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CASE STUDY

Electric vehicle retrofitting: A case study of Electric Powered Vehicles Africa

A Mpumalanga-based company has addressed the electric vehicle (EV) access challenge that is experienced by fleet owners through the retrofitting of existing internal combustion engine (ICE) vehicles to electric.

List of acronyms:

EV	Electric vehicle
EPVA	Electric Powered Vehicles Africa
ICE	Internal Combustion Engine
NRCS	National Regulator for Compulsory Specifications
NRTA	National Road Traffic Act

1. Purpose

This case study describes the innovation of retrofitting of internal combustion engine (ICE) vehicles to electric in Mpumalanga, as a decentralised, localised and sustainable solution to the challenges that are preventing fleet owners from going electric. Electric Powered Vehicles Africa (EPVA) is one of the leading electric vehicle (EV) retrofitting companies in South Africa. The rising cost of fuel, with particularly large increases during the COVID-19 pandemic (2020 to 2021), has extended to further sharp rises in 2022. This has been a key driver of fleet owners looking to procure electric vehicles as a possible solution to save on fuel costs. This case study highlights the potential for the retrofitting of ICE vehicles to electric for fleet owners.

This case study is written for: Fleet owners in the last-mile delivery, tourism, agriculture and mining industry that are exploring operational cost-saving and sustainability measures.

2. Challenge

EVs are typically imported into the South African market and are either too expensive or are not suitable for fleet applications such as last-mile delivery, tourism, agriculture and mining. The South African automotive manufacturing industry has not yet adapted production lines to supply EVs to the local or export markets. This is due to a range of factors such as the scale of the local market, uncertainty with regard to electric mobility policy and EV manufacturing support (e.g. EV production subsidies). This creates an access challenge for fleet owners that wish to transition to electric vehicles to save fuel costs, but are unable to do so due to cost and availability of suitable vehicles.

The manufacturing of electric vehicles is a resource and energy intensive process, in particular the manufacturing of lithium-ion cells for batteries which require the use of rare earth minerals. The transition to electric vehicle manufacturing in South Africa may have short to medium term resource and supply chain challenges, in part due to the geo-politics associated with the input materials. There is a need for a more circular, low energy intensity approach towards electric vehicle production. Retrofitting and the use of second life battery packs offers such a solution.

Key insights:

- Retrofitting of existing ICE vehicles to convert them to EVs is an innovative means to enable access to EVs in the South African context.
- Although there is a relatively long payback period, there are operational costs benefits for retrofitting EVs both in terms of predictability of cost and relative operating cost compared to ICE vehicles, as well as environmental benefits including no emissions or noise at point of use.
- When retrofitting using second-life EV batteries there are also longer-term resource efficiency, supply chain and circular economy benefits.

3. EV retrofitting as an innovative solution

EV retrofitting is a decentralised, localised and sustainable approach towards addressing the accessibility of electric vehicles for fleet owners. The process of EV retrofitting allows vehicle owners to extend the life of their existing ICE vehicles through electric conversion. This could amount to an additional 10 to 15 years of additional lifespan depending on the battery pack that is used. Retrofitting involves the removal of the internal combustion engine, exhaust
and fuel tank and replacing them with an electric powertrain and a battery pack.

The body of the vehicle remains intact which reduces the cost of producing an electric vehicle. Fleet owners generally allocate budget for fleet replacement annually. The commercial lifespan of an ICE vehicle is generally between five to seven years, depending on the application. The annual fleet replacement budget could instead be used to retrofit existing vehicles to electric when they reach the end of their lifespan. Electric vehicle retrofitting is therefore an elegant solution to the access challenge by creating a mechanism for fleet owners to access electric vehicles that are fit for purpose and more affordable than purchasing a new electric vehicle.

[1]EV retrofitting is the process of converting an ICE vehicle to electric through the removal of the internal combustion engine, exhaust and fuel tank and replacing them with an electric powertrain and battery pack

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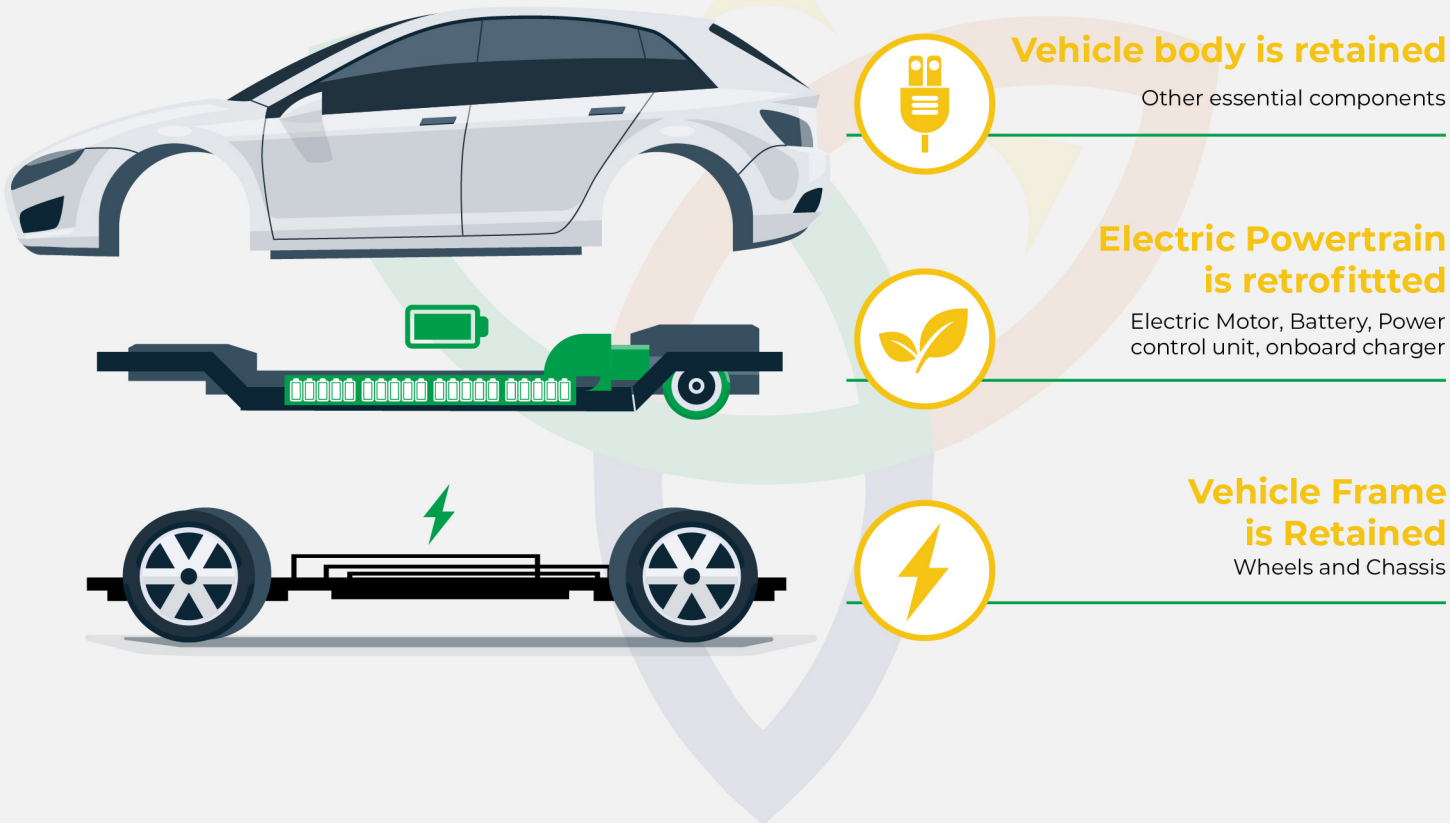
A further innovation in the case of Electric Powered Vehicles Africa (EPVA), a Mpumalanga-based electric vehicle retrofitting company, is the use of second life lithium-ion battery packs sourced from used electric vehicles in Europe. The particular battery packs that are used have a remaining lifespan of up to 90% of their original expected lifespan and are still productive in the context of EV retrofitting. This is an example of a circular approach to the management of end-of-life lithium-ion battery packs from the growing global EV industry, which insulates EPVA from supply-chain pressures which are currently affecting EV manufacturers.

Fig 1. Showing the electric vehicle retrofitting process (Source: Zunjurkar, 2021)

4. Sustainability impact of EV retrofitting

In addition to addressing the challenge of EV access for fleet owners, retrofitting accelerates the electrification of fleets with lower resource and energy consumption compared to the manufacturing of new EVs. The worldwide consumption of steel and aluminium metals in the transportation sector is estimated to be 17% and 27% respectively of the world's total usage of these important metals. EV retrofitting retains much of the vehicle body and chassis which means less raw materials are consumed in the conversion process than would be in the production of a new EV.



The share of plastics used in the manufacturing of vehicles has been steadily rising, which is problematic with regards to the transition away from fossil fuel based industries and the move towards a low carbon economy in South Africa by 2050 . The ongoing global semi-conductor chip shortages, which started during the COVID-19 pandemic, exposed the vulnerability of electric vehicle manufacturing supply chains . New EVs have complex electronics and are also heavily dependent on rare-earth magnets, which are used in electric motor technologies, and lithium, cobalt and graphite, which are used to manufacture battery cells. This further builds the case for electric vehicle retrofits with reused batteries as a sustainable solution for the EV transition in South Africa.

EV battery packs contribute significantly to the negative environmental impact of EVs from a total lifecycle analysis point of view.

[8]EPVA's use of second life battery packs in their retrofitting process provides a circular solution to the disposal challenge associated with end of life batteries as well as minimising energy and resource use associated with the manufacturing of new lithium-ion batteries for the EV industry.

Rare and valuable materials such as lithium and cobalt are often mined from environmentally sensitive ecosystems and in many cases are tainted by other social issues. This approach to EV access therefore contributes holistically towards ensuring that the EV transition in South Africa is sustainable.

5. Regulation of EV retrofitting

In order to be able to sell retrofitted vehicles on the South African market certain legislated processes need to be followed. The National Regulator for Compulsory Specifications (NRCS) is the designated authority assigned by the Department of Trade, Industry and Competition with a mandate to oversee compulsory specifications and technical regulations.

The Automotive Department of the NRCS has been appointed by the National Department of Transport as per the National Road Traffic Act (NRTA) to be the inspectorate for all Manufacturers, Importers and Builders (MIB) of motor vehicles in South Africa. Regulation 38 of the NRTA requires that all manufacturers, builders, importers and modifiers of motor vehicles to be registered as an MIB. EV retrofitters in South Africa would have to register as a "builder".

According to the NRCS, a builder is defined as: "Any person who manufactures or assembles motor vehicles in whole or part from used components or modifies motor vehicles using new or used components". After registration, the homologation process as per the published guidelines should be followed . (Homologation is the approval process to enable the vehicle to be sold on the market).

6. Company background - Electric Powered Vehicles Africa (EPVA)

Electric Powered Vehicles Africa (EPVA) is an EV start-up based in Mbombela, Mpumalanga, that is rapidly scaling its operations. EPVA specialises in converting internal combustion engine vehicles into EVs. They initially started with the retrofitting of safari game viewing vehicles for various private game reserves in Mpumalanga. This was driven by the need for game viewer fleet owners to save operational costs in the context of fluctuating fuel prices. In addition, electric game viewing vehicles are sought after due to their "quiet" nature which prevents wildlife from being frightened away during safari tours.

Electric game viewing vehicles do not have greenhouse gas emissions at the point of use and could be considered to be a low carbon solution on a life-cycle basis, if renewable energy is used to charge the vehicles. The use of EVs improves the sustainability of safari tours which in turn attracts more eco-conscious tourists. EPVA has completed the electric retrofitting of 12 safari game viewing vehicles to date and has subsequently diversified into the last-mile delivery space with the conversion of a light delivery vehicle for an online grocery delivery service provider in Mbombela. Research and development is currently underway with regards to the design, wiring diagrams and systems for the retrofitting of agricultural and mining vehicles as future growth markets. They currently have 42 permanent staff members and have completed R27 million worth of EV retrofits to date in Mpumalanga.

As of October 2022, EPVA has a pipeline of 30 planned EV retrofit projects with an estimated value of R60 million.

7. Operational cost benefit analysis

Fleet owners have been experiencing increasing fuel price increases post the COVID-19 pandemic and this has continued into 2022. For comparison purposes, an ICE vs electric game viewer is used as an example to calculate the operational cost per km in Rands. The cost of electricity in Mbombela for commercial users such as fleet owners is 223.90c per kWh . This means that the electricity cost to charge an electric vehicle privately at a fleet depot would cost approximately R2.24 per kWh. The range of an electric retrofitted vehicle is approximately 300km on a fully charged 55kWh battery pack. It would cost approximately R123.20 to fully charge a 55kWh battery which equates to 0.183kWh of energy consumption per km. The cost per km to operate an electric game viewer would therefore amount to R0.41 per km.

The current fuel price in Mpumalanga (October 2022) is R22.06 per litre for petrol and R24.15 per litre for diesel . The fuel consumption of a game viewer that uses petrol is 0.077 litres per km and 0.076 litres per km for the diesel variant . That means that its costs R1.69 per km to drive a petrol powered game viewer compared to R1.84 per km to drive a diesel powered game viewer.

According to Steve Blatherwick, the CEO of Electric Powered Vehicles Africa, the lifespan of the second-life lithium-ion battery packs that are used in the EV retrofits amounts to roughly 15 years, and it takes 4-5 hours to fully charge. Retrofitting a game viewer vehicle to electric would create savings of approximately R140 160 per year using a petrol powered baseline and R156 585 in savings per year from a diesel baseline. Using this savings model, the payback period with regards to electric vehicle conversions is approximately 10 years depending on the storage capacity (in kWh) of the battery pack that is used.

It is also noted that electric vehicles have fewer moving components as part of the electric drive train and therefore have a lower maintenance requirement. This reduction in maintenance costs will therefore be passed onto the fleet owner as well.

Table 1: Showing an operational cost benefit analysis between an ICE and electric game viewer vehicle

Parameter	Petrol Game Viewer	Diesel Game Viewer	Electric Game Viewer
Fuel Type Used	Petrol	Diesel	Electricity
Fuel Consumption (per km)	0.077 litres	0.076 litres	0.183 kWh
Fuel Price (Rands)	R22.06 per litre	R24.15 per litre	R2.24 per kWh
Cost per km (October 2022)	R1.69	R1.84	R0.41
Cost per Day in Rands (Average 300km per day)	R507	R552	R123
Cost per Year (Rands) **Average 109 500km per year**	R185 055	R201 480	R44 895
Fuel Cost Savings per Year Due to EV Conversion (Rands)	R140 160	R156 585	-

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