# Vehicle-to-grid Policy in South Africa: State-led v. Market-directed Approaches

*Fadiel Ahjum* [a] *and Andrew Lawrence* [b]

## 1. Motivations underlying the research

For economic, no less than ecological and energy security reasons, transitioning from coal to less expensive, cleaner, and more reliable renewable energy sources has become increasingly urgent for South Africa. Energy parastatal Eskom provides more than 90 percent of the country's electricity, and depends on coal for more than 90 percent of its generation; yet this source is proving to be increasingly expensive and unreliable, with power reductions and outages costing more than 1 percent of GDP loss in recent years. While the country's world-class wind and solar endowment has already proven to be less expensive than current (let alone new) coal and gas generation, it presents the challenge of intermittent generation, and thus of energy storage.

This article presents the first exploratory study of a solution to South Africa's energy storage challenge that would cost a fraction of the chronic blackout losses: the provision of bi-directional or Vehicle-to-Grid (or V2G) charging infrastructure, using electric vehicle (EV) batteries as complementary storage. Because South Africa's current rate of electric vehicle uptake is low compared to most Organization for Economic Cooperation and Development (OECD) countries, we explore the option of providing V2G infrastructure to the most widely used subgroup of vehicles for mass transportation, minibus taxis. An additional advantage is that, because the minibus taxis are heavily concentrated in urban areas with relatively short commuting routes (well within the typical electric minibus range of 150-200 km per charge), the oft-cited "range anxiety" that prospective electric vehicle drivers face is far less of a concern.

We model for the effect of V2G adoption v. the rollout of uni-directional EV charging infrastructure, while also comparing stipulated charging – using time slices (TS) to account for daily variation in demand, such as morning and evening commutes – to unstipulated charging. Whereas uni-directional infrastructure is less expensive, it does not afford the storage capacity of V2G infrastructure. With approximately 300,000 minibus taxis currently in use in South Africa, the combined storage potential of a completely electrified fleet would approach 6 GWh—almost twice that of the country's combined pumped storage capacity.

## 2. A short account of the research performed

Our study provides the first national modelling study investigating the feasibility of adapting V2G policy to an African context. To this end, we use the South African Times model (SATIM) for energy and transport, and for economic modelling, the South African General Equilibrium model (SAGE), together known as SATIMGE. We calculate alternative scenarios to 2050, using 2030 and 2040 as milestone years for a scenario of V2G against a reference scenario of no V2G. We assume purchase parity for all EV vehicle types by 2030. Taking into account the two variables of the presence or absence of V2G infrastructure and of time slice charging stipulations yields five scenarios: (1) Minibuses are provided with V2G charging stations, including time slice (TS) charging stipulations; (2) Minibuses are provided with V2G charging stations, excluding TS charging stipulations; (3) No investment in either EV charging infrastructure, or in V2G infrastructure, excluding TS charging stipulations; (4) Investment in EV charging infrastructure, but not in V2G infrastructure, including TS charging stipulations; and

a Energy Systems Research Group, Dept. of Chemical Engineering, University of Cape Town Rondebosch, Cape Town, 7700, South Africa. mf.ahjum@uct.ac.za

b Corresponding author. School of Governance, University of the Witwatersrand 1 Jan Smuts Avenue, Braamfontein, Johannesburg, 2000, South Africa. Andrew.Lawrence@wits.ac.za

(5) Investment in EV charging infrastructure, but not in V2G infrastructure, excluding TS charging stipulations.

### 3. Main conclusions and policy implications of the work

We find that from the exclusive perspective of maximizing renewable energy generation capacity, the most preferable scenario would be (2): minibuses are provided with V2G charging stations, excluding TS charging stipulations; followed by (4): investment in EV charging infrastructure, but not in V2G infrastructure, including TS charging stipulations; (3): no investment in either EV charging infrastructure, or in V2G infrastructure, excluding TS charging stipulations; (1): minibuses are provided with V2G charging stations, including time slice (TS) charging stipulations; with (5): investment in EV charging infrastructure, but not in V2G infrastructure, excluding TS charging stipulations, being the least preferable. Our findings suggest that V2G policy could increase storage capacity by ~4-6 GWh: almost 25 percent of current levels. As presently configured in the model, therefore, V2G policy with an emphasis on the minibus taxi as an energy service provider could potentially play a role in the electricity sector by 2040 if network augmentation costs are addressed along with flexible charging infrastructure.

Several policy implications may be inferred from these findings, albeit ones that are contingent upon model refinement, future cost inputs (e.g. for batteries and V2G infrastructure), and specificities of policy implementation. If EV battery prices or estimated feasible minibus battery capacity maintenance level should fall further than estimated, the scenarios excluding V2G infrastructure could become more competitive. Conversely, a price rise (or bottlenecks in scaling up battery production) could make the minibus V2G scenarios more attractive. The level of interest in minibus V2G implementation is most obviously contingent upon engagement with the minibus taxi industry, and the state's terms of inducement to convert the taxi fleet. Uncertainties pertaining to these and other variables may suggest the desirability of engaging in policy experimentation at the local or provincial level as a precondition for national policy adoption.