

# Development of battery management systems (BMS) for electric vehicles (EVs) in Malaysia

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**Abstract.** Battery Management Systems (BMS) is an electronic devices component, which is a vital fundamental device connected between the charger and the battery of the hybrid or electric vehicle (EV) systems. Thus, BMS significantly enable for safety protection and reliable battery management by performing of monitoring charge control, state evaluation, reporting the data and functionalities cell balancing. To date, 97.1% of Malaysian CO<sub>2</sub> emissions are mainly caused by transportation activities and the numbers will keep rising as numbers of registered car increase close up to 1 million yearly; double the amounts in the last two decades. The uncertainty of a battery's performance poses a challenge to predict the extended range of EVs, which need BMS implementation of optimization of optimum power management. Hence, using MATLAB/SIMULINK software is one of the potential methods of BMS optimization with power generated by Hybrid Energy Storage system of lithium-ion battery. Therefore, this paper address through reviewing previous literatures initially focuses on the BMS optimization for EVs (car) in Malaysia as prognostic technology model improvement on performance management of EVs.

## 1 Introduction

Battery Management Systems (BMS) is an electronic devices component, connected between the charger and the battery of the hybrid or electric vehicle (EV) systems. BMS can be consider as the brains behind of battery packs or as vital fundamental components of the battery base electrical vehicle. There are two mains critical functions of BMS which are function as safety protection (the most single important) and energy management. Thus, BMS are able to manage the output, command the charge-discharge input and provide notification on the status of the battery packs. They also provide critical safeguards to protect the battery from damage. While for energy management, BMS be able to monitor the state of battery and evaluation such as State of Charge (SOC) and State of Health (SOH) for the purpose of driving range estimation by shown with BMS indicator [1]. This energy management concept is just about the fuel gauge meter that we have in conventional gasoline car or internal combustion engine (ICE).

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The safety and reliability not only subject to the technology of the battery but also the battery management system. For that reason, there is a crucial needs to invent on optimizing vehicle operation and improving battery performance in a safe and reliable manner for a BMS, due to on chemistry history, a lithium-ion battery is possible to explode if overcharged because of instability, entropy changes and flammability. Therefore, BMS functions could be comprehensively determined as for safety protection, data achievement, transport of battery status and authentication to a user interface, ability to control battery charging and discharging, ability to determine and predict the state of the battery, communication with all battery components, thermal management, cell balancing and prolonged battery life. There is an imperative needs to develop a mature and comprehensive BMS for future of overall due to the swift growth global market of the EVs and HEVs [1].

Thus, this present paper is review on BMS, focussing study for optimization of BMS for EVs that will lead to reliability of BMS and optimize power performance of EVs. Analysis from the literature search, there is a need on the improvement of BMS performance in future for EVs. Therefore, Hybrid Energy Storage System (HESS) is the potential outlook of the future BMS which should integrate of ultracapacitor combined with lithium compound battery in order to have prognostic technical model improvement on deploying performance management of EVs. Therefore, there is a very significant for Malaysia to have an expert on the development of BMS due to find a prognostic technology model improvement on performance management of EVs. Since as we know that hybrid car only can deliver less emission compare to EVs can deliver 'zero emission' nor pollution, energy saving and environmental friendly.

## **2 Status electric vehicles (EV) in Malaysia**

Malaysia commencement with green technology initiative on year 2009 when Malaysia Government has committed to reduce greenhouse gases by 40% of year 2005 levels by the year 2020 right after UN Climate Change Summit, Copenhagen (COPs 15) in Denmark. Subsequently, the Malaysian Green Technology Corporation (MGTC) and the Malaysia Automotive Institute (MAI) established as green authority agencies spearheaded with the aims to fast-track the implementation of the Electric Vehicles (EV) policy and regulations for public and private transportation, targeting for 2,000 electric buses and 100,000 electric cars on the road by 2020. On top of that, to emphasis for the development and promotion of green vehicle the Prime Minister of Malaysia was launched the National Automotive Policy (NAP) and the National Green Technology Policy on 24th July 2009. One of the main point stated inside of National Green Technology policy is "Transportation is one of the main emphasized sector that contributed as the 2nd highest for carbon emission. While NAP stated "Promote Hybrid and Electric Vehicles and Development of related infrastructure [2][3].

Malaysia already committed to reduce up to 40% greenhouse gas (GHG) emissions by the year 2020. The study also found that a vast portion of national GHG emissions in Malaysia was coming from the transport sector - in technology journal about Assessment of Greenhouse Gas Emission Reduction Measures in Transportation Sector of Malaysia [4]. To date, 97.1% of Malaysian CO<sub>2</sub> emissions are mainly caused by transportation activities and the numbers will keep rising as numbers of registered car increase closed up to 1 million yearly; double the amounts in the last two decades [5].

PROTON Holding Berhad as the leading car manufacturer in Malaysia already done a pilot project EV called as Fleet Test Vehicle (FTV) with a numbers of 200 REEV Exora with 50 EV Saga around city of Putrajaya and Cyberjaya. The driving range about 140km and 130km respectively with normal mode charging overnight 8 hours. This programme is

under phase 2 pilot project of Roadmap for the Deployment of EV for Malaysia, trial for 12 month started September 2011 until end of September 2012 as shown in Figure 1 [6].



**Fig. 1.** Pilot Project for PROTON FTV location around Putrajaya and Cyberjaya [6].

Proton supposed to meet the projected mass production by 2014 as National roll out (phase 4) but decided to extend the projection by 2017 due for certain reasons. Other project is CMS Consortium private/public partnership between Malaysia Automotive Institute (MAI) and Malaysian Green Technology Corporation (MGTC) roll with first EV car sharing programme, called Cohesive Mobility Solution (COMOS), and was officially launched during 2014 as shown in Figure 2. This initiative, is the first kind in the ASEAN region. COMOS programme only available in hot spot prime city of Peninsula Malaysia, with the total of 30 -40 EV as for public charging stations. Eventually, the aim is have 3,500 EVs in the COMOS loop nationwide by 2020. COMOS also having plans to have EV charging stations at every R&R along the North-South highway by the fifth year of the programme. Average driving range for COMOS vehicle programme is 144km with a single charge 30 minutes to 9 hours. The objective of COMOS programme as a part of awareness campaign for the public about the EVs and know how to operate and get use to EV with seeing is believing. Then eventually build up the interest of the public to own the vehicles in substitution of conventional ICEs [7].

Recently, there is a project undertaken by China's Beijing Auto International Cooperation (BAIC), the country's top and world's second biggest electric vehicle manufacturer, in collaboration with a Malaysian partner, Amber Dual Sdn. Bhd. with targeted EVs production by July 2016 and aspire to lead Malaysia's for EV technology [8]. Even electric cars status in Malaysia is still new and on growing development but it is decent to see that Malaysia is on effort taking measures to ensure that the future of the electric car will be a promising one. As the impact of electric cars are more energy efficient and definitely have cleaner emissions than a HEV and better on conservation environment compare to conventional ICEs, which EVs will be the best option for environmentally-friendly in the future endeavour. Therefore, this BMS's study is very significant that will provides future insight for knowledge contribution and innovation invention for EV industries towards year 2020 as the first time ever in Malaysia. As well as for training in public and private institution to design on the optimization of BMS for EVs in Malaysia.

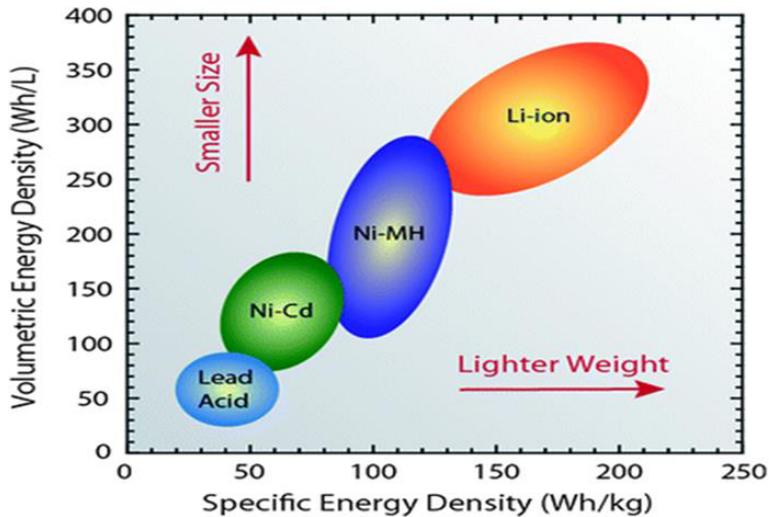


**Fig. 2.** COMOS programme [7].

### 3 Battery and battery management system

The switch from conventional ICEs to EVs is well underway. However, limited mileage of current EVs due to the confined energy storage capability of available battery systems is a major reason why these vehicles are not more common on the road [9]. Research revealed that with fast charging ten-minute period, be able to move the vehicles for one hundred mile and ability to provide enough energy in battery packs of EV. Thus, with the aim of to lengthen the batteries lifespan it is important of the BMS in the EVs playing the vital roles as a component device to control the operation of the battery's [10]. Also very important for BMS to well-maintained the battery reliability and safety, ensure the state monitoring and evaluation, cell balancing and charge control are well functional. A battery chemistry as an electrochemical devices, also will acts differently under different operational and environmental conditions. Due to that uncertainty of a battery's performance poses a challenge to the implementation of these functions [1].

Lithium-ion battery (LIB) has been extensively determined as high technology applied and developed since past a go decade when the BMSs development for EVs arisen globally, due to higher energy density, lower self-discharge, and longer life cycle. Figure 3 is adapted by Rohan which represented Commercial Evolution of Rechargeable Batteries to Higher Density.

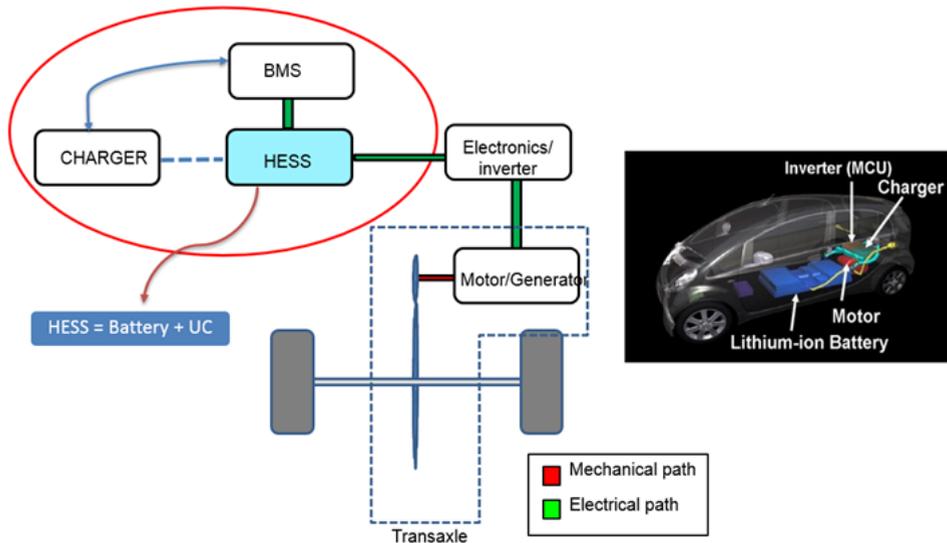


**Fig. 3.** Commercial evolution of rechargeable batteries to higher density [11].

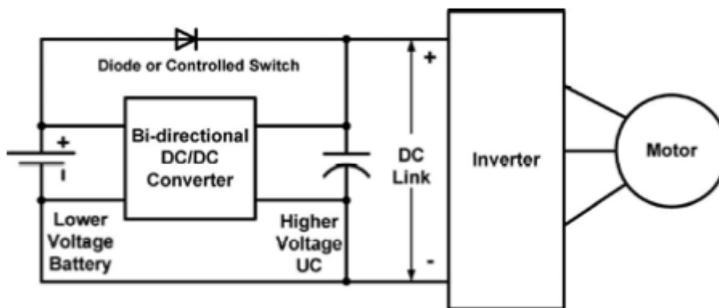
LIB chemistry also well acknowledged as the technology of choice for energy storage in EVs towards sustainable mobility. Nevertheless, there are still needs of more research points and still open for enhancement in the future endeavours. These included the best choices of the cell materials and the development of electronic circuits and algorithms for a more effective battery utilization for EVs [12]. The battery parameter to consider for BMS optimization were voltage, current, and temperature can be applied to forecast the SOC of battery [13-16]. Another challenges imposed of the performance of vehicle related to BMS is thermal management system would be required to maintain the optimal cell performance and also to achieve a full battery lifespan [14,17].

#### 4 A proposed BMS optimization

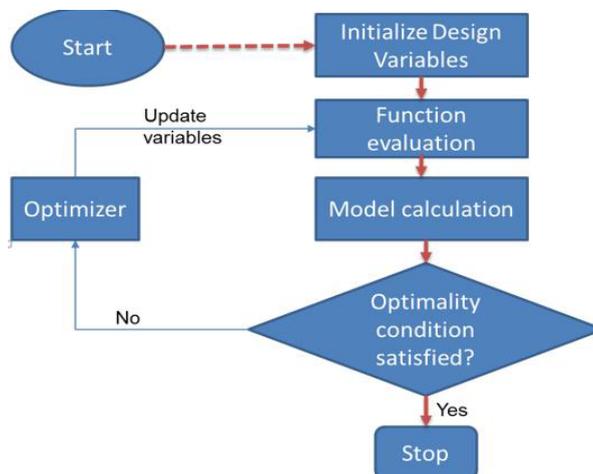
The needs of more power will lead to have a large voltage supply that's very difficult to arrange the battery power. The development of battery technology by using the ultra-capacitor (UCs) in automotive solved this problem[18]. This development combined form of battery and ultra-capacitor as hybrid energy or can called as Hybrid Energy Storage Systems (HESS) as shown in Figure 4. UCs have a high power density, but a lower energy density compared to batteries. The combination inherently offers a better performance in comparison to the use of them alone of either one. Figure 5 is sketches which represented proposed HESS configuration. The concept of optimization using the MATLAB/SIMULINK shown as in Figure 6.



**Fig. 4.** Proposed EV schematic diagram.



**Fig. 5.** Proposed HESS configuration [18].



**Fig. 6.** Experimental methodology for optimization of BMS.

So that in this study, this paper initially focus on the optimization of power generated by lithium-ion cathode with graphene anode using MATLAB/SIMULINK software in order to obtained experimental performance data (charge-discharge, power capacity and life cycles). Therefore, based on the reviewed analysis, this report would open the horizon of new method of BMS optimization to satisfy the objective on the BMS prognostic model in order to have a management performance and driving range extended of the electric car. Thus, increasing the performances of EV will lead to reliability of Battery Management and optimize power performance of EV. This will become essential in the literature especially in Malaysia. Thus, as the first time for the development of the BMS as well as for battery electric vehicles in Malaysia.

## 5 Conclusions

It is very important for BMS to well-maintained the battery reliability and safety, the state monitoring and evaluation, cell balancing and charge control are well functional. Thus, this present paper is review on BMS, focussing study for optimization of BMS for EVs that will lead to reliability of BMS and optimize power performance of EVs. Analysis from the literature search, there is a need on the improvement of BMS performance in future for EVs. Therefore, Hybrid Energy Storage System (HESS) is the potential outlook of the future BMS which should integrate of ultracapacitor combined with lithium compound battery in order to have prognostic technical model improvement on deploying performance management of EVs. It is expected that to provide future innovation invention to the EV industries towards year 2020 or beyond. Moreover, the target reducing greenhouse gas (GHG) emissions by up to 40% towards year 2020 will be achievable. Nevertheless, due to varying situation, there is no standard solution setting for BMS performance and different strategies still need to be applies to improve the performance of BMS for future HEVs and EVs.

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