Prof. Thinus Booysen

The minibus taxi in the process of being retrofitted for electric propulsion.

ON THE BUMPY ROAD TO electric mobility in SA: a second life for combustion engine minibus taxis

A research team from Stellenbosch University joined forces with Rham Equipment to retrofit a minibus taxi with electric propulsion. This is the first electric taxi of its kind in South Africa. Electric vehicle manufacturers in South Africa have a window of opportunity now to open plants in Africa to produce electric vehicles locally. Most of the locally manufactured petrol cars are being exported, but this boon to the economy will end with developed countries transitioning to electric vehicles in the run-up to (or before) 2035. This is according to Prof. Thinus Booysen of the Department of Industrial Engineering at Stellenbosch University (SU).

"Remaining in the slow lane of the electric vehicle transition could put thousands of jobs at risk," says Booysen, who holds the research chair in the Internet of Things. "The automotive industry and our government cannot afford to be asleep at the wheel."

Leading the way in this regard, Booysen and his team at SU joined forces with Rham Equipment to retrofit a minibus with electric propulsion. This means converting a petrol or diesel minibus to an electric vehicle.

This prototype electric taxi, which will be used to prove the concept and for testing, was recently completed and is operational. It is currently being tested for road safety, after which performance testing will commence. The South African National Energy Development Institute (SANEDI) provided funding for the retrofit, and Transport Services at SU donated one of the minibuses in its fleet.

The project manager at SANEDI, Dr Neville Smith, expressed his excitement about this novel approach to retrofitting normal combustion engines with electric vehicle engines, emphasising that this initiative will contribute extensively to achieving our national climate change objectives and targets.

Booysen says the first retrofitted minibus is just the beginning.

"More than 70% of the trips in South Africa are by minibus in the informal sector, which is why we are hoping to encourage the retrofitting of some of the 250 000 minibuses in the country with electric propulsion. These will be cheaper and much more environmentally friendly than new electric vehicles. With this venture, we want to help build the skills that will be needed to manufacture electric vehicles locally and also create awareness about how much we could save with electric taxis."

According to the CEO of Rham Equipment, Kevin Reynders, "Groundbreaking innovation and local skills development

are at the core of our company's ethos. Working on this project with Stellenbosch University allowed us to plough back into engineering students' development and to contribute to sustainable mobility in South Africa's dynamic vehicle landscape."

One of Booysen's team members, Stephan Lacock, who is doing his master's degree in electronic engineering at SU and is funded by Golden Arrow Bus Services, helped design the retrofitted minibus with partners at Rham Equipment.

Lacock says they removed the internal combustion engine of the minibus and its associated components such as the petrol tank, manual transmission, gas pipe and radiator. He adds that throughout the development process, the retrofit needed to comply with national road safety regulations, particularly the strict requirement not to make any permanent changes to the minibus chassis (base frame), such as drilling or welding and specific weight requirements.

"Overcoming design challenges, Rham Equipment and our research team have successfully created a reproducible 'kit' that includes the main components of the electric powertrain or system that propels the vehicle forward. These include an electric motor, inverter, charger, electronic control unit, and a single-speed reduction gearbox. The powertrain is skilfully connected to a custom-designed battery pack that meets the specific operational needs of a minibus."

Lacock says one of the standout features of the retrofitted minibus is its advanced regeneration system that harnesses energy generated during deceleration and downhill driving, enhancing the vehicle's energy efficiency and overall range.

"As a result, the minibus is now equipped to travel an estimated range of approximately 120 km, with a maximum speed of 120 km/h. It has an electric motor power of 90 kW and a battery capacity of 53.76 kWh. This ensures that it meets all load and driving requirements comparable to those of traditional internal combustion engine minibuses. Moreover, the electric powertrain brings enhanced agility and an exhilarating driving experience to the minibus."

"Thanks to the inclusion of a 20 kW charger, the minibus can be efficiently charged in just over two hours."

Lacock says it is important to keep in mind that this is just the initial model, and that future iterations and advancements in technology will likely lead to more improvements in charging times, longer ranges by increasing the battery capacity, and overall performance.

Although Booysen is optimistic about the retrofitting of taxis, he is also mindful of the challenges related to powering them in a country where the national grid already operates at half its capacity.

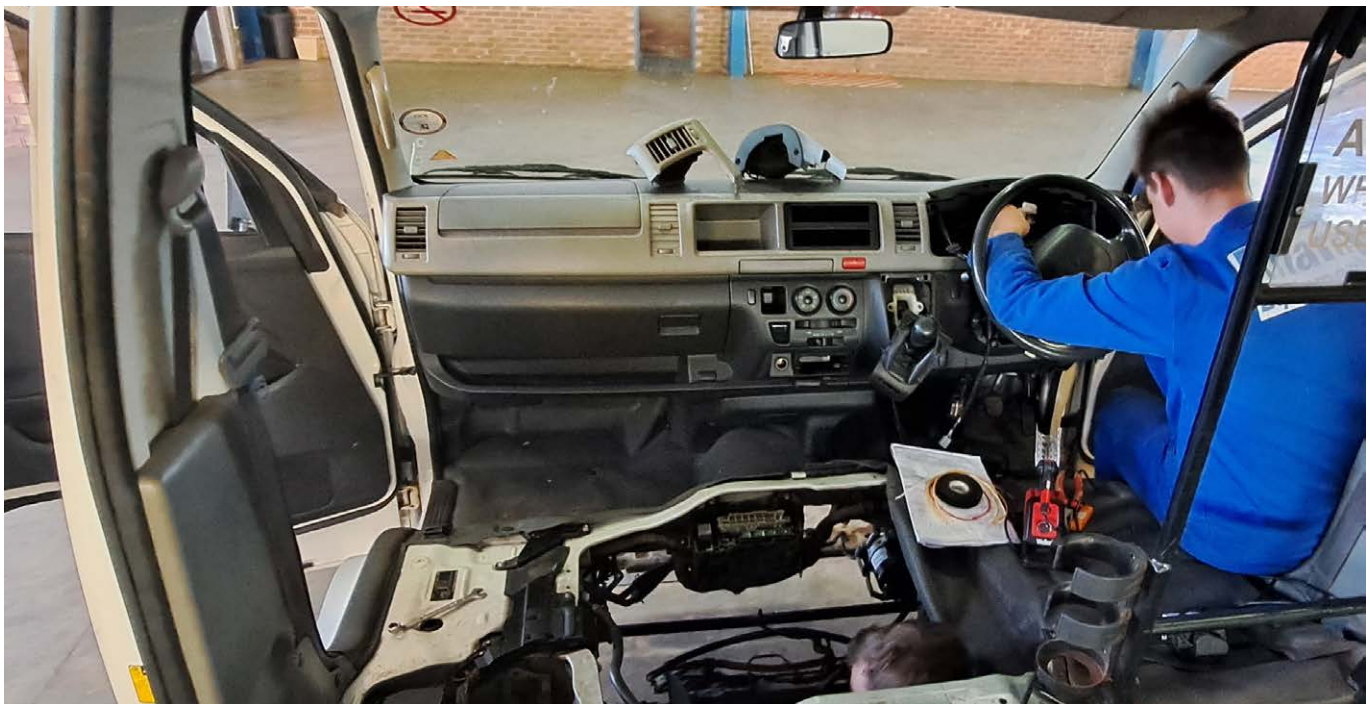
"We need to look at what the impact would be if we add an extra load of electric vehicles to the grid. Given that people who can buy electric vehicles can also afford to install fast chargers, the impact of those vehicles will quickly slay a grid already on its knees."

"With petrol and diesel vehicles, we could drive to the nearest gas station because there was adequate infrastructure, sufficient 'range' on a tank, and the refilling was quick. With electric vehicles, the problem is the 'filling' takes a long time, and the range and energy source are limited."

Echoing Booysen's sentiment, PhD student and team member Johan Giliomee says the expected charging times that result from the way minibus taxis operate is a concern because of the additional load the simultaneous charging will put on the grid.

"Research results show that electrifying all minibus taxis in South Africa could add a load of 5% of what the grid can currently deliver.

"As most taxis have similar operational hours, peaking before and after the workday, their charging opportunity



window also aligns. This will result in a significant peak power draw that needs to be accounted for when planning for the electrification of the minibus taxi sector. In addition, the total energy required for a given operational period also requires in-depth analysis."

Giliomee points out that minibus taxis could be supplied with electricity through the installation of solar panels and battery energy storage systems at taxi ranks. Hydrogen could also be used as an alternative electricity source or for interim energy storage.

Given the current severe electricity constraints, Booysen suggests moving the national discussion from electric vehicles to a system perspective of electric mobility to include the decentralised provision of electricity.

"We must think anew about how we buy a car; it must be sold as part of a mobility package, that is, the car, solar panels and a large battery as a system, rather than just an electric car that will mess up our grid and will be restricted by our grid."

Booysen says in the next phase of the project they will collaborate with Rham Equipment and Golden Arrow Bus Service to retrofit one of the company's buses.

- Stellenbosch University

Tshigwada tsha thoduluso iyo ubva ngei gudedzini la stellenmbosch vho tanganya mannda Na tshiimiswa tsha Rham equipment u vusuludza dzangano la dzi thekhisi nga mudagasi. Ndi thekhisi ya uthoma ya mudagasi kha la South Africa.

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