Drivers Impacting Battery Electric Vehicle Monthly Repayments

Author: Nalini Sooknanan Pillay
Dpt of Industrial Engineering, Stellenbosch University, Private Bag X1, Matieland, 7602, S.A.
Eskom SOC
Private Bag 40175, Cleveland, 2022, S.A.
Fax: +27 86 663 9159
Email: pillayna@eskom.co.za

Co-author: Alan Colin Brent
Dpt of Industrial Engineering & Centre for Renewable and Sustainable Energy Studies, Stellenbosch University, Private Bag X1, Matieland, 7602, S.A.
Sustainable Energy Systems, Engineering and Computer Science, Victoria University of Wellington, 6140, New Zealand
Email: alan.brent@vuw.ac.nz

Co-author: Josephine Kaviti Musango
School of Public Leadership, and Centre for Renewable and Sustainable Energy Studies, Stellenbosch University, Private Bag X1, Matieland, 7602, S.A.
Email: jmusango@sun.ac.za

Keywords: Battery electric vehicles; monthly repayments; system dynamics, production costs

The South African national focus on reducing carbon emissions has given rise to various technological initiatives, including green transport technologies incorporating battery electric vehicles (BEVs), as part of the Department of Energy's Green Transport Strategy (DOT, 2016). The market penetration rate of BEVs is dependent on various factors including subsidies, tax rebates, charging infrastructure, improved battery technology and retail prices. This study explored the impact of the changes in the drivers which affected the retail price (fuel cost, import taxes, battery cost and government subsidies) and compared the BEV monthly repayments to those of the internal combustion engine vehicles (ICEVs), using a system dynamics model known as E-StratBEV (Pillay, Brent, & Musango, 2018). These factors were mathematically linked in a stock-flow-feedback structure using a system dynamics methodology to run scenarios, thus establishing which drivers resulted in the lowest monthly repayments for BEVs. The software used for this study was iSee Stella 10.0.6 (iSee Systems, 2016).

Figure 1 shows the causal loop diagram (CLD) of the factors affecting BEV market penetration and monthly repayments that were considered in this study. **BEV Attractiveness Loop (R1):** BEV production costs are significantly influenced by the cost of the lithium-ion batteries (limit control). If the battery costs decrease, then the overall BEV production costs will drop, thus resulting in a lower retail vehicle value. The retail cost is also impacted by import taxes (currently at 41%) and if import taxes decrease, the overall BEV retail cost similarly decreases. Lower retail costs allow for lower BEV monthly repayments. With lower BEV monthly repayments, BEVs become more attractive and affordable to the average consumer who then proceeds to purchase BEVs, thus increasing the market penetration for BEVs. This ultimately increases the substitution of ICEVs with BEVs. **Manufacturing Incentive Loop (R2):** The need for more BEV market penetration results in manufacturing subsidies being used to incentive producers of electric vehicles for large volumes of BEVs. The introduction of manufacturing subsidies reduces the production cost, and leads back into reinforcing loop R2. **Internal Combustion Engine Vehicle Attractiveness Loop (B1):** ICEVs result in high carbon emissions, which reduce the attractiveness of ICEVs that then decreases the overall number of ICEVs in the passenger car market. Fuel cost is also a deterrent and limit control on ICEV attractiveness for the lower and middle income groups. Factors such as the exchange rate and the oil price impact the cost of fuel required for ICEVs. If the fuel cost decreases then the number of ICEVs increases but this then results in increased carbon emissions in the transport

sector. The carbon emissions then result in a penalty for commuters', which further reduces the attractiveness of ICEVs, again increasing ICEV substitution with BEVs.

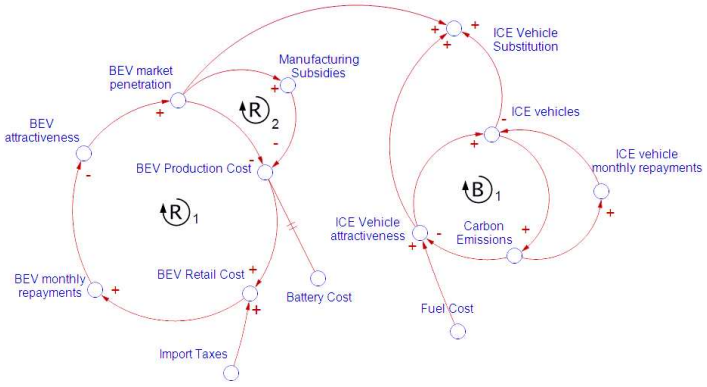

Figure 2: Causal Loop Diagram of Factors Impacting BEV Market Penetration

Before commencing with the model structure, data mining and preliminary was necessary using MS Visual Basic sub-routines and regression analysis. In the case of the ICEV monthly repayments, a fixed retail price for an ICEV (R222 000) was added to the ICEV fuel costs and ICEV insurance costs, equivalent to a Nissan Tiida. A BEV retail price equivalent to a Nissan Leaf of R400 000 was used. Calculations were made for a 5 year payment period, 14% VAT and 12% interest rate. BEV insurance was set at 25% more than that of the ICEV. The monthly repayments for ICEVs was a constant R5 679.

Monthly repayments for BEVs, with no drivers, was R8 174. Results show that this decreased to R5,245 with a reduction in battery costs, to R4 949 with the introduction of government subsidies, and to R7 375 as a result of import tax reduction. The combined impact of all the drivers affecting BEVs resulted in a monthly repayment of R2 339 which is significantly lower than the ICEV repayments (R5 679).

Future research could consider the entire value chain for electric vehicles from the raw materials and processing to the manufacturing of the discrete components including the electric motor, transmission, batteries, electronics, capacitors, braking system, structural elements, wheels and tyres, as well as the vehicle base. This will allow for a detailed financial model to be developed to know the cost elements and identify which variable changes will add the greatest benefit for cost reduction.

Acknowledgements to Eskom SOC, Research Testing & Development for the use of data and from the 2015 BEV pilot study and the Eskom System Dynamics CoE for support with the model validation.

References

DOT. (2016, August). *Draft Green Transport Strategy: (2017-2050)*. Chemical & Allied Industries Association: **https://www.caia.co.za/wp-content/uploads/2016/08/Draft%20GTS%20Revised%20v5.pdf**. Retrieved January 17, 2018.

iSee Systems. (2016). *iSee System Products*. Retrieved from iSee Systems: http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx.

Pillay, N. S., Brent, A. C., & Musango, J. K. (2018). *An Adapted System Dynamics Approach to Determine the Linkage Between Battery Electric Vehicle Affordability and Real Disposable Income in South Africa. 29th Annual Conference of SAIIE*. Stellenbosch: SAIIE.