxi services does not incentivize climate friendly operations and driving behaviour. The basis for drivers' remuneration is the number of passengers they carry in a day, leading to aggressive driving and speeding – the latter especially on the return segment of trips during peak demand periods to secure as many full loads of passengers as possible. Drivers also need to pay owners for the use of the vehicle and cover the entire fuel bill, which are daily target amounts that drivers need to cover before they make any money of their own. The daily target is a set amount, so drivers rather attempt to lower their spending on fuel.

Diesel minibuses are more economical on fuel with only a modest new price differential to petrol models (Motus Toyota, 2021). Also, the cheapest petroleum fuel in ready supply in the country is 500ppm diesel, which – unlike petrol – does not have a regulated retail price. Thus, fuel retailers can manipulate the price to attract high-consumption clients such as minibus drivers, or minibus associations or owners can purchase diesel in bulk at discounted prices for their own drivers' use. This dynamic, in turn, makes it beneficial for owners to opt for diesel vehicles, as it allows them to charge a higher daily rental target amount despite the purchase price premium – drivers know they can make more money with a diesel minibus. As a result, both the current minibus vehicle and petroleum fuel market structures nudge minibus-taxi drivers and owners to rely on diesel and diesel-powered vehicles.

> **54.1%** of Cape Town households used **minibus-taxis** as their preferred mode of travel

2.3.1 ELECTRIC VEHICLES AND INFRASTRUCTURE

The use of electric vehicles is growing in South Africa, concentrated in the private vehicle market and in small increments. In 2020, only 92 EV units were sold, bringing the total EV ownership to 1509 vehicles (Greencape, 2020). Though many of these companies have local manufacturing bases, all these EV models are imported fully built (Greencape, 2020).

The interest in electric mobility in South Africa first appeared in the 1970's; between then and the early 2000's saw the piloting of Volkswagen shuttle buses, a utility vehicle, and an electric game viewer vehicle (Greencape, 2020). The South African government has continued to express interest in EV's, with much of its investment focusing on lithium-ion battery research. There is little evidence of EV use in the public transport sector, with the standout example being the attempt to use electric buses in a BRT project in Cape Town. In 2016 the municipality initiated the, with the city administration initiating the procurement of ten a small fleet of electric busses for pilot use as part of the city's MyCiTi bus system (City of Cape Town, 2016). A fleet of 11 electric buses was acquired in the 2017/2018 financial year at a cost of ZAR128m (±USD8.5m), with operational testing being conducted at the time (Nombembe, 2018). Due to political upheavals in the municipality the EV bus pilot project stalled, and the buses have been standing unused since then (Herron, 2019).

From the point of view of EV uptake, whether in the paratransit sector or more broadly, the current source of electricity supply is also problematic. Cape Town sources most of its energy from the South African national grid, of which 95 percent is generated from coal. The balance is sourced from a combination of nuclear, which contributes close to five percent. A minimal contribution is sourced from a local wind farm, and additional electricity is sourced from a hydropower dam for load management. Solar PV energy supplies do exist within Cape Town; however, these are largely used for on-site consumption (City of Cape Town, 2015). The transport sector contributed 29 percent of carbon emission in Cape Town in 2017 (City of Cape Town, 2020), and 63 percent of carbon emissions was caused by electricity usage (City of Cape Town, 2017).

The possibility of EV minibus uptake in the public transport industry is dependent on several key factors: the purchase or financing cost of the vehicle, the comparative operational costs, and environmental benefits, of changing energy sources, and the return on bulk infrastructure investment to enable the transition energy and vehicle supply shifts, and policies and political motivations directing the actions of core stakeholder groups.

2.3.2 CLIMATE POLICY FRAMEWORKS

Government in South Africa has continued to express interest in electric mobility and there is a clear intention to use electric mobility to address climate change (Pillay et al, 2020; DTIC, 2021). Climate change related legislation, regulations, strategies, and policies exist at all three levels of government.

The 2018 Climate Change Bill seeks to have Sector Emissions Targets set every five years. A sector response plan must be developed, for which the Minister must report to the Presidency on implementation progress and Provincial MECs and Mayors are responsible for developing and implementing climate change response plans in support of the Sector Emissions Targets. (Draft Climate Change Bill, 2018)

The National Department of Transport (NDoOT) responded to the Climate Change Bill with the Green Transport Strategy for South Africa: (2018 – 2050) (GTS). The GTS sets out to achieve a five percent reduction in GHG emissions in the transport sector by 2050. To achieve this target, the strategy seeks to convert five percent of the public and national sector fleet to cleaner, alternative fuel sources, including the use of renewable energy for electric vehicles, by 2025; as well as investing in electric vehicle related infrastructure. The GTS also seeks to incentivise the manufacturing of EVs in South Africa for local and export markets. In terms of public transport vehicles, the GTS promotes transitioning to dual-fuel vehicles, rather than electric public transport vehicles. (Department of Transport, 2018)

Considering the GHG emission reduction target set by the NDoOT, the Western Cape Government published its cross-sectoral Climate Change Response Strategy and is in the process of compiling the transport sector response. In the provincial cross-sector response strategy, the WCG recognises the potential for climate change mitigation through switching to electric and hybrid-fuel vehicles. (Western Cape Government, 2014)

The City of Cape Town's Climate Change draft strategy was opened for public comment in August 2020. The draft strategy sets the goal for a complete transition to electric or alternative fuel powered taxi vehicles by 2050. However, the strategy notes that transitioning to electric vehicles will only be beneficial to climate change mitigation efforts if South Africa's energy supply shifts to cleaner and renewable sources. Electric vehicles are heavily subsidised in developed countries and therefore, the technology transition is expected to continue to scale, with the risk of leaving South Africa in its wake. The draft strategy seeks to mitigate this risk by harnessing opportunities to access the global green economy despite South Africa's current reliance on coal-generated energy. (City of Cape Town, 2020)

2.3.3 AIR POLLUTION

Car centered development in Cape Town, urban sprawl that creates significant travel distances and increased minibus-taxi use in the last five years have negatively impacted on air quality. Minibus-taxi operators largely use low-quality diesel and often do not undertake preventative vehicle maintenance, resulting in more polluting emissions. Diesel and petrol, combined, contributes approximately 30 percent of the carbon emissions in Cape Town (City of Cape Town, 2018)

> **Diesel and petrol,** combined, contributes approximately **30% of the carbon emissions** in Cape Town

2.3.4 ENERGY SECTOR

Aside from the complex balancing act between domestic automotive manufacturing and global technology trends, the energy sector in South Africa does not make transitioning to electric vehicles in the medium term an attractive prospect (Liu, Hildebrandt, and Glasser, 2012).

"As long as we are burning coal in SA to produce electricity there is no benefit to switching to EV's. In fact, we are much better off driving an advanced ICE with Euro-six fuel." (Interview by Manuel, M., February 15, 2021).

South Africa committed at the UNFCCC to reduce GHG emissions by 42 percent by 2025. However, coal is likely to be the dominant energy source for decades. It is estimated that South Africa has 66 billion tons of coal resources and reserves remaining, which can provide more than 200 years of energy supply at current production rates (Department of Energy, 2016). That said, South Africa boasts significant renewable solar and wind energy sources; which offers an opportunity to achieve net negative carbon emissions for electric vehicles, if EV's are charged using solar energy during working hours (Buresh et al, 2020; Department of Energy, 2016).

"If South Africa was to transition to EV's, it is possible for EV energy requirements not to place additional strain on electricity supply provided that charging coincides with off-peak demand." (Montmasson-Clair, personal interview, 2021 February 23).

Given the abundance of coal reserves in South Africa there is little incentive for the the national government to incentive mobilize for a shift away from coal, while without the shift to cleaner energy sources, there are no additional GHG emissions benefits from EVs in comparison to ICE vehicles (Liu, Hildebrandt, and Glasser, 2012).

2.3.5 FINANCE SECTOR:

The financial case for EV minibuses in Cape Town is not particularly compelling. Importing EV minibus-vehicles attracts significant tariffs and taxes, incentives to encourage automotive manufacturing favours fairly large-scale manufacturers, and the present stage of battery technology is not congruent with profitable minibus-taxi industry operations.

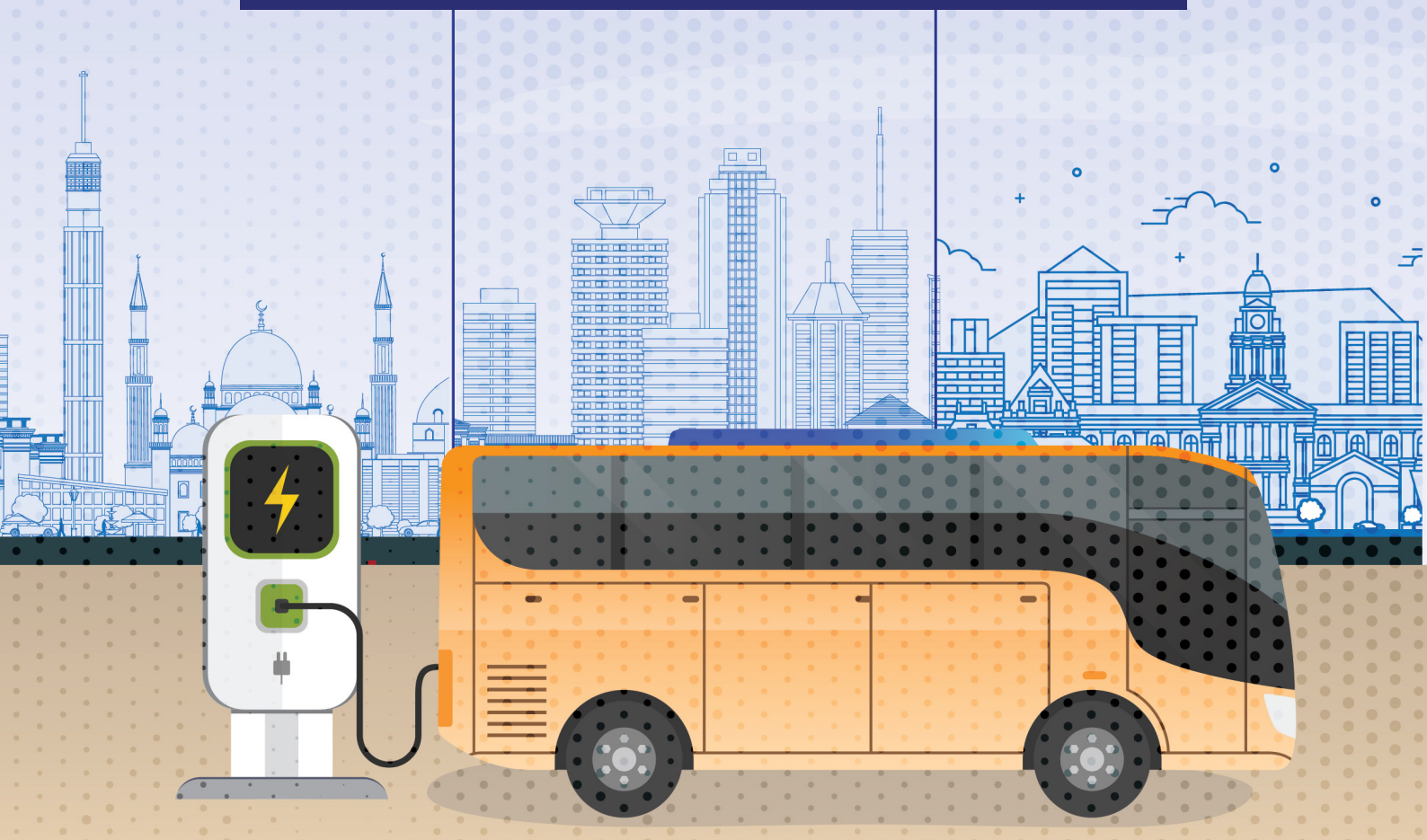
All vehicle imports into South Africa incur an import duty, to protect the local industry, and an ad valorem tax, the latter a tax on luxury goods. Based on the extended Automotive Production and Development Programme (APDP), a minibus would incur a 25 percent import duty, while ad valorem tax ranges from 0.75 to 20 percent based on the market price of the vehicle (DTI, 2017). However, since the ad valorem tax has not been updated since 1999 (Barnes, personal interview, 2021 February 15), and given the high cost of electric vehicles in general, a EV minibus import is likely to incur the maximum 20 percent ad valorem tax. Therefore, EV minibus imports are likely to incur 45 percent tax.

Despite the incentives that reduce import tariffs for automotive manufacturers, the threshold to access the incentives remains high (Interview by Manuel, M. February 23, 2021). The result will be that major manufacturers are most likely to drive EV imports and assembly in South Africa, rather than local SMEs being able to drive EV innovation and avoid the steep import tariffs on EV minibuses (Interview by Manuel, M., February 23, 2021).

In addition to the high initial capital outlay required, the impact of battery technology on profitability of minibus-taxi operations acts as disincentive. Battery technology continues to develop to reduce weight and increase range. However, at present the weight penalty remains considerable for public transport vehicles which seek to be able to travel between 200 to 300 kms between charges. (Interview by Manuel, M., February 23, 2021) The weight penalty reduces vehicle capacity (Interview by Manuel, M., February 23, 2021), this could undermine the safety of minibus-taxi services because the industry relies on overloading to ensure adequate daily income.

Like Nairobi and Cairo, Cape Town faces significant air pollution from vehicles and a growing interest in EVs as one way to address that problem. Like Nairobi, Cape Town is developing climate targets that involve reducing transport emissions including using renewable energy for electric vehicles by 2025, as well as investing in electric vehicle related infrastructure. However, unlike Kenya, South Africa relies heavily on low grade coal for its electricity making transport electrification unlikely to have a strong impact on carbon emissions unless off grid solar can be used for charging, and this is more feasible for smaller personal vehicles. Further, current financial incentives do not bode well for minibus taxi electrification in Cape Town and as in Egypt, the government promotes transitioning to dual-fuel vehicles, rather than electric public transport vehicles.

3: COMPARING THE ENVIRONMENT FOR MINIBUS ELECTRIFICATION IN CAIRO, NAIROBI, AND CAPE TOWN

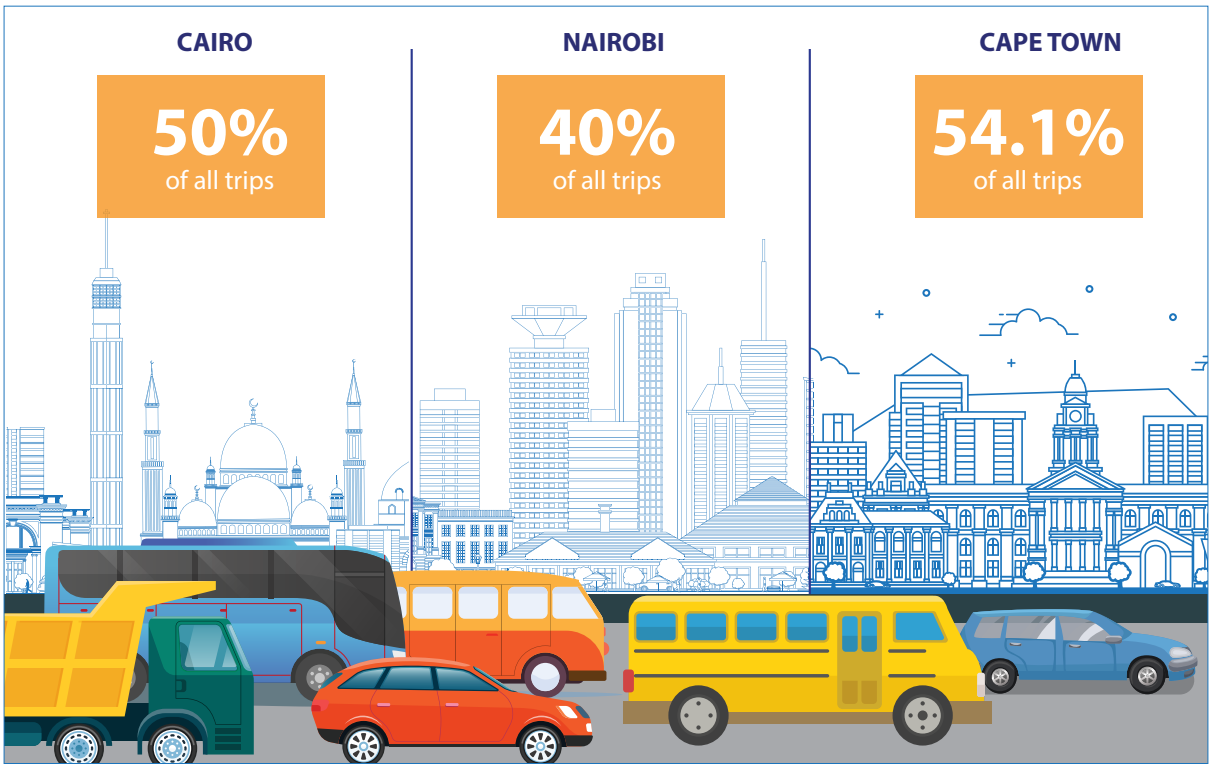


Having provided a background on EVs in Cairo, Nairobi, and Cape Town, this section draws out the similarities, differences, and unique realities across the three cities. It aims to offer comparison on the degree of enabling environments for the uptake of electric minibuses.

3.1 MINIBUS MODAL SHARE

In all three cities, minibuses operated by private entrepreneurs form an integral part of the public transport system. In fact, in Cape Town and Cairo, minibuses dominate the modal share for public transport, acting as the main means for socio-economic access, for most city residents. This reiterates the need to invest in sustainable minibus operations that support public health reforms on addressing air pollution and the climate crisis.

Figure 1: Minibus Modal share across Cairo, Nairobi and Cape Town

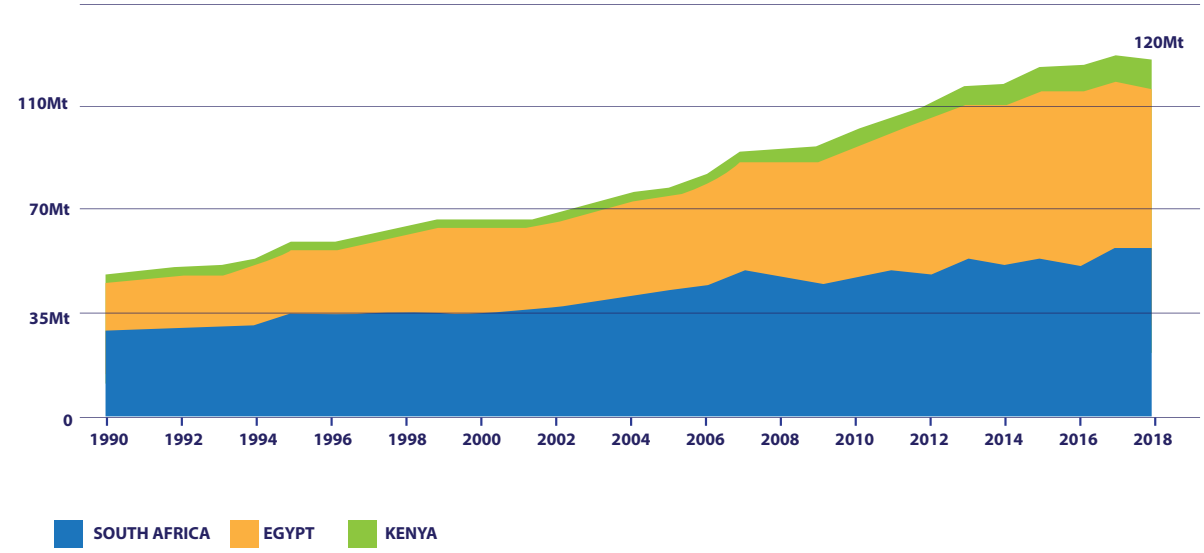


3.2 TRANSPORT SECTOR EMISSIONS OUTLOOK

The transport sector is a significant contributor to the climate crisis and air quality deterioration in many cities across the globe. It contributes to a growing amount of total GHG emissions constituting approximately 33% in South Africa, 15% in Egypt and 10% in Kenya (World Resources Institute). Across the three cities, it is clear that mobilization around addressing climate change by reducing transport emissions is one key driver for electrification of the transport sector. Air quality in all three cities has often surpassed the WHO safety limits. The fact that transport emissions are concentrated in urban areas causing serious pollution and health concerns is a big concern.

Kenya and South Africa have explicit climate change policies seeking to utilize EVs as a means of reducing emissions and decarbonizing the transport sector. This displays a level of political will to promote the uptake of electric mobility. On the other hand, Egypt lacks robust climate regulations and air quality improvement actions are focused on converting minibuses to run on compressed natural gas, with no mention of EVs as a complementary measure. Notably though, there is significant development of World Bank and private sector investment in Cairo, focusing on E-buses as a climate strategy in the transport sector.

Figure 2: Transport Sector Greenhouse Gas Emissions across South Africa, Egypt, and Kenya



Source : (ClimateWatch, 2021)

3.3 EV INFRASTRUCTURE DEVELOPMENT

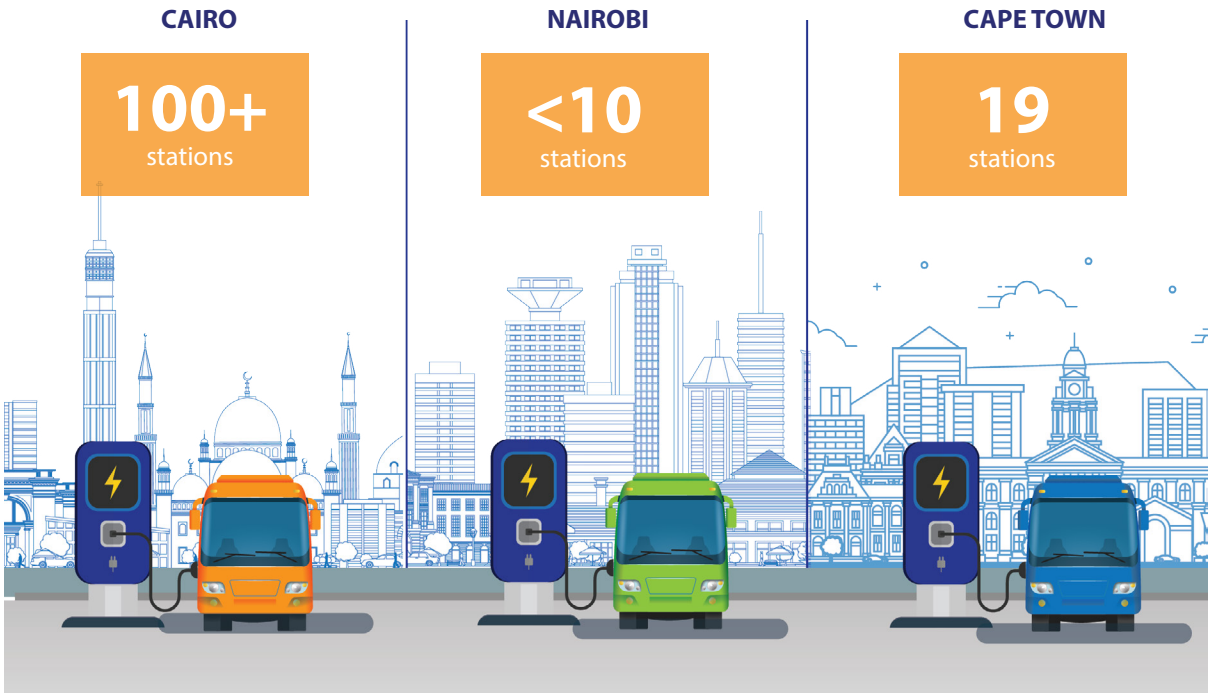
As EV uptake grows, African countries must contemplate the capacity to manufacture and locally assemble vehicles, to capitalize on some of the socio-economic gains from the e mobility transition. Cape Town is leading in the number of registered EVs at 1509, followed by Egypt at 300, and Nairobi at 190.

Despite South Africa and Egypt having vehicle manufacturing capacity, all registered EVs including e-buses have been imported, fully assembled. In both countries, there are initiatives towards promoting local EV manufacture. In Egypt, public policy targets seek to triple the share of locally manufactured EV components to 46% by 2030. South Africa has recently launched the Auto Green Paper to lay a roadmap for new energy vehicle manufacture. Kenya's vehicle manufacturing capacity is still quite low and heavy reliance is placed upon imports, complemented by minimal local assemblage. The government has supported locally assembled e- 3 wheelers and handcarts, while an upcoming e-bus pilot seeks to retrofit ICE buses to run on electricity, signalling desire to build local EV assemblage and gradually manufacturing capacity.

Standards will play an important role in regulating and enabling the growth of the EV sector in African cities. Kenya has developed EV standards covering safety, operation, and testing procedures, with ongoing processes to localize them to address local realities. Egypt and South Africa are yet to develop explicit standards on EVs

In all three cities, EV charging infrastructure is gradually developing commensurate with the number of EVs. Cairo is leading at almost 100 stations and more than 200 in the pipeline, Cape Town at 19 stations- and Nairobi with less than 10 stations, with the intention to gradually increase them.

Figure 3: EV Charging Stations across Cairo, Nairobi, and Cape Town.

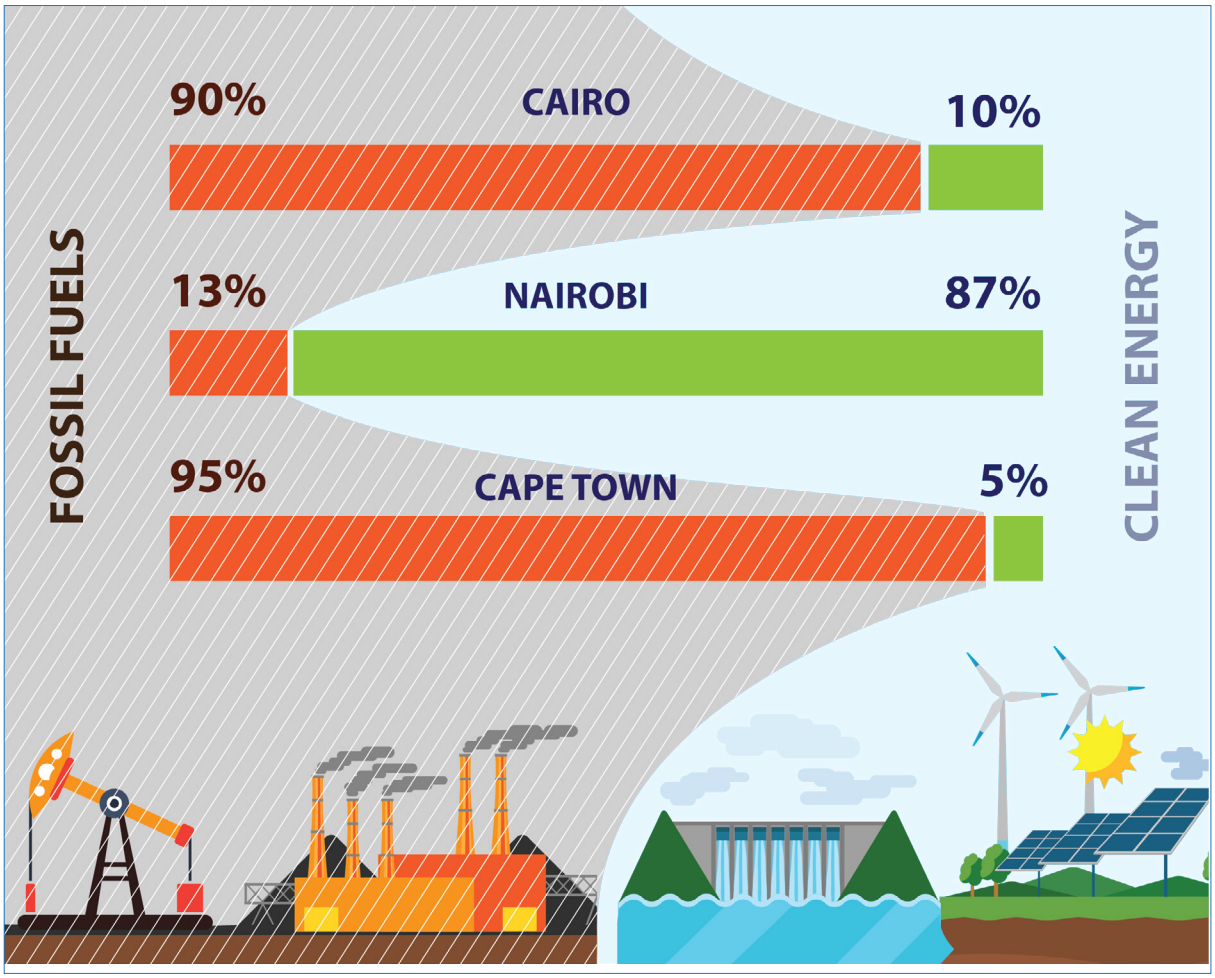


3.4 ENERGY DYNAMICS

EVs are proffered as part of transport decarbonization and air quality improvement strategies in Nairobi and Cape town. Therefore, analyzing energy sources is important to determine to what extent EV uptake can contribute to greening the transport sector.

Cape Town sources most of its energy from the national grid, of which 95% is generated from coal, with projections that coal will be the dominant electricity source for decades because of South Africa's rich coal reserves. According to Cape Town's Climate Strategy and expert interviews, transitioning to EVs will only be beneficial to climate mitigation efforts if South Africa's energy supply shifts to cleaner and renewable sources. Cairo draws electricity from the national grid of which 90% is fossil fuel generated. However, there is a target to increase clean energy generation from the current 10% to 35% by 2030. In stark contrast, Nairobi draws its energy from the national grid of which 87% is generated from renewable energy, making for a net clean energy source. Both Egypt and Kenya produce surplus electricity making EVs viable on account of energy availability. On the other hand, South Africa's challenge in maintaining undisrupted electricity transmission should be analyzed, in the context of supporting EV proliferation.

Figure 4: Energy Sources across Cape Town, Cairo, and Nairobi



3.5 WHERE IS THE FINANCE?

Across the three cities, the upfront cost of EVs is still quite high and out of reach for minibus operators, creating little incentive for transition. South Africa and Egypt are keen on protecting their local manufacturing industries. In South Africa, trends indicate that EV imports are likely to continue attracting high import tariffs, while Egypt has put in place some tax relief. Though Egypt and Kenya have some levels of tax incentives, these are still insufficient to significantly reduce the upfront cost of EVs in general.

Kenya and Egypt have contemplated tapping into climate finance as a means of injecting capital into the EV agenda and exploring retrofitting as a possible avenue to reduce costs. In Egypt, local banks are expected to provide financing for vehicle retrofitting, while in Kenya, EV entrepreneurs struggle to attract financing from local banks, who seem to have little appreciation for the interlinkages between climate finance and EVs. In other parts of the world, given the public benefits from cleaner air and climate mitigation, governments subsidize the up-front costs of EV infrastructure, and this will need to be part of the policy mix in Africa as well.

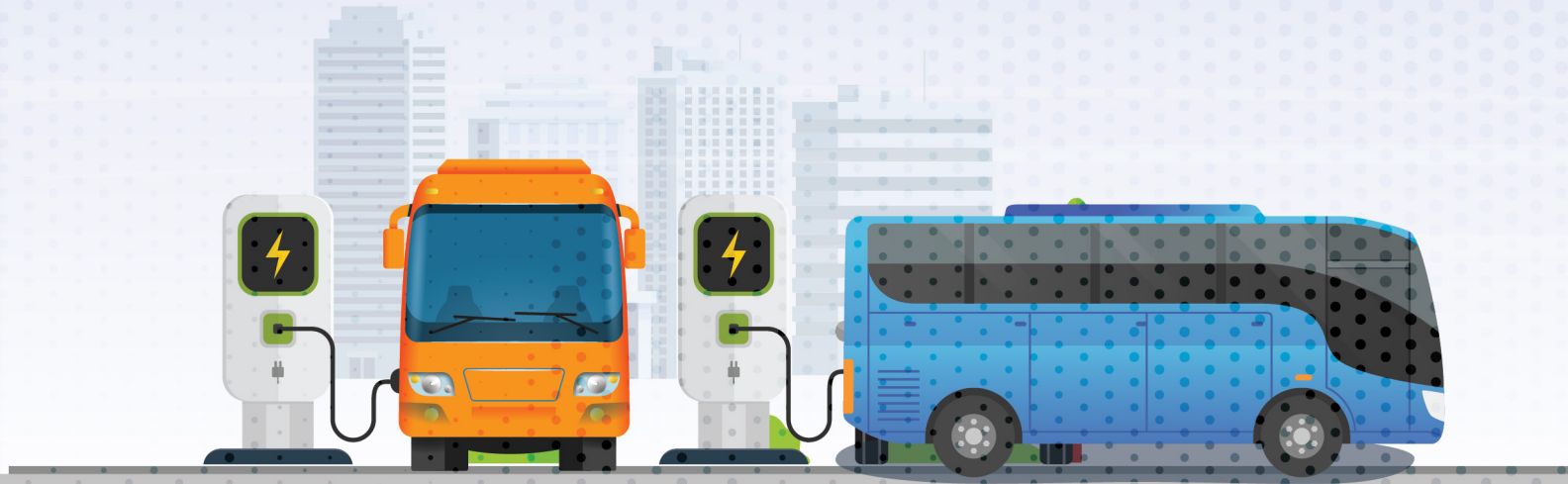
Below is a summary table that shows some of the enabling factors that are present, present to some degree or absent in each of the cities. This is by no means a comprehensive or sufficient list of factors that are influencing public transport electrification progress across the three case studies, but it gives a rough indication of the different policy environments in relation to potential for minibus electrification. Currently, Nairobi seems most favourable to the development of e-minibuses and indeed, this is where we see at least one pilot emerging.

Table1:Summary of enabling factors promoting minibus electrification across Cairo, Nairobi and Cape Town

	CAIRO	NAIROBI	CAPE TOWN
 EV and Climate Policy and Targets			
 Air pollution problems linked to vehicle emissions			
 EV Standards in development			
 Clean electricity			
 Financial Incentives/ tariff reductions			
 Finance/ Public/ Private	**Green bonds**		
 Private Sector Investment in EVs			
 E-bus pilots planned		**Minibus pilot planned**	**stalled**
 Foreign Investment			

in progress some movement no to little movement

4: RECOMMENDATIONS AND CONCLUSIONS: ENABLING ENVIRONMENTS FOR E-MINIBUS UPTAKE IN AFRICAN CITIES



Emerging out of concern for growing air pollution and the climate crisis, as well as interest in new business opportunities emerging from rapidly improving EV technologies, we found some movement towards transport electrification in all three African cities. While efforts to introduce electric buses as part of public transport improvement projects were visible in Cape Town (myCiti bus electrification), Cairo (Greater Cairo Air Pollution Management and Climate Change Project bus electrification) and Nairobi's (BRT project), the potential for minibus electrification has remained largely unexplored. The only pilot so far discovered was in Nairobi. Investing in pilots can serve as useful learning opportunities that address local realities.

Given that vehicle electrification will continue to advance as one way to cut growing vehicle emissions and that EV companies are already present in African cities, it is imperative that African governments put into place proper legal and policy frameworks as well as strategies to nurture local innovation and take full advantage of these new technologies.

RECOMMENDATIONS

4.1 Review of counterproductive policies to encourage uptake of E-buses

One critical step to encourage the uptake of EVs, is for African governments to review counterproductive policies that place e-mobility at a competitive disadvantage, with internal combustion engines. African governments should discourage old, polluting, second- hand imports and low-quality fuel standards. Across the three cities, there are policies that need to be reviewed to support the viability and growth of the EV sector.

Kenya needs to review the policy allowing for the importation of eight-year second-hand vehicles. This encourages the purchasing of fuel inefficient vehicles that pollute the environment. This policy should be altered to complement the goals of the revised INTP which seeks to promote clean mobility.

Egypt needs to review the fuel quality standards, allowing for the usage of low-quality diesel. This is exacerbating the air pollution crisis, by encouraging cheaper polluting options and less incentive to transition to cleaner options such as e-mobility.

South Africa must move away from coal as the main source of energy supply and invest more in clean energy sources to make uptake of EV a viable climate mitigation strategy as envisaged in the Climate Change Strategy.

4.2 Stabilization of energy supply to support viable electric public transport systems

Electrifying mass transit demands a reliable energy supply. At slightly over 40 percent, Africa has the lowest electrification rate in the world. Some 640 million Africans lack access to energy. Many countries on the continent are still grappling with stabilising energy supply just for household use, let alone commercial and industrial consumption (Odhiambo, 2021). African governments should prioritize stabilization of energy supply and encourage innovative off-grid charging solutions such as solar rooftop charging stations, to complement grid supply. Kenya and Egypt have excess electricity production which will go a long way in supporting EV proliferation, while there is a need for South Africa to interrogate electricity supply in relation to supporting a viable electric public transport system.

4.3 Development of EV Standards to govern the E-bus value chain

As the EV agenda takes root in Africa, African governments are in a good position to develop regulations while the sector is still emerging, to maximize the benefits from the EV transition. Some of the standards that need to be well developed include those on safety, battery disposal and recycling, importation of second-hand electric vehicles, and safeguarding ethical mining of raw materials that are used in the production of electric vehicles (Aljazeera, 2021). These Standards should be developed using consultative processes that include e-mobility stakeholders.

Egypt and South Africa currently lack EV standards, while Kenya has developed some EV standards for vehicles and charging infrastructure. Though commendable, Kenya needs to localize the EV standards to adopt them to homegrown contexts including the widespread use of minibuses for public transport. These standards should accommodate local testing procedures that are unique to locally manufactured or retrofitted EVs, guided by the technology used and the local environment. It is worth emphasizing that more efforts towards disseminating the EV standards and to promote awareness and public participation are needed generally. Standards need to be created with useful input from key EV stakeholders who possess industry knowledge.

4.4 Encouraging co-design of E-bus solutions.

The EV agenda in Africa, should be cognizant of the needs and realities of African cities as well as social equity and environmental justice concerns. African cities rely heavily on minibuses as their main means of motorized public transport. Efforts towards greening the transport sector should place emphasis on maximizing socio-economic impact and realizing equitable environmental gains. Currently, there is minimal conversation on public transport electrification and much of the EV focus is on high end personal cars. More investment in exploring public transport modes including minibuses is needed.

Minibus stakeholders across the value chain including government agencies should be part of participatory and inclusive dialogues on the potential for e-buses. More pilots should be encouraged for learning and awareness. The industry knowledge possessed by minibus operators, must be valued, and considered to successfully design e-bus programs. Across the three cities, the viability of minibus electrification can tremendously benefit from initiatives that foster dialogue among all key stakeholders, to objectively discuss the gains and pains of electrification.

In Cairo, the EV charging stations' network is fully geared towards private car owners and does not bode well for minibus operators, who have vastly different needs and interests. For instance, they would need access to safe and secure overnight charging, and to vehicles that can operate all-day on one charge. While this is possible with advanced forms of current technology, the cost differential is just too big to gap.

In Nairobi, there is a need for more analysis on optimal locations for charging infrastructure; for example, is it existing fuel stations, parking lots, malls, or a combination of different locations? Determining the most convenient locations for charging points should be done in consultation with key actors, especially matatu stakeholders who possess industry knowledge on bus operations. Deliberate inter-agency cooperation not only within transport, but across finance, industry environment and energy are imperative to buttress a viable EV industry in Kenya

In Cape Town, there are significant vested interests in this vehicle-energy policy nexus. The conditions that can spur action amongst government, automotive, energy and paratransit sectoral stakeholders need to be investigated to understand at the fine-grained local level how these vested interests can lead mobility towards collective climate action. It is likely that operational and business behaviour changes will be needed on the part of the minibus owners and operators. Besides the complexities and costs of making EV minibuses and reliable energy available, investments will need to be made in training and other forms of information sharing to facilitate such a shift in behaviour.

4.5 Exploring innovative finance to address affordability of e-buses

Affordability of EVs including e-buses is still a major deterrent towards minibus electrification. African countries are keen to build their local capacity to manufacture and assemble vehicles including EVs. This presents a delicate balance while offering tax and fiscal incentives for EV imports in the short term, but still safeguarding local capacity. In Egypt and Kenya, the tax incentives, though commendable, are still insufficient to give EVs a competitive advantage. However, both countries have shown that there is opportunity for EVs to tap into other sources of finance such as climate finance as a means of addressing affordability. E-mobility stakeholders should consider other forms of non-traditional finance, to bridge the affordability gap.

5.0 CONCLUSIONS

Minibuses play a key role in the public transport systems of African cities including as we have seen in Cairo, Nairobi, and Cape Town. As transport electrification continues to move forward as part of decarbonisation and air quality strategies in African cities, it is important to continue to explore the potential of minibus electrification. Otherwise, as we have seen the focus and investment will largely be on private vehicles or mass transit as well as smaller vehicles like motorcycles that are more easily electrified. This leaves out the mode that carries the most passengers and plays a key role in multi-modal integrated public transport systems at the core of any effective decarbonisation plan. A minibus focus is also important for equity and the need to address the working environment for workers in the sector. Finally, EVs are a superior technology, the benefits of which must be leveraged for public transport. Otherwise, the personal car will continue to gain in its allure; yet, whether using an internal combustion engine or electricity, private cars cause a myriad of problems for our cities including congestion and crashes and ongoing air pollution in the form of particulate matter from tires.

This report is just the beginning of what must be more work looking into benefits -including to public health and climate-as well as costs. Overall, a broader and more detailed discussion is needed of when and under what conditions supporting electrification of minibuses makes sense as part of urgent efforts to lower emissions. These efforts must include reducing personal car travel and building up low emissions public transit systems and non-motorized transport; electrification must play strategically into these core goals. We hope this report contributes to this much needed policy conversation as we face an age of African city building in a time of deep inequality and climate crisis.

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