The Factors Driving Africa's Electric Vehicle Future Might Be Different Than You Think

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The growing climate crisis is making a complete transformation of the world's energy systems increasingly urgent. Transportation is one of the most significant emissions drivers, accounting for sixteen percent of global greenhouse gas (GHG) emissions and twenty-four percent if we consider only direct CO_2 emissions from fuel combustion.

To address mounting emissions, many countries are establishing ambitious targets for electrifying transportation – thirty countries pledged to phase out internal combustion engine (ICE) vehicle sales by 2040 during the Glasgow climate summit. Government support, coupled with technological advancements and rapid reductions in technology costs, are driving the deployment and adoption of electric vehicles (EVs) as a viable alternative to ICE vehicles, predominantly in industrialized countries like China, Norway, Sweden, Germany, and the United States. There are currently over ten million EVs on the world's roads, and the well-established electricity and transport sector policies in these countries create a promising outlook for continued deployment – nearly one hundred and forty-five million EVs are forecasted to be in use in these countries by 2030. However, the global EV stock will need to reach two hundred and thirty million by 2030 to fulfill all current net-zero pledges.

While EVs are taking off in many industrialized nations, they are nascent across Africa, and the pathway for expanded deployment in the region is far less clear. Nonetheless, some countries, like South Africa, Zimbabwe, Rwanda, Egypt, and Kenya, have announced non-binding vehicle electrification targets and incentives for adoption and already have growing EV fleets.

While the key driver of the EV transition in industrialized regions is clear– to reduce carbon emissions, there is not a single uniform driver of the transition for the African continent as a whole. The African EV market will likely follow an entirely different path because of the region's heavy reliance on used car imports, rapid motorization growth, and significant power grid constraints. In addition, many African consumers will likely face a significant cost barrier to EV adoption, requiring compelling, innovative business models and policies to drive increased adoption. Even within the continent, the outlook and pathway for EVs will likely differ among countries. Therefore, it is essential that EV policy be realistic and tailored to the local context and each country's unique strengths and challenges.

Understanding the relationship between the transportation sector, power sector challenges, environmental challenges, and climate goals could help highlight key drivers and challenges of African countries' EV transitions and give insight into their potential value propositions for electrifying transit. In a series of four graphs, we explore country-level data on air quality, GHG emissions, electricity generation, motorization, and fuel and electricity prices to understand these relationships better and discuss what this means for the continent's approach to EVs.

Bad Air, Getting Worse

The potential for EVs to improve urban air quality is a crucial driver for investments in electrifying transportation systems. Rapid urbanization and the growth of the middle class in African cities have led to rapidly growing vehicle fleets, mainly from high-emitting used vehicles. Fuel combustion from on-road transportation is considered the primary source of toxic air pollutants, especially fine particulate matter ($PM_{2.5}$), the world's leading environmental health risk factor, with an estimated four million premature deaths annually worldwide. The World Health Organization recommends that annual average concentrations of $PM_{2.5}$ should not exceed five µg/m. Our first graph examines urban air pollution, represented as annual $PM_{2.5}$ exposure, as a function of the change in motorization rate.[1]

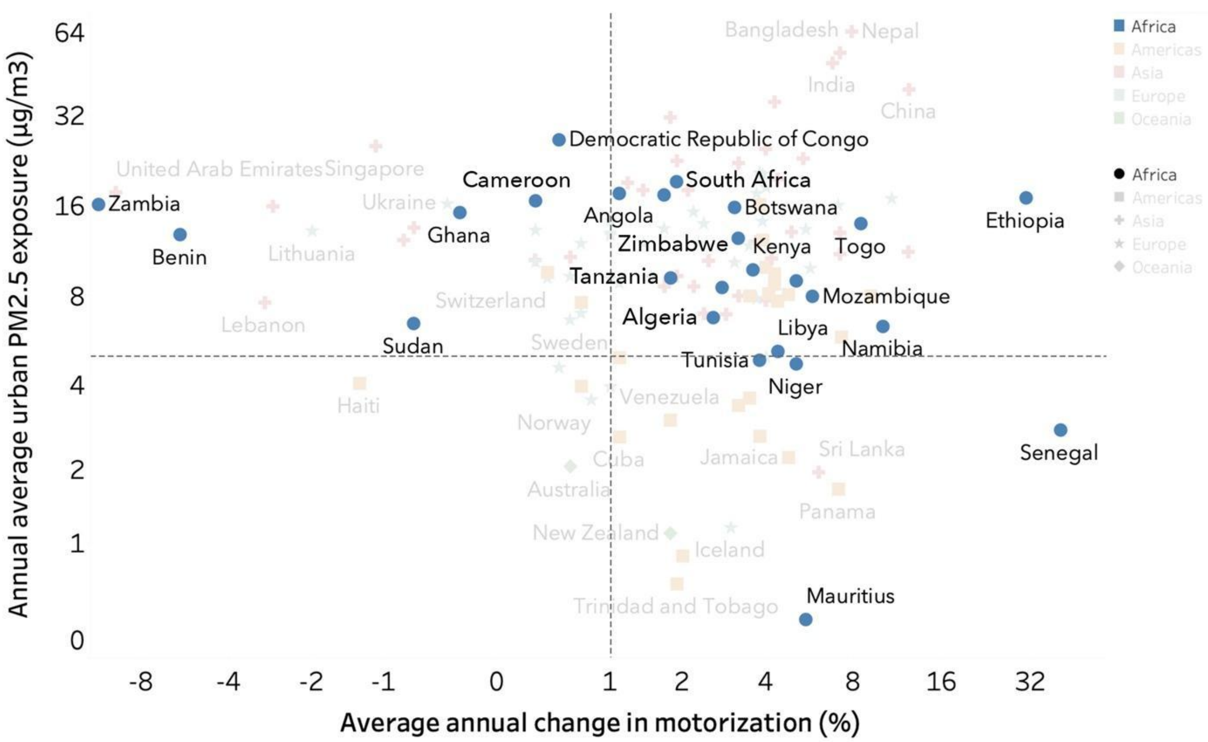

Figure 2: Annual average urban $PM_{2.5}$ exposure vs. annual average change in motorization rate. Notes: The motorization rate is the number of registered vehicles per thousand people. The symbol color and type indicate the continent; data representation from one hundred and sixty countries.

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[1] We obtained data on mean annual concentrations of $PM_{2.5}$ for all urban areas in each country from 1998 to 2016 from the NASA Socioeconomic Data and Applications Center (SEDAC). We calculated the annual average $PM_{2.5}$ values in each country by weighting the area of urban extents so that the larger cities contribute more towards the country's urban average than the smaller cities.

Several African countries have high urban $PM_{2.5}$ exposure and rapidly increasing motorization rates (top right quadrant of the graph), implying a high value proposition for accelerated EV deployment to tackle urban air pollution. Further, coupling EV adoption with policies to increase the efficiency of used car imports could prevent new vehicles from exacerbating urban air pollution. The accurate scale of the air quality problem in African countries is also likely underestimated – **only seven of the fifty-four African countries have real-time air pollution monitors to collect the data**. However, the value proposition to accelerate the transition to EVs would be much less for countries with declining motorization rates (top left quadrant of the graph).

Not Every EV Earns the Same Climate 'Bang For The Buck'

The climate impacts of EVs are not limited to replacing fossil fuels in vehicles. EVs' carbon footprint also depends on how they are charged. Our second graph examines the relationship between the proportion of per capita GHG emissions from the transportation sector and the percentage of electricity generated from renewable sources in 2018.[2]

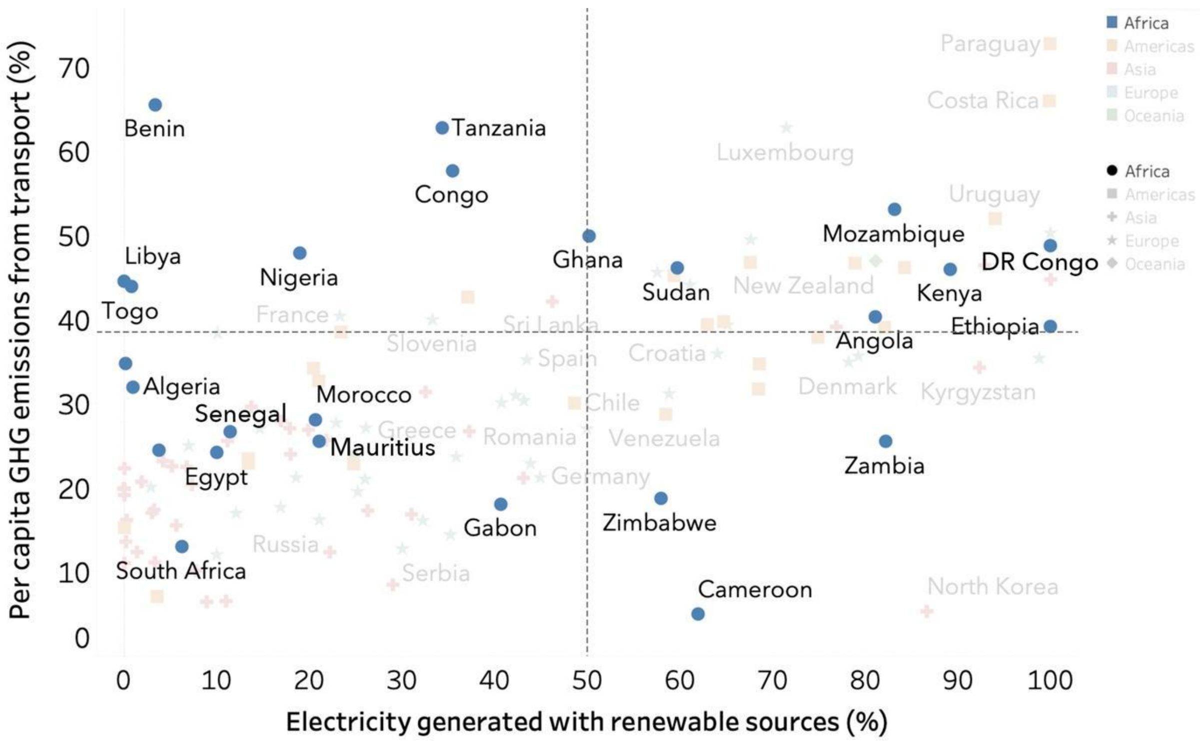

Figure 1: Proportion of per capita GHG emissions from the transportation sector vs. the proportion of electricity generated with renewable sources. Notes: The symbol color and type indicate the continent; data representation from one hundred and twenty-nine countries.

Countries with high per capita GHG emissions from transportation and significant renewable generation (top right quadrant of the graph) are well positioned to have substantial environmental benefits from near-term or immediate vehicle electrification. On the other hand, countries that fall in the bottom left quadrant of the graph have a low value proposition for EVs from an emissions

[2] Calculated based on historical GHG emissions data from the World Resources Institute (WRI) Climate Watch database and data on the electricity generation mix by fuel source from the International Energy Agency (IEA) database

perspectiveand could benefit from prioritizing policies for grid decarbonization over efforts to accelerate large-scale EV adoption.

Whose Grids are Underpowered?

While the impact on air quality, emissions, and changing motorization rates from cheap high-emitting car imports offer key value propositions for an EV transition in Africa, there are substantial technical, social, economic, and political barriers to widespread EV adoption. Chiefly, the existing energy infrastructure. Our third graph, therefore, examines the growth in electricity generation required to support a fully electric transportation sector.[3] The growth of the transportation sector compounds this requirement. We, therefore, examine the additional electricity requirements needed to electrify transportation as a function of the change in motorization rate.[4]

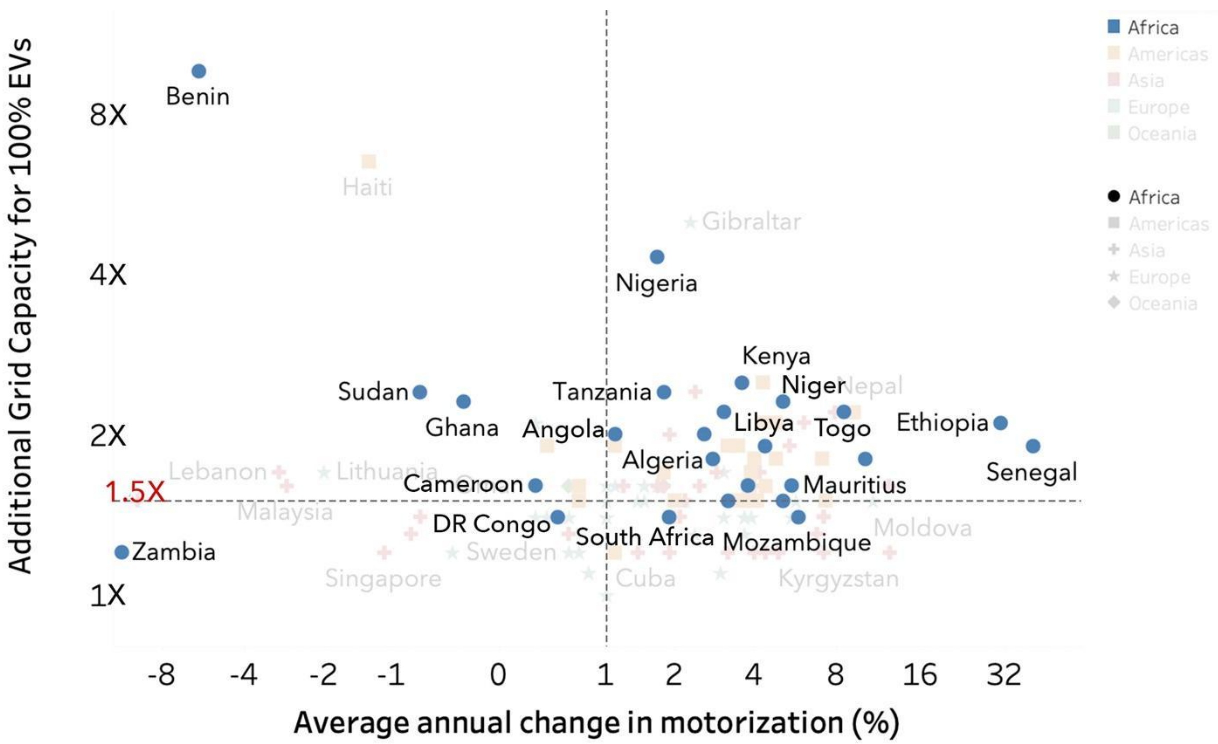

Figure 3: Additional grid capacity (electricity generation) required for one hundred percent electric transportation sector scenario vs. annual average change in motorization rate. Notes: The motorization rate is the number of registered vehicles per thousand people. The symbol color and type indicate the continent; data representation from one hundred and thirty-three countries.

Many African countries fall in the upper right quadrant of the graph, suggesting that they would require a substantial investment in increased generation capacity and improved grid infrastructure to fully electrify their rapidly growing transportation systems. On the contrary, countries that fall in the bottom quadrants of the graph would require less investment in new generation and infrastructure upgrades to convert their current fleets.

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[3] We did not consider spare capacity, only electricity generation.
[4] Estimation technique derived from work by researchers at the University of Texas at Austin to estimate state-level EV electricity demand across the US. Data on the amount of oil products every country consumed for transportation and electricity consumption data for 2018 obtained from the IEA database.

Cheaper to Recharge or Refuel?

Another key barrier to scaling EV adoption is the cost competitiveness of operating EVs compared to their gasoline-powered counterparts, which depends heavily on the cost of electricity. Therefore, our final graph examines the relationship between the gasoline price per kWh equivalent and the commercial electricity tariff in one hundred and seventy countries.[5,6]

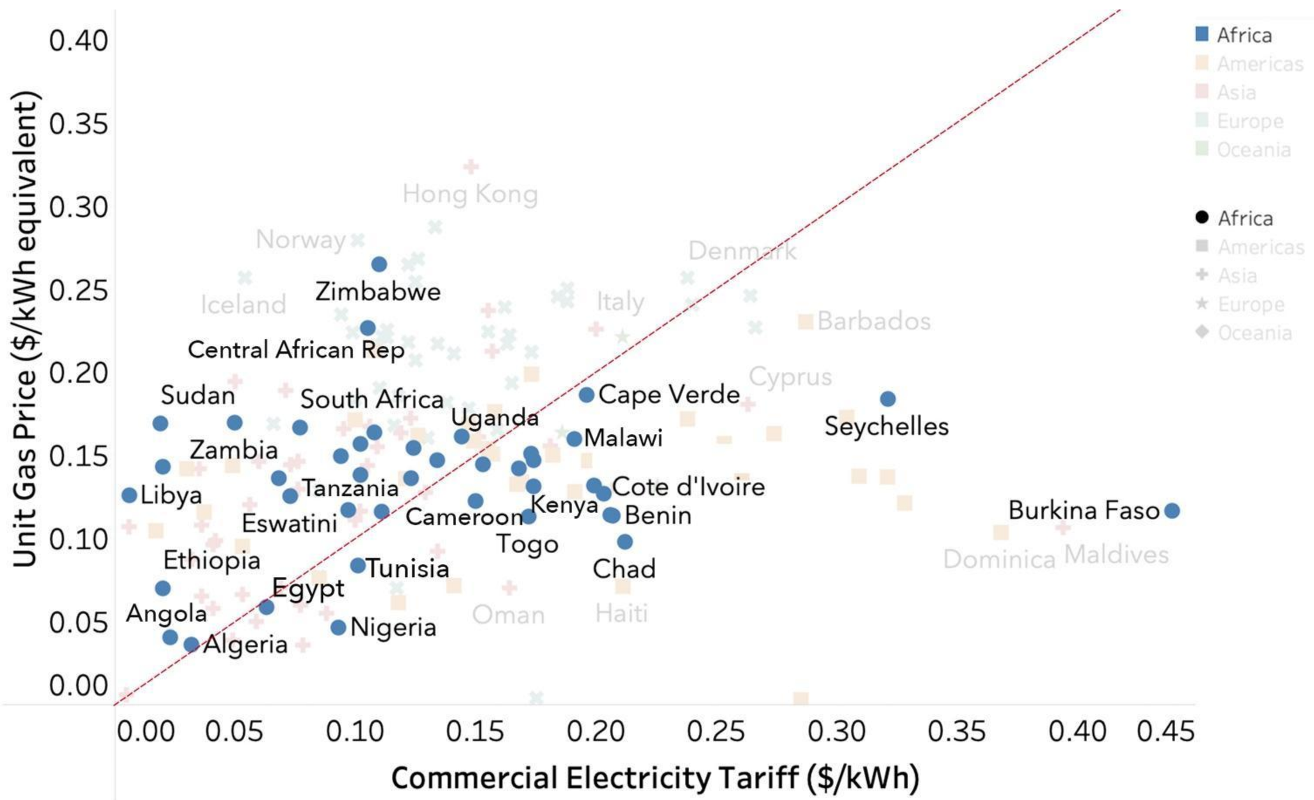

Figure 4: Average gasoline price per kWh equivalent vs. average commercial electricity tariffs. Notes. The symbol color and type indicate the continent; data representation from one hundred and seventy countries.

From an operations cost perspective, EVs with electricity tariffs lower than the comparable gasoline price (countries that fall above the diagonal line) could have a competitive advantage over ICE vehicles. On the flip side, countries, where electricity tariffs are higher than the equivalent unit gasoline price, would have to implement policies and strategies that lower the cost of electricity for EVs to give them an operating cost advantage over their gasoline-powered counterparts. We caveat that these costs include country-specific fuel and electricity subsidies, noting that many countries may fall above the diagonal line without these subsidies.

While this summarizes the general picture of the continent, different value propositions for accelerating the transition to EVs such as urban air quality, the changing landscape of vehicle

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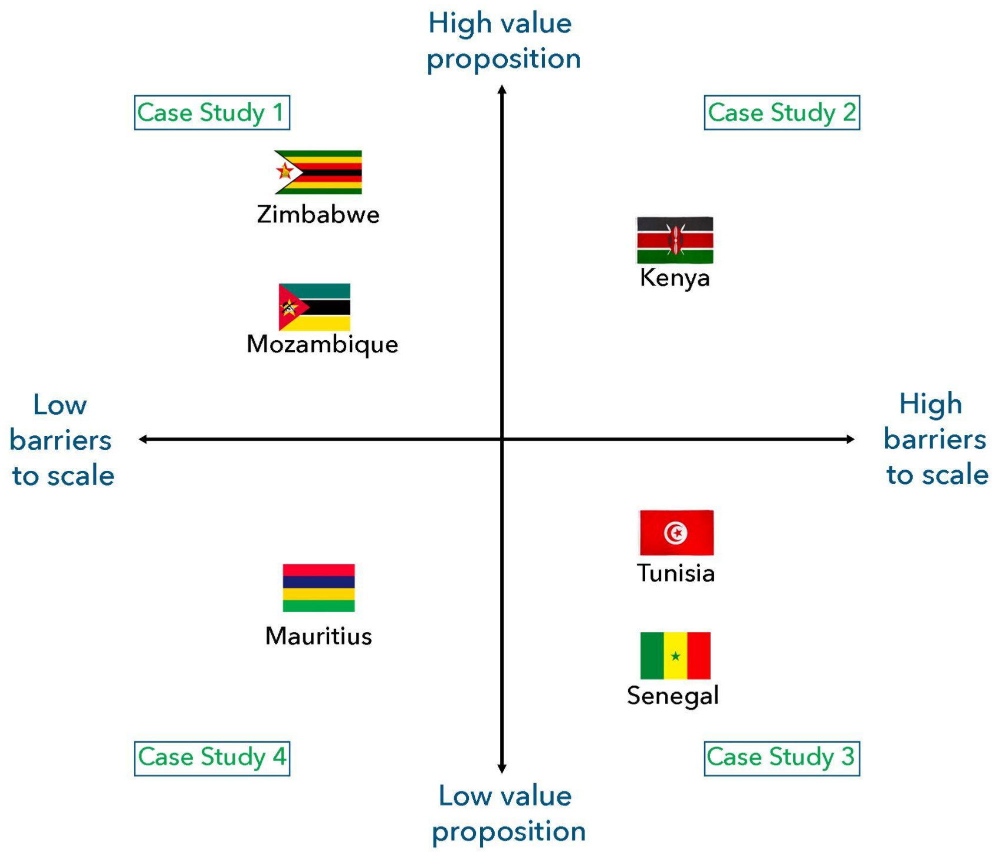
[5] We calculated the gasoline price per kWh equivalent by considering the miles per gallon of gasoline-equivalent (MPGe) of a typical electric vehicle with an ICE counterpart, paired with its electricity consumption (kWh/mile). The Environmental Protection Agency (EPA) introduced the MPGe in 2010 to compare the amount of energy consumed by EVs to those of ICE vehicles.

[6] Data used is the 2022 gasoline prices and 2021 commercial electricity tariff datasets from Global Petrol Prices.

ownership, and the 'cleanliness' of grids, will differ from country to country. Similarly, the extent to which factors such as grid capacity requirements, the cost of electricity, and the cost of fuel challenge the widespread adoption of EVs will also differ from country to country. For instance:



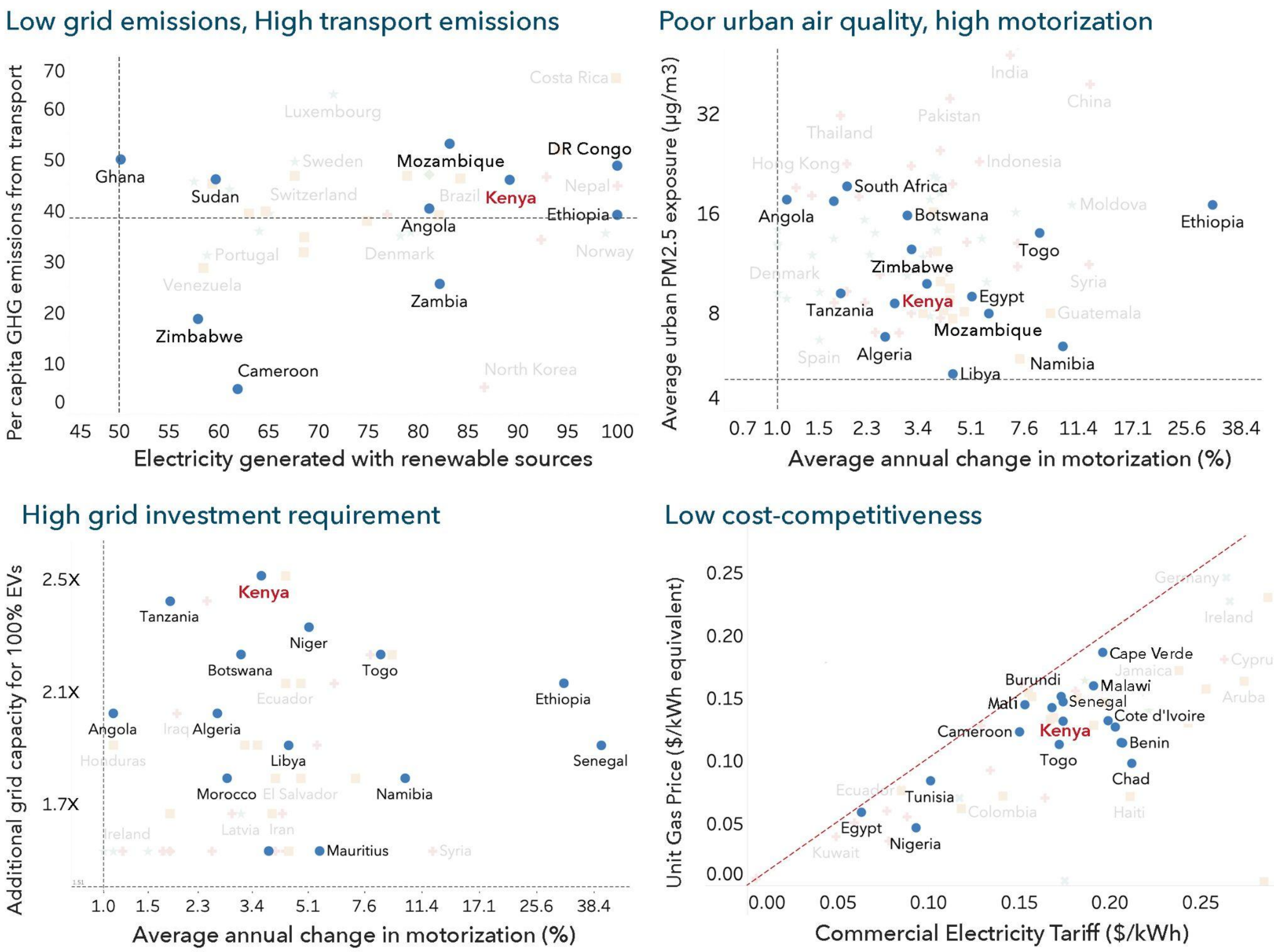
Case Study 1: High value proposition, low barriers to scale

Countries like **Zimbabwe and Mozambique** have climate and public health incentives to accelerate EV adoption owing to their significant renewable generation and poor urban air quality. In addition, the fast-changing landscape of vehicle ownership increases the value proposition for accelerated EV adoption coupled with stringent regulations on used vehicle imports. These countries have a lower requirement for additional grid capacity to support an all-electric transportation system than other African countries, suggesting a lower threshold for grid capacity and infrastructure upgrades. Furthermore, EVs could be immediately cost-competitive against their fuel-powered counterparts, given that electricity costs are lower than fuel costs.

Case Study 2: High value proposition, high barriers to scale

A country like **Kenya** has a high value proposition to focus on immediate or near-term investments and policies enabling accelerated EV adoption from both a climate and public health lens. It already has a clean grid, generating over eighty percent of electricity from renewable resources, which could support net positive emissions reductions from decarbonizing its transportation sector. In addition, the rapidly changing landscape of vehicle ownership coupled with stringent regulations on used vehicle imports could further increase the value proposition for widespread EV adoption.

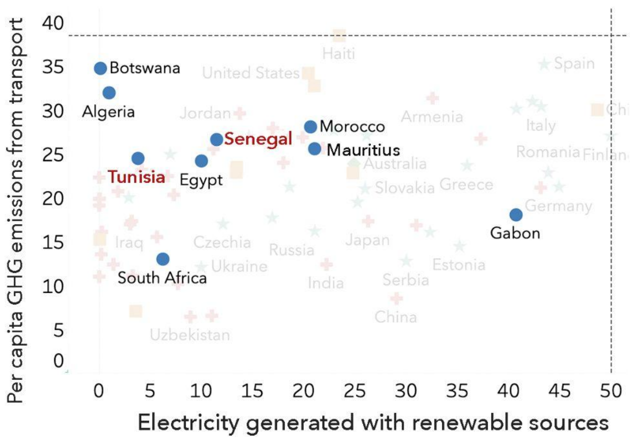
However, significant investments would be needed to upgrade electricity grid capacity and infrastructure while ensuring that electricity remains affordable for consumers. Utilities would need to outline clear steps they plan to take to invest in distribution network upgrades to enable EV interconnection in areas where the overall power demand could force substation and electric line improvements. Additionally, it would be challenging to make a case for the cost-competitive nature of EVs, given that electricity tariffs are higher than the equivalent unit gasoline price. It is noteworthy that Kenya spends a significant proportion of its fiscal budget on fossil fuel subsidies. Therefore, policies and strategies to reduce and maintain a low cost of electricity would need to be accompanied by well-planned fossil fuel subsidy reforms.



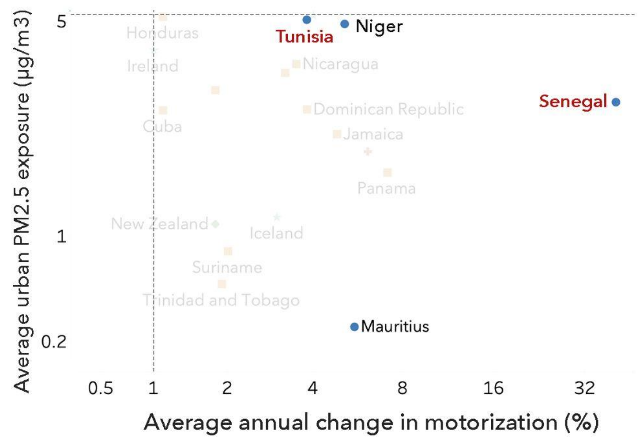
Case Study 3: Low value proposition, high barriers to scale

Countries like **Tunisia and Senegal** are unlikely to see substantial overall positive environmental and climate impacts from an immediate EV rollout because of their significant electricity generation from non-renewable sources. In addition, they have relatively low urban air pollution and GHG emissions from transportation, suggesting that near-term policies supporting the decarbonization of their grids before focusing on EVs would contribute more to their climate action plans. However, with a non-trivial annual growth in motorization of over three percent, the EV conversation cannot be entirely placed on the back burner, especially for Senegal, which is experiencing a yearly motorization growth rate of over thirty percent. They would benefit from policies regulating ICE vehicle imports and providing incentives for EV imports to ensure that the changing landscape of vehicle ownership supports climate action and public health policy. Furthermore, strategies that lower the cost of electricity would be required to make EVs cost-competitive over ICE vehicles at the time of adoption, in addition to investments to upgrade electricity grid capacity and infrastructure. With a proper policy framework, these countries could benefit from better grid infrastructure, technology improvements, better electricity tariffs, fuel subsidy reform policies, and investment opportunities, lowering the entry barrier for EVs at the time of adoption.

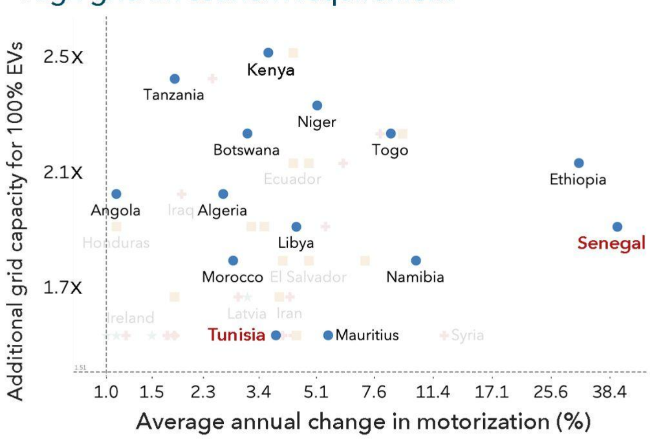
High grid emissions, Low transport emissions



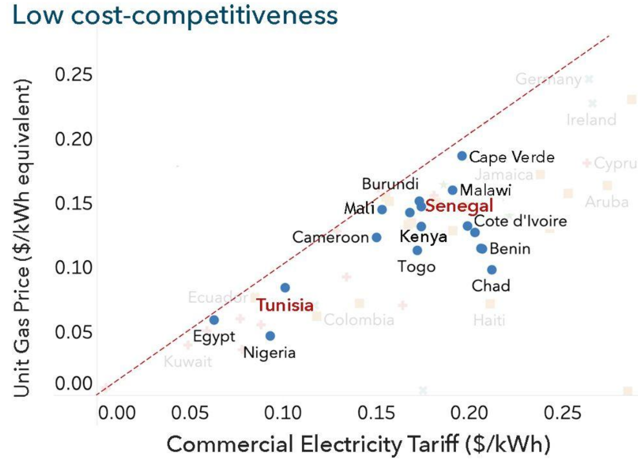
Good urban air quality



High grid investment requirement



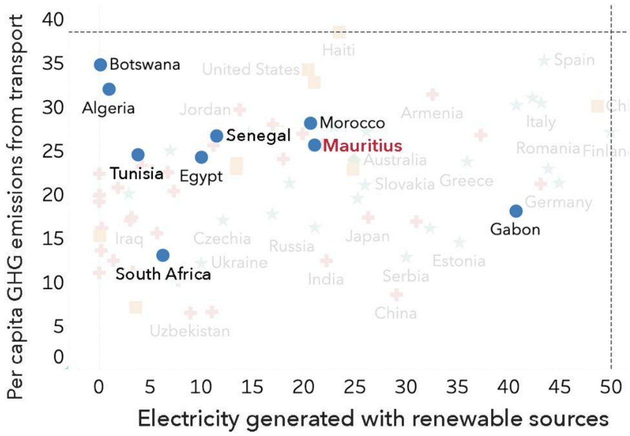
Low cost-competitiveness



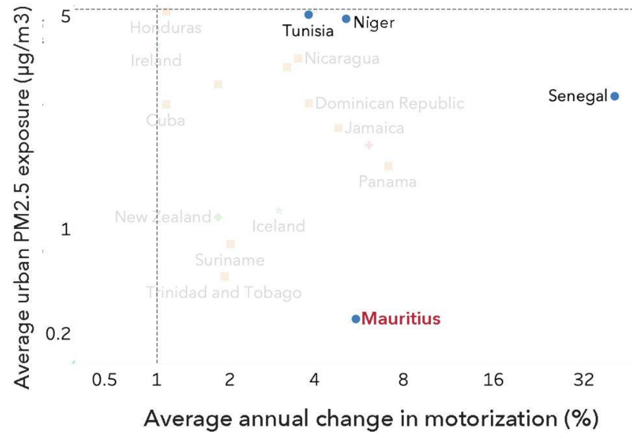
Case Study 4: Low value proposition, low barriers to scale

A country like **Mauritius,** with good urban air quality, low GHG emissions from the transport sector, and significant electricity generation from fossil fuels, has a low value proposition for investing in accelerating EV adoption. However, EVs could be immediately cost-competitive against their fuel-powered counterparts. Also, the investment required for grid capacity upgrades is lower than in many other African countries. Mauritius could therefore benefit from prioritizing policies for grid decarbonization over efforts to accelerate large-scale EV adoption. Later, when widespread EV adoption occurs, it could likely benefit from better grid infrastructure, electricity tariffs, and investment opportunities. However, due to increasing vehicle ownership rates, it would have to regulate the quality of imported cars to align with its climate action and public health policies.

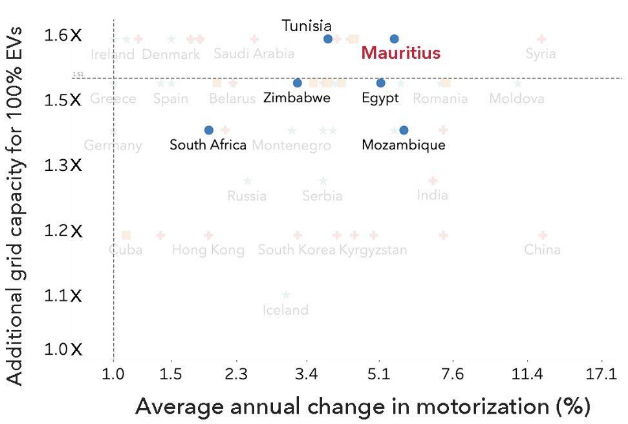
High grid emissions, Low transport emissions



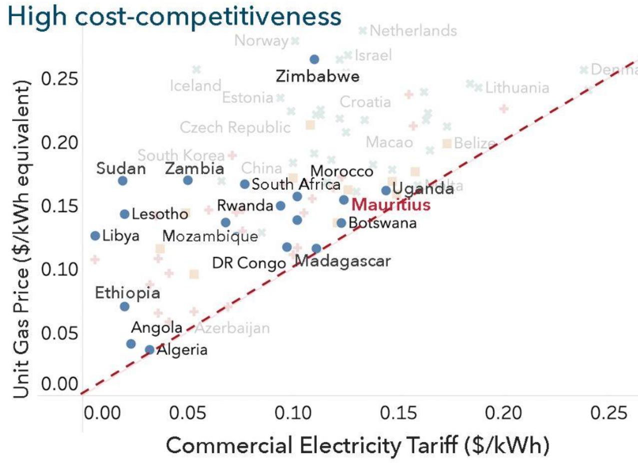
Good urban air quality



Lower grid investment requirement



High cost-competitiveness



Call to Action

With development as Africa's top priority, the big question is where EV policy fits into Africa's development and climate agenda. As evidenced by the rapidly changing vehicle ownership landscape, consumers are making decisions now that will affect air quality and GHG emissions for decades to come. Therefore, we must start creating an enabling environment and framework for EV adoption. This article shows that the drivers and potential challenges of widespread EV adoption within the continent will differ from country to country. Therefore, the policies, timing, and approach to EV adoption must be tailored to each country's unique strengths and challenges. Governments and policymakers will need to create energy, climate, and macroeconomic policies that support increased clean energy supply, grid infrastructure upgrades, well-planned fuel subsidy reform, and regulate used vehicle imports. At the same time, they must drive development by creating an enabling environment for local EV manufacturing and skill-building, supporting innovative business models that address the upfront cost barrier to EV adoption, and ensuring that electricity tariffs and transportation remain affordable for all.