Utilization of Used Electric Vehicle Batteries for The Design of Mini-Generating Systems

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Abstract. One of the main objectives of this research is to reduce battery waste from electric vehicles, namely by processing the battery waste to be used as electrical energy storage which is then used in mini generators. Therefore, it is necessary to have methods and stages to do it all. The method used with BMS (Battery Management System) with the Battery Cell Balancing model. It aims to determine the classification of the total battery capacity and battery life time, and determine which batteries can still be reused. The results of the balancing of the battery cells will be used as recommendations and are more economical in power generation storage systems and also provide practical solutions in the management of used electric vehicle battery waste to prevent pollution of active ingredients in battery cells, and also become an alternative for energy storage choices. For reuse. This research can be considered in the future for the electric vehicle industry to be able to reuse used batteries from electric vehicles, as well as the design design of the use of used batteries for mini generation systems.

Keywords: Battery Management System, Cell Ballancing Model, Energy Storage System, Electric Vehicle, Solar Power Plant

1. Introduction
Advances in the use of technology are increasing every year, especially the increase in transportation by using a variety of the latest technologies, ranging from machinery to transportation energy storage. Moreover, in Indonesia, the use of electric vehicles has begun to be found in many areas, such as one made by the nation's children, the GESITS electric motor. nevertheless, with the increasing number of users, exactly, the battery usage will also increase, and give rise to new problems, namely, there is damage to the battery or a decrease in the performance of the battery itself, thus making users switch to replacing the old battery with a new battery. On the other hand, the battery from the use of electric vehicles can be transferred to a new smart grid [1]. In reference [1-3] mentions that the use of used electric vehicle batteries will be reduced by 70-80% of their original capacity, and that is considered the end of their first life, with a typical battery capacity of around 5-24 kWh [mild hybrid electric vehicle (MHEV) 5 kWh–electric vehicle battery (BEV) 18–24 kWh battery]. Where the estimated battery life for ordinary users is around 10 years, with 40 minutes of battery use per day with a DoD (Depth of Discharge) 35% with 200 annual charges.

Lithium-Ion batteries are the most widely used type of battery, because they are rechargeable and are widely used in various applications ranging from electronic products to electric vehicles and also as energy storage for power generation scales, where the advantages are high energy / high power, low
self-discharge, and also has a long-life cycle [4]. Battery life can be extended by balancing the cells, thus requiring a battery management system [Battery Management System (BMS)] [5-7].

The aim of this research is to reduce the waste of used electric vehicle batteries by utilizing the used batteries into electrical energy storage in PV power plant system using the battery management system method with a battery balancing model, and also to find out to what extent these used batteries can be reused and find out which batteries are still worth reusing.

2. Research Method
In this study the battery from the electric vehicle will be tested with a battery tester, to see the capacity of the battery and the voltage on the battery, because the main function of the BMS is to monitor and balance the battery cells in the battery pack. There are 2 things that cause and affect the imbalance of the cell battery, namely intrinsic and extrinsic. Where these intrinsic factors are related to the manufacturing process, causing the number of variations of the active ingredients, and internal barriers. While the extrinsic factors include how to connect (series/parallel), charging/discharging currents, and hot condensation.

A battery pack are balanced if at multiple SOCs, all cells are at the same SOC. The BMS will balance the battery cells to ensure that charging is maximized so that the battery can deliver the required amount of charge each time, otherwise it will cause battery damage problems such as heating effect, charge reduction, reduced energy efficiency and accelerated degradation [6].
Figure 1. Flow Chart Method

Figure 1. It is a research flow chart diagram, after conducting a literature study related to the second use of electric vehicle batteries, then a mini generator system design will be made first, after that apply the BMS method with battery cell balancing, the BMS method that will be applied will be simulated in Matlab Simulink, by dividing 3 modes, namely Standby Mode, Charge Mode and Discharge Mode, which are described in Figure 2 [3]. The following steps will be carried out based on Figure 1:

1. The first stage is conducting a literature study by looking for references from previous research. And direct data retrieval to Ultima Automotive Design and Braja Electric Motor Workshop, a GESITS motorcycle team, in Surabaya.
2. The second stage is to design a Mini Generating System, which includes a new renewable energy generation unit, namely a Solar Power Plant. This stage uses Simulink Matlab to design and test the simulation. Then design the BMS method for battery cell balancing.
3. If it doesn't work, it will repeat the next step, after it is successful, the BMS method will be implemented on the power plant system.
4. The last stage is to analyze the performance of the BMS performance on the power generation system

![BMS Method Cell Balancing Batteries](image)

**Figure 2. Battery Cell Balancing Scenario**

The BMS method in Figure 2 has 3 modes, the standby mode is set if the battery capacity is less than 25%, while the charging mode will be active if the battery capacity is 20%, and the last discharge mode will be active when the battery is in a condition more than 85%, for that constraint on this BMS is SoC and Voltage. There are 3 conditions for this BMS method:

a) Batteries with unbalanced total capacity, where one cell is highly charged  
b) One of the highly charged cells  
c) Full charge condition with safe SoC

3. Research Results and Discussion

The scenario from Figure 2 will be designed using Matlab Simulink, by starting to create categories from the 3 existing modes, the initial assumption is to create a battery group according to the results of the battery capacity test. The type of battery used is a Lithium-Ion with capacity 2.6 Ah, 3.6 volt, specifications as shown in Figure 3. Figure 4. There are several batteries to be tested, using a battery tester in Figure 5.

![Battery Spesification](image)

**Figure 3. Battery Spesifications**
After balancing, the battery will be retested using a battery tester, the results of checking the battery tester are parameters for the design of Simulink Matlab, as shown in Figure 5. The tester battery is given a load of 5 watts of the resistor. Before knowing the final capacity results, the battery is first emptied, and then recharged until the timer on the display stops or is in a constant position, then the value that appears is the current battery capacity. Figure 6 is a battery that has been checked and separated by capacity. The range value of the battery capacity is 2.4 Ah – 2.6 Ah.

**Figure 4.** Battery Cell Balancing Step

**Figure 5.** Batteries after checking the capacity
The measurement results using a battery tester will be used as input parameters in Simulink Matlab. Before designing, it is necessary to know that the BMS block diagram will be made as follows as shown in Figure 7. The BMS is in charge of regulating when the battery will be used and also managing the control circuit. In summary, Figure 7 represents the overall design of the method design, but for the initial stage, the results of the battery tester measurements are used as input values in Simulink Matlab as shown in Figure 8.

**Figure 6. Battery Tester**

**Figure 7. Block Diagram BMS**
From Figure 2 it has been explained previously that there are 3 conditions where these conditions are obtained:

\[ V_{\text{bat}_1} + V_{\text{bat}_2} + \cdots + V_n = 1 \]

a) Full charge condition with the same SoC

if \( V_{\text{bat}_{\text{total}}} = 1 \)

b) Batteries with unbalanced total capacity where one of them is highly charged

if \( V_{\text{bat}} > 1 \)

c) One battery one is low charged

if \( V_{\text{bat}} < 1 \)

The three conditions above are implemented into Simulink Matlab as shown in Figure 8, the condition of the battery cell balancing. The parameters used are SoC, voltage, and current on the battery. The condition in Figure 8 is a condition full charge.
Figure 8. Cell Balancing Condition

For conditions, B and C are represented in Figure 9. With the same parameters, and conditions are made below 20%, with one of the conditions of the battery being low. After the design of the BMS method is made, the BMS method is included or combined with the design of the mini solar power plant system design. In the design of the mini generator system, the battery is made in a pack. So that each previously balanced battery cell will be made into one image (In the mini generator system circuit there is 1 battery, where the battery represents each cell that has been previously balanced) so that the form of the BMS implementation design in the mini generator system is represented by a figure 10.
4. Conclusion
The second battery life of electric vehicles is generally not reused, this study intends to be able to reuse used batteries from electric vehicles as a store of electrical energy in the generating system. Therefore, it is necessary to check whether the battery is feasible or not to be used as a source of energy reserve storage, one of which is the cell balancing battery model. The Future research is the testing stage for the household scale.

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