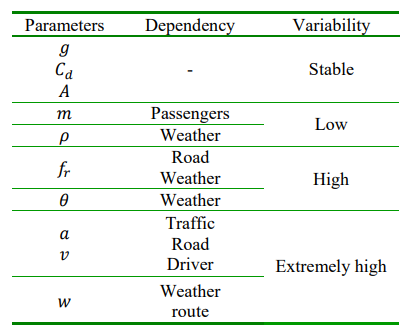
Literature Review

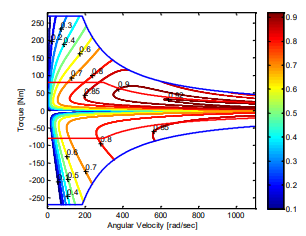
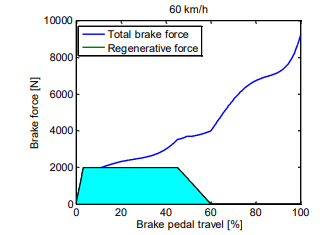
The project is a comparative study of Regenerative Braking Energy recovery between three motors IM, BLDC and SynRM. The project can be broken down into two main segments, the first segment primarily deals with the electric vehicle modelling and driver influence with braking. The second segment comprises of the comparison of the three motors.

Several studies have been performed to develop model and simulate hybrid electric vehicles and Electric vehicles[prf]. The paper by J.Wang, I.Besselink and H.Nijmeijer [prf] proposes the energy consumption modelling and prediction based on road information. It takes into account the dependency of characteristic vehicle parameters on different driving and weather conditions as shown in table 1.

Table : Dependency of Characteristic Parametres.



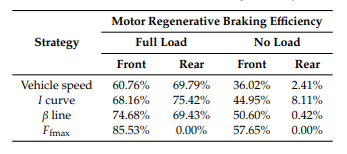
It implements a parallel braking system. It discusses the safe use of the Regenerative braking in the EV. The regenerative braking is a function of the percentage of brake pedal depression. Arguing that at speeds greater than 60km/hr, when the brake pedal is depressed more than 60%, the regenerative braking is reduced to zero and mechanical braking is only applied to ensure braking stability in case of emergency. It also highlights the powertrain efficiency in traction and regenerative braking mode.

A problem regenerative braking Is that current is limited to safe operating region of the batteries, as high currents during regenerative braking decreases the life of the batteries [8]-[9]. A solution to this issue is using flywheel and ultracapcitors for regenerative braking as discussed in this paper by S.Bhurse and A.Bhole which conclues that this combination would lead to an increase of range by 16.25%[x1].

There are many regenerative braking strategies, several papers are published comparing different approaches[x2]-[x3]. The paper by W.Zhang, J.Yang, W.Zhang and Ma[x4] compares four different regenerative braking control strategies for Pure Electric Mining Dump Truck. Vehicle Speed based control strategy, which is parallel braking strategy in which the regenerative braking force increases as the speed of the vehicle increases. This seems a bad approach for braking due to the fact that at high speeds, to maintain braking controllability for safe operation mechanical braking should be engaged. The paper restricts the speed of the vehicle to 15km/hr. I-Curve based control strategy this control strategy is maximum driver feel braking strategy, It follows the I-Curve for front and rear braking forces. β Line control strategy is based on the distribution of axle braking forces are a constant β ratio. The last control strategy is Ffmax based strategy. The paper concludes that Ffmax based strategy improves braking energy recovery compared to other strategies.

Table : Front and rear motor braking efficiency



The experience of the driver also affects the power and energy consumption. An unexperienced driver increases the power need by 36.74% and range by 4.95% in FTP75 cycle. Whereas, an experienced driver reduces the power need by 2.13% in FTP75 cycle and 7.92% in WLTP cycle[x5].

References:  
[8] Pay, S., Baghzouz, Y., “Effectiveness of battery-supercapacitor combination in electric vehicles,” Power Tech Conference Proceedings, 2003 IEEE Bologna, vol.3, no., pp. 6 pp. Vol.3, 23-26 June 2003

[9] Gagliardi, F., Pagano, M., “Experimental results of on-board batteryultracapacitor system for electric vehicle applications,” Industrial Electronics, 2002. ISIE 2002. Proceedings of the 2002 IEEE International Symposium on, vol.1, no., pp. 93- 98 vol.1, 2002

[x1] A Review of Regenerative Braking in Electric Vehicles Sneha S. Bhurse A.A. Bhole

[x4]Research on Regenerative Braking of Pure Electric Mining Dump Truck Wei Zhang \* , Jue Yang , Wenming Zhang and Fei Ma

[x2] Switched Robust Control of Regenerative Braking of Electric Vehicles Xie Jing1, 2, Cao Binggang1 , Zhang Huarong1 , Xu Dan

[x5] A Method to Analyze Driver Influence on the Energy Consumption and Power Needs of Electric Vehicles Rayad Kubaisi, Frank Gauterin, and Martin Giessler