Title: Electric Vehicles in Kenya- Impact of Integration into The Kenyan Distribution Network, Milestones and Challenges.

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ABSTRACT

Adoption of Electric vehicles (EVs) is among the most effective ways of reducing environmental pollution, fossil gas emissions in line with foundations of Kenya Vision 2030 and agendas 7 and 11 of United Nations' Sustainable Development Goals (SDG). Production of Electric vehicles has significantly increased worldwide with over 6.8 million Vehicles in use globally by December 2020. The number of EVs in cities like Nairobi is fast increasing with charging stations already installed at Two Rivers Mall, the Hub Karen, and Thika Road Mall. In early 2019, the Kenya Bureau of Standards (KEBS) adopted Electric vehicle standards aimed at reducing excise duty on EVs from 20% to 10%; hence encouraging the adoption of EVs. In March 2021, Kenya Power Company Limited PLC, announced plans to install charging stations along major highways, malls, and parking lots to catalyze the demand for electric cars.

Increased EVs in Kenya will lead to increase energy demand, hence more stress on the power grid among other challenges. This paper looks at the impact of electric vehicle integration into the Kenyan electricity distribution network, progress of EVs adoption in Kenya and, challenges faced as the country adopts EVs.

Keywords: Electric Vehicle, Kenya vision 2030, fossil gas, Sustainable Development Goals, Standards.

1. INTRODUCTION

The United Nations Sustainable goals aims at ensuring that by the year 2030, there is universal access to affordable, clean, reliable energy worldwide as well as environmental conservation and urgent combat of climatic changes and the impacts. Kenya's vision 2030 is anchored on increased efficient generation of affordable and environmental friendly energy. Kenya's installed electricity generation capacity has been increasing since the year 2016 with 2840 MW installed capacity as at 30th June 2020 and over 88% of total installed capacity comprising of environmental friendly mechanism of generation (KPLC, 2020).[1]

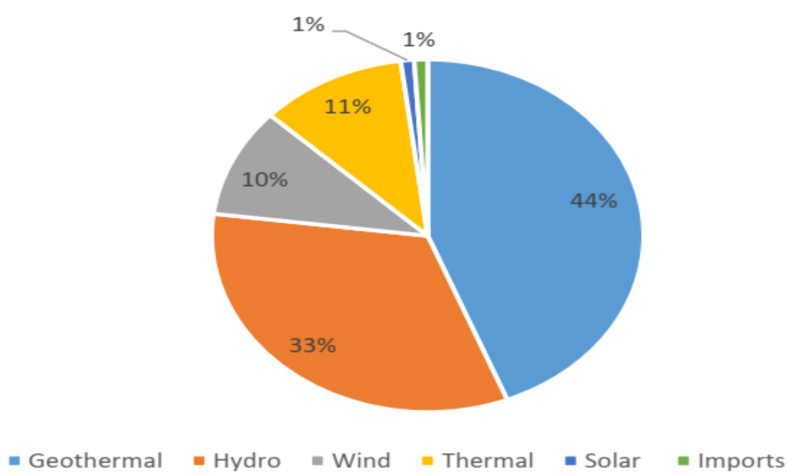

Fig. 1. Kenya's electricity generation sources

Source: KPLC annual report and financial statement 2020

According to Paris Declaration on Electro-Mobility and Climate Change 2015, Transportation using internal combustion engine's (ICE) contributed to 23% of global greenhouse gas (GHG) emissions as of December 2015 and it was projected to increase to 50% by 2050 if remedial action was note. The declaration aims at keeping global temperature rise this century well below 2°C above pre-industrial levels by ensuring that more than 20% of all road transport vehicles be electrically driven by 2030. This translates to over 100 million cars, 400 million two and three wheelers. The Paris Agreement was enforced in Kenya on 27th January 2017. In Kenya Transportation using ICE is expected to account for 17% of total GHG emissions by 2030 (Government of Kenya, 2018)[2], thus an urgent need to adopt Electric Vehicles

Globally, there were about Ten million electric vehicles by end of 2020 with china and Europe being the world's largest EV markets and an increased worldwide Electric Vehicle registration by 41% (IEA, 2021)[3] Despite this increase, Africa is still lagging behind on uptake of electric vehicles. Kenya imported 327,176 Vehicles including motorcycles and three wheelers in 2019. (KNBS, 2020)[4]. This is despite the milestones and incentives given by the government of Kenya. Plans are underway to install electric vehicle chargers along major highways by Kenya Power PLC.

Installation of chargers will increase Maximum electricity demand which was 1926 MW for 2019/2020 with an average annual increase of about 4.96% since 2015/2016 against installed and effective capacities (MW) of 2840 and 2708 respectively (KPLC, 2020).[1].This is likely to affect power quality of the grid and might increase system losses which stood at 23.5% of purchased energy for 2019/2020. (KPLC, 2020).[1]

Table 1. Kenya's Power Statistics 2015- 2020

Power Statistics	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
System Peak Demand (MW)	1,586	1,656	1,802	1,882	1,926
System Load Factor	70.6%	70.3%	67.8%	69.7%	67.9%
Sales % of Energy Purchased	80.6%	81.1%	79.0%	76.3%	76.5%
Losses as % of Energy Purchased	19.4%	18.9%	21.0%	23.7%	23.5%
Annual Growth: - Energy Purchased	5.8%	3.9%	4.9%	7.4%	-0.3%

Source: KPLC annual report and financial statement 2020

In this regard, this research paper looks at the impact of electric vehicle integration into the Kenyan electricity distribution network, progress of EVs adoption in Kenya and, challenges faced as the country adopts EVs

2. Overview of electric vehicle type and effects on distribution network

There are three major categories of EVs; battery electric vehicles (BEV), plug-in hybrid (PHEV) and hybrid electric vehicles (HEV).

Battery electric vehicles (BEVs), these are pure electric vehicles powered entirely by electricity. Battery electric cars are powering by plugging into a public or at home charge point and accessing energy from the grid. An Inverter converts the electric current in the form of Direct Current (DC) into Alternating Current (AC) The electricity is stored in rechargeable batteries. These batteries power the electric motor (instead of an internal combustion engine).

Plug-in hybrids (PHEV) combine a gasoline or diesel engine with an electric motor and large rechargeable battery. Like the BEVs, the electric battery can be charged using an external charger, and it uses conventional fuels for its second motor in the same way as the Conventional Hybrids.

Hybrid electric vehicles are a type of vehicle driven by two propulsion systems, a conventional one, consisting of an internal combustion engine and an electric one, consisting of one or more electric motors [10].

Adoption of electric vehicles in power networks has the following effects:

- Power demand increases.
- Increase in short-circuit currents.
- Violations of the voltage level regulated limits.
- Reduced lifespan of the power equipment.

3. Case study.

The case study is performed on 8 bus system (fig.2.) a section of kplc Kisumu distribution network, for a day, using specialized software (Digsilent). The impact regarding the voltage level, power demand and active power losses for different penetration levels and power demand scenarios of the electric vehicles is analyzed. Power demand scenarios takes in consideration that users can charge their electric vehicles simultaneously or they can charge their electric vehicles starting at different hours, for different models of EV. The EVs are connected on a low voltage bus as shown in the (fig. 2.).

Summary of analyzed EVs battery capacity and their respective charging duration is presented in table 2.

Table 2. EVs battery capacity and charging duration.

Electric Vehicle	Battery Capacity (KWh)	Regular Charging at home (22 kw) (h	Regular Charging at Station (22 kw) (h)	Fast Charging duration at Station (50KW DC) (h)
Nissan Leaf	40	19	8	1
Renault	41	19	8	1
BMW i8	42.2	20	4	1
Tesla model s	100	33	6	1.3

In this case the charging is uncontrolled taking into account the dynamic nature of power consumers. Power demand and voltage profile levels are thus analyzed within a period of 24hours.

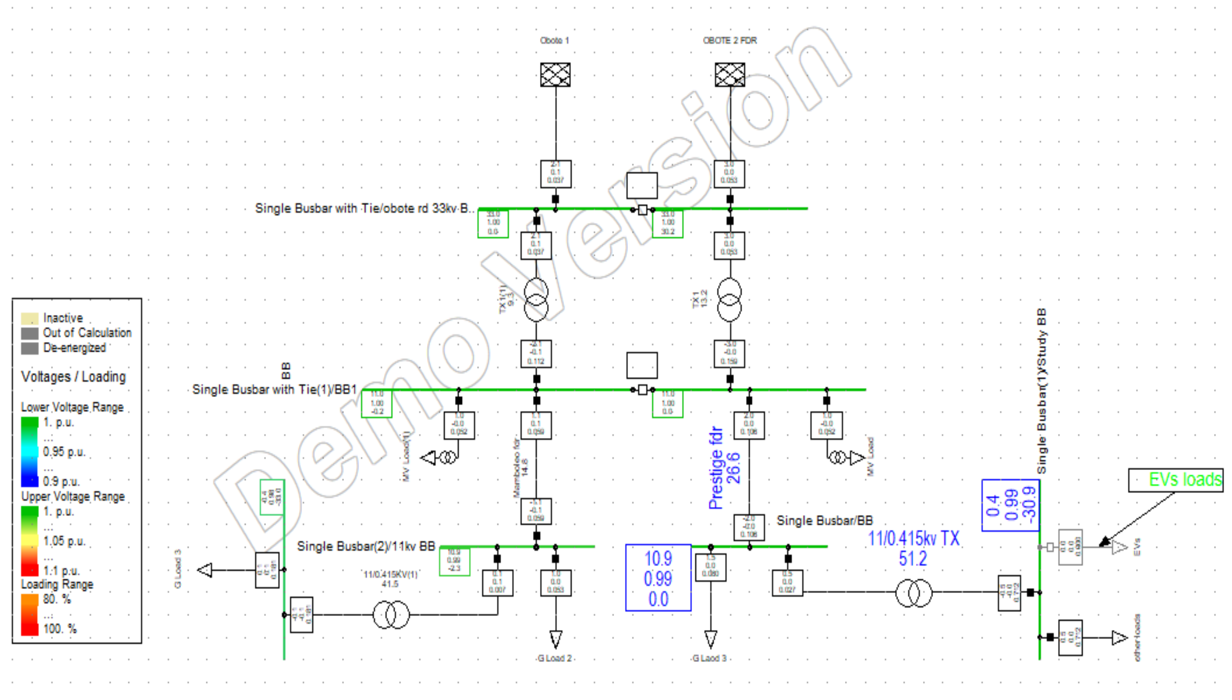

Fig. 2. 8 bus Kisumu distribution network.

Power demand is as shown in fig. 3

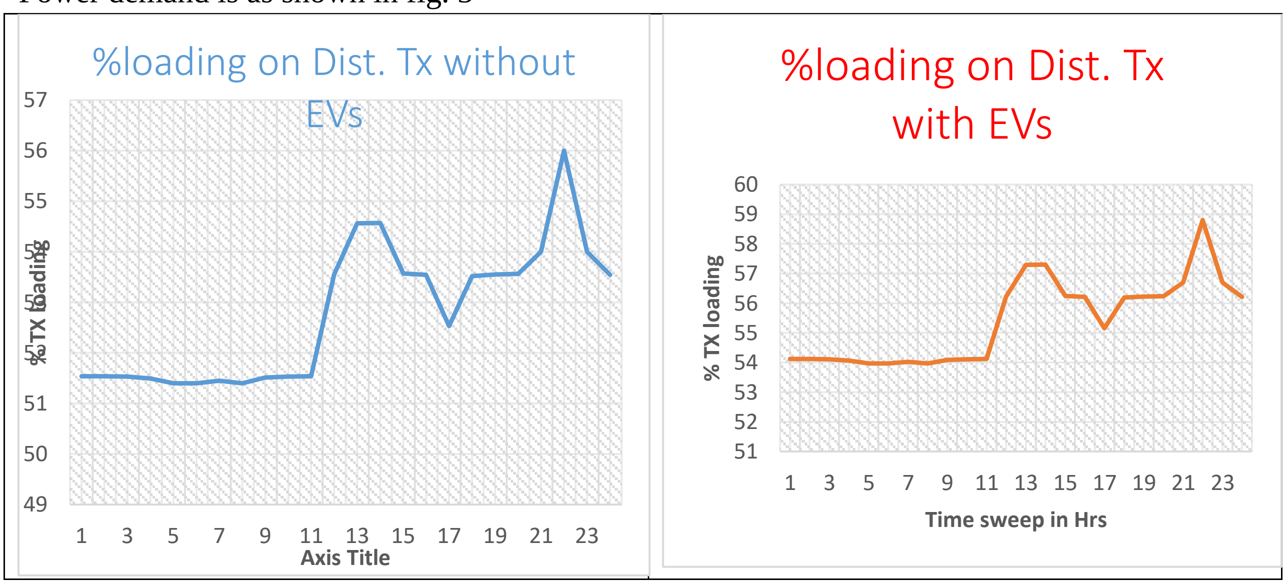

Fig. 3. Power demand of the system without and with EVs respectively.

From the simulation results the voltage level decreases, but is remains within the regulated limits of 0.9-1.1 p.u. In fast charging the voltage level decrease is higher than regular charging due to the high power demand in a shorter amount of time. The comparison of the power losses depends on the power demand in the respective case. The increase in power demand as observed pushes the loading on the distribution transformer to the bottle neck in this case. The power losses are lower in the uncontrolled mode. However, the unpredictability of the power demand in the uncontrolled charging can cause problems for the grid operator, therefore the best option for charging is the controlled one.

4. Milestones, Challenges and way forward of EV in Kenya

With the Maximum peak demand of power being less than 70% of the Installed capacity and enhanced reduction of system losses, there shall be enough power to kick start massive EV rollout.

Higher importation costs of EV as compared to ICE vehicles has decelerated the rollout of EVs. The government of Kenya through finance Act of 2019 caped the Exercise duty for EVs at 10%.

There are no standards governing Electric vehicles, Chargers and Batteries in Kenya. However, KEBS is currently working on EV standard ‘’Electric Power train specifications’’[5]. Meanwhile adoption of international standards and regulations as well as formulation of friendly policies is inevitable for the successful rollout of EVs in Kenya.

More government initiatives like last mile, rural electrification program, Kenya Off-Grid Solar Access Project (KOSAP), shall ensure countrywide electricity supply. This shall open up remote regions for installation of more charging points in addition to those that shall be installed by Kenya Power. More public (Counties, KENHA, KURA, KERRA, KURA) and private partners need to be onboard for successful rollout of EVs.

Environmental preservation should also be ensured especially on batteries. Recycling, reuse or safer disposal mechanisms should be put in place. This calls for adequate Public and Private Partnership as well as public awareness on the same as well as enhanced research on best technologies.

5. Conclusions

From the case study performed for a day it’s clear that the voltage levels tend to reduce when EVs are introduced in the network. This in effect leads to operations of automatic voltage regulation devices in the system mostly tap changers. However for areas with transformer with off load tap changer there is a risk that with the penetration of EVs the areas are likely to be subjected to poor voltages from the grid.

From the analysis power demand rise does not lead to over stressing of the existing network structures, however with increased adoption of EVs in Kisumu and Kenya at large it’s evident that some of the equipment will be stressed.

It’s clear that as kplc plans and embraces the EVs charging station they will be need on uprating some power infrastructures. Adoption of EVs in Kenya will not only increase kplc power demand Vis installed capacity but also reduce on the fossil gas emissions.

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