Battery Optimisation and Control System for E-Vehicle

[1]Dr.B.Tharani, [2]Anusuya T, [3]Dharini, [4]Kalaivani B, [5]Sanjay V G,
[1]*Associate Professor, Department of Electrical and Electronics Engineering,*
2,3,4,5 Student, Department of Electrical and Electronics Engineering,
Sri Shakthi Institute of Engineering and Technology, Coimbatore-62, Tamil Nadu, India.

ABSTRACT - The demand for efficient and reliable energy storage solutions has grown exponentially in recent years, with battery technology emerging as a pivotal player in this landscape. This abstract delves into the realm of battery optimization and control systems, a critical facet of maximizing the performance and longevity of batteries in various applications, including electric vehicles, renewable energy integration, and portable electronics. To address the challenges associated with batteries, such as capacity fade, thermal management, and state- of-charge control, advanced algorithms and control strategies are required. This paper explores recent developments and strategies in battery optimization, encompassing intelligent charge-discharge profiles, predictive maintenance, and real-time monitoring. It investigates the integration of machine learning, data analytics, and innovative materials to enhance energy density and cycle life. Additionally, the abstract delves into the role of intelligent battery management systems in extending battery life, ensuring safety, and contributing to sustainable energy solutions. The findings in this study highlight the significance of battery optimization and control systems in meeting the ever-growing demand for cleaner, more efficient, and longer-lasting energy storage technologies, thus shaping the future of energy management and sustainability.

I. INTRODUCTION

Consumers are aware on this green technology to save the environment. Thus, automotive industry has develops a renewable energy which is Electric Vehicle to minimize petrol usage. Automotive manufacturers are moving forward in enhancing this technology as a reliable product in the market. Battery consumption on Electric Vehicles (EV) model leads to energy saving. At the moment NiMH battery type is the mainstream technology for Electric Vehicle. However, Lithium Ion Polymer battery is being introduced on the market because it produces equivalent energy as the NiMH for longer period and half of the weight. Lithium Ion Polymer battery characteristic needs to be monitor because of it is sensitive to overvoltage and under voltage where it can shorten the life cycle.

Electric vehicles (EVs) have emerged as a promising and sustainable solution to address the environmental challenges associated with traditional internal combustion engine vehicles. The heart of any electric vehicle is its battery system, which plays a pivotal role in determining the vehicle's performance, range, and overall efficiency. To harness the full potential of electric vehicles, it is essential to have an efficient and sophisticated Battery Optimization and Control System (BOCS) in place. The Battery Optimization and Control System is a multifaceted technological framework designed to enhance the performance and longevity of EV batteries while ensuring a seamless and safe driving experience for users. It encompasses a range of cutting-edge technologies, algorithms, and control mechanisms that are continually evolving to address the specific needs of electric vehicles.

In this era of climate consciousness and the quest for greener transportation options, the development and refinement of battery optimization and control systems for electric vehicles are more crucial than ever. This technology not only optimizes the use of energy stored in batteries but also manages thermal characteristics, regulates charging and discharging rates, and monitors the overall health of the battery pack. By doing so, it ensures that electric vehicles can provide reliable, efficient, and environmentally friendly transportation. This introduction will delve deeper into the significance of battery optimization and control systems for electric vehicles, exploring how they contribute to extending the range, improving efficiency, and enhancing the overall driving experience, while also addressing the environmental impact of transportation.

II. LITERATURE REVIEW

The literature review on Battery Optimization and Control Systems for electric vehicles (EVs) is a comprehensive exploration of the rapidly evolving field of electric vehicle technology. With the increasing demand for sustainable transportation, there is a growing need to enhance the efficiency, performance, and longevity of the batteries that power these vehicles. This review delves into the extensive body of research and development efforts focused on optimizing and controlling batteries in the context of EVs. It begins by elucidating the fundamental challenges associated with EV batteries, such as limited range, charging time, and the overall cost. Researchers and engineers have been diligently addressing these issues through various strategies, including advanced battery chemistries, thermal management systems, and predictive control algorithms. The review encompasses a wide array of battery technologies, including lithium-ion, solid-state, and emerging post-lithium-ion technologies. It examines the advantages and drawbacks of each, shedding light on the potential breakthroughs that could revolutionize the EV industry. Furthermore, the paper highlights the importance of efficient battery management systems (BMS) in prolonging battery life and optimizing performance. Advanced BMS technologies have emerged as a critical component in the transition to electric mobility, as they not only ensure safety and reliability but also play a pivotal role in balancing battery cells, managing thermal conditions, and implementing smart charging strategies. Additionally, the literature review delves into the role of artificial intelligence and machine learning in battery optimization and control. These technologies enable predictive maintenance, adaptive energy management, and intelligent charging strategies, which are crucial for the efficient utilization of EV batteries. The review also discusses the implications of government regulations and incentives on the adoption of advanced battery technologies in the automotive industry.

In conclusion, the literature review on Battery Optimization and Control Systems for electric vehicles paints a vivid picture of the current state of research and development in this field. It underscores the remarkable strides made in improving the performance and longevity of EV batteries, while also recognizing the challenges that lie ahead. This comprehensive overview serves as a valuable resource for researchers, engineers, and policymakers working towards a sustainable and electrified future of transportation.

III. METHODOLOGY

The philosophy for battery improvement and control frameworks is a basic system for upgrading the presentation and sturdiness of energy stockpiling arrangements in an undeniably charged world. These frameworks assume an essential part in applications going from electric vehicles and sustainable power reconciliation to matrix adjustment. An obvious procedure includes a precise way to deal with guarantee productive energy utilization, expand battery duration, and keep up with functional security.

The most vital phase in this procedure is System Characterization. This includes a thorough investigation of the battery framework, including understanding the battery's science, limit, voltage range, warm properties, and the different variables adding to its maturing. An intensive evaluation of the battery's conduct under various functional circumstances and ecological impacts is fundamental for lay the foundation for powerful control and streamlining.

Then, Data Assortment and Monitoring become possibly the most important factor. Executing a vigorous information assortment and observing framework with sensors is fundamental. This framework consistently gauges key boundaries like voltage, current, temperature, and condition of charge. Continuous information assortment is the foundation of productive control and long haul advancement.

Model Development is another vital perspective. Precise numerical models are expected to depict the battery's way of behaving. These models include electrochemical and warm elements, as well as maturing impacts. They are basic for anticipating battery execution under shifting circumstances, empowering exact control techniques.

Advancement, the centre of this approach, includes Optimal Control Algorithms. High level control calculations are utilized to adjust functional boundaries to augment energy proficiency, broaden battery duration, and guarantee safe activity. Strategies like Model Prescient Control (MPC), fluffy rationale, and brain organizations can be utilized to accomplish these goals.

Province of-Charge Management is fundamental to forestall cheating or profound releasing that could decrease battery duration. Control systems need to keep up with the battery's condition of charge inside safe cutoff points.

Warm administration is similarly urgent in the technique. Fostering a Thermal The board System guarantees that the battery works inside an ideal temperature range, moderating the dangers of overheating or exorbitant cooling that could unfavourably influence battery execution and life span.

Issue Identification and Diagnostics are coordinated to recognize any oddities or debasement in the battery framework. Early recognition is fundamental to forestall disastrous disappointments and to successfully plan support.

The philosophy ought to likewise envelop an easy to use interface, permitting administrators or end-clients to Monitor and Control the battery framework easily. This connection point gives ongoing information, framework status, and the capacity to change functional boundaries.

The philosophy comes full circle with Testing and Validation, where the situation is thoroughly assessed under different circumstances, including outrageous temperatures and popularity situations. Gathered information is utilized to calibrate control calculations and models for ideal execution. At last, the way to long haul achievement is Continuous Improvement. Standard updates and advancements in view of new information and developing battery innovation are important to adjust to changing functional circumstances and broaden the battery's duration.

All in all, a very much organized strategy for battery enhancement and control is fundamental for the productive and reasonable activity of energy stockpiling frameworks in a quickly developing energy scene. It includes efficient portrayal, information assortment, model turn of events, high level control techniques, condition of-charge and warm administration, shortcoming recognition, UI configuration, testing, and persistent improvement, guaranteeing ideal execution, life span, and security.

IV. PROPOSED SYSTEM

Our proposed framework for battery improvement and control addresses a creative and extensive way to deal with overseeing and boosting the effectiveness of energy stockpiling arrangements. As the world changes towards cleaner energy sources and electric power turns out to be progressively essential in different areas, from transportation to environmentally friendly power combination, it is basic to foster a modern framework that can successfully make due, screen, and enhance battery execution. At the core of our framework is a hearty Data Obtaining and Observing Infrastructure. Using an organization of sensors, this framework constantly gathers continuous information on urgent battery boundaries, like voltage, current, temperature, condition of charge (SoC), and impedance. This high-recurrence information securing guarantees that the framework has a profound comprehension of the battery's working circumstances and can answer proactively to any deviations. The Advanced Battery Model in our proposed framework assumes a critical part. It utilizes numerical models that precisely address the electrochemical and warm way of behaving of the battery. This model considers exact state assessment and execution expectation, fundamental for advancing functional boundaries. The centre of our framework is the Optimization and Control Module. We utilize progressed control calculations, including Model Prescient Control (MPC) and Computerized reasoning (artificial intelligence) procedures, to tweak functional boundaries continuously. These calculations expect to boost energy proficiency, broaden battery duration, and guarantee safe activity by powerfully changing charge and release rates, adjusting the condition of charge, and effectively overseeing warm circumstances. A foundation of our framework is State-of-Charge and Territory of-Wellbeing Management. This includes exact control techniques that keep up with the battery's SoC inside safe cutoff points, forestalling cheating and profound releasing, while additionally surveying the battery's condition of wellbeing to distinguish and address debasement issues almost immediately. Warm Management is another basic angle. Our framework integrates a high level warm administration framework that guarantees the battery works inside an ideal temperature range. By forestalling overheating or unnecessary cooling, we alleviate the dangers of warm prompted debasement and execution misfortune. To address security and dependability, we've coordinated a Fault Recognition and Diagnostics Mechanism that constantly screens the battery framework for peculiarities or indications of corruption. Early recognition empowers convenient mediation and upkeep, diminishing the gamble of disastrous disappointments. For client communication, our framework offers a User-Accommodating Interface that gives ongoing information, framework status, and the capacity to set functional boundaries. This connection point guarantees that administrators and end-clients have full control and knowledge into the framework's exhibition. Before sending, our situation goes through thorough Testing and Validation under different natural circumstances, load profiles, and situations. This approval cycle guarantees that the framework performs dependably and actually, considerably under the most requesting conditions. Ultimately, our framework is intended for Continuous Improvement. Standard updates and improvements, in view of information driven experiences and arising battery advances, are a basic piece of our methodology. This versatility guarantees that the framework stays at the front of battery streamlining and control abilities.

All in all, our proposed battery enhancement and control framework addresses a state of the art answer for expanding the exhibition, life span, and wellbeing of energy stockpiling frameworks. With an emphasis on constant information procurement, high level battery demonstrating, dynamic enhancement, wellbeing the board, and nonstop improvement, our framework is ready to address the difficulties of a developing energy scene, adding to an additional feasible and proficient future.

V. BLOCK DIAGRAM FOR PROPOSED SYSTEM

Voltage sensors come in dfferent kinds, including simple and computerized sensors, and they can gauge both AC (rotating current) and DC (direct current) voltage levels. They commonly give a result signal that compares to the voltage they are estimating, which can be utilized for show, recording, or control purposes. Some voltage sensors are intended for explicit voltage ranges, while others are more flexible and can cover a wide range of voltages. Here we have used voltage sensor (ACS712) model which senses the voltage between the range of 0-25V. This sensor is connected across the battery.

A current sensor is also known as a current transducer or current probe. This device is used to measure current through the connected electric circuit. They play a major role in safeguarding electronic devices and equipment from overcurrent conditions, which can lead to damage or malfunctions. Current sensors are used to monitor current levels in electrical systems, ensuring that they remain within safe and operational limits. Here we have used current sensor(ACS712) model which is used to measure the current driven by the load of the e-vehicle. This sensor can measure the current to the maximum of 5A.

A temperature sensor is a gadget that actions the temperature of its environmental factors and converts this estimation into an electrical sign or computerized information. Normal sorts incorporate thermocouples, resistance temperature detectors (RTDs), and thermistors. These sensors are utilized in different applications, from observing natural circumstances to controlling modern cycles and guaranteeing the wellbeing and execution of electronic gadgets. Here we have used temperature sensor(LM35) model which senses the temperature range between -55°C to 150°C. This sensor is connected on the surface of the lithium ion batteries, which can monitor the real time temperature of the battery.
Lithium-ion (Li-ion) batteries are the most used batteries in the market which is known for its high energy density, long cycle life, and versatility. Li-ion batteries can typically go through hundreds of charge and discharge cycles before their capacity significantly diminishes. Li-ion batteries are used in a wide range of applications, including smartphones, laptops, digital cameras, electric vehicles, power tools, and renewable energy storage. Here we have used 4 Lithium ion batteries each with the rating of 4V. The batteries totally discharge 16voltage which is used to drive the parts of e-vehicle. Arduino Uno is important for the open-source Arduino ecosystem, and that implies that you can get to an immense library of free programming and assets to assist you with fostering your undertakings. The Arduino Uno is viable with many safeguards, which are extra sheets that can be stacked on top of the Uno to add additional features and it is Known for its easy to understand improvement climate utilizes the Arduino IDE (Coordinated Advancement Climate), making it open to amateurs and experienced engineers the same. Here we have used Arduino microcontroller to monitor and display the real time voltage, current and temperature of the e-vehicle batteries.
A relay module is an electronic gadget that comprises of at least one transfers (electromechanical switches) mounted on a printed circuit board (PCB).Relays are electromechanical changes that utilization an electromagnet to open or close electrical contacts. They are utilized to control high-voltage and high-current circuits with a low-voltage, low-current control signal. Transfer modules commonly contain at least one transfers. Relay modules are regularly utilized in robotization, home and modern applications, IoT ventures, and advanced mechanics. They permit microcontrollers or other control frameworks to control a wide assortment of electrical gadgets. Transfer modules give electrical segregation between the control signal and the exchanged burden. This confinement safeguards the control circuit from voltage spikes or commotion in the heap circuit. Here we have used 5V relay module to control the power to the e-vehicle parts during charging and discharging period of battery.
A LCD (liquid crystal display) is a level board innovation utilized in different electronic gadgets to introduce visual data. It comprises of a layer of liquid crystals sandwiched between two straightforward cathodes. At the point when an electric flow is applied to the terminals, the liquid precious stones change their direction, permitting or obstructing the entry of light, which brings about the showcase of pictures or text. LCD shows are broadly utilized in gadgets, for example, PC screens, TVs, cell phones, and computerized watches because of their thin structure factor, energy proficiency, and capacity to deliver top notch visuals. Here we have used LCD display to display the real time values of the sensors connected to the e-vehicle battery.

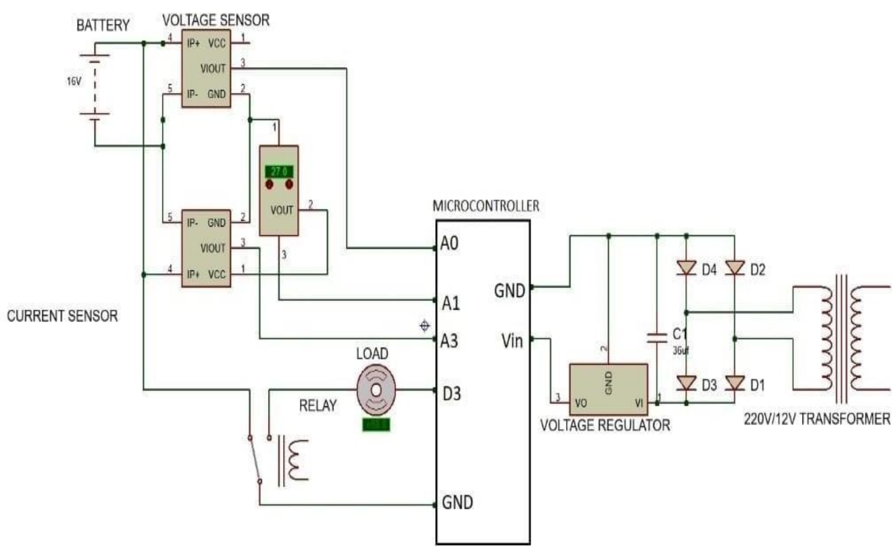


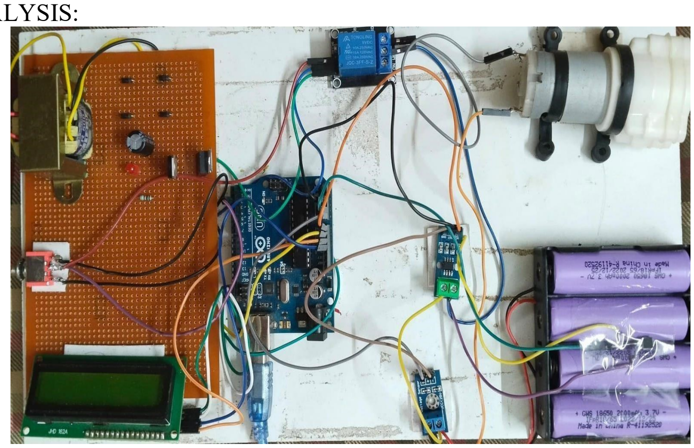
Figure – Circuit Diagram

VI. WORKING OF THE SYSTEM

The working of a Battery Optimization and Control System for an electric vehicle (EV) involves a combination of hardware and software components designed to manage and regulate various aspects of the battery's operation. Here is an overview of how these systems function:

- Data Collection and Monitoring: Battery optimization and control systems begin by collecting real-time data from various sensors located within and around the battery pack. These sensors measure critical parameters such as voltage, current, temperature, and state of charge (SoC).
- Data Processing: The collected data is processed by the system's control unit, which often includes a microcontroller or microprocessor. This unit runs control algorithms and decision-making software.
- Battery Modelling: The system relies on a mathematical model of the battery's behaviour, developed during the design phase. This model predicts how the battery will respond to various conditions and inputs. Energy Management: Control algorithms use the data from sensors and the battery model to make real-time decisions regarding the flow of energy into and out of the battery. This includes managing the charging and discharging processes.
- Safety Measures: The system incorporates safety mechanisms to prevent unsafe conditions. For instance, if the battery temperature approaches dangerous levels, the system can reduce charging power or initiate cooling measures.
- Optimization of State of Charge (SoC): The system ensures that the battery's state of charge is maintained within safe and efficient limits. This involves regulating charging and discharging rates to avoid overcharging or over- discharging.
- Thermal Management: To maintain the battery at an optimal temperature range, the system may activate heating or cooling elements within the battery pack. This ensures that the battery operates efficiently and safely.
- Regenerative Braking Control: In many electric vehicles, the battery optimization system also manages regenerative braking, where energy is captured and stored during braking or deceleration.
- User Interface: An interface is provided for the driver to interact with the system. It may display information about battery health, SoC, and energy consumption. Drivers may also set preferences or modes, such as eco-mode or performance-mode.
- Telematics and Communication: The system often includes connectivity features that enable communication with external networks or remote control. This allows for remote monitoring and software updates (OTA updates).
- Continuous Learning and Adaptation: Some advanced systems incorporate machine learning or adaptive algorithms to improve decision-making based on the battery's historical performance and the driver's behaviour.
- Battery Life Extension: Over time, the system's efforts to maintain optimal battery conditions, prevent overuse, and balance cell states can extend the overall life of the battery.
- Real-time Feedback and Alerts: If the system detects any issues, it can provide real-time alerts or feedback to the driver or vehicle maintenance personnel. This ensures immediate attention to potential problems.

RESULT AND ANALYSIS:



V. CONCLUSION

We conclude that the battery Optimization and Control System in an electric vehicle is a complex integration of hardware and software that continuously monitors, controls, and optimizes the behaviour of the vehicle's battery. By managing key parameters, optimizing energy usage, and ensuring safety, these systems contribute to improved battery life, enhanced vehicle performance, and a more efficient and reliable EV driving experience. Ultimately, a well-designed Battery Optimization and Control System contributes to improved battery life, enhanced vehicle performance, extended driving range, and a safer, more efficient electric vehicle driving experience.

REFERENCES

[1] Karlsen, Haakon, Tao Dong, Zhaochu Yang, and Rui Carvalho. "Temperature- Dependence in Battery Management Systems for Electric Vehicles: Challenges, Criteria, and Solutions." IEEE Access 7 (2019): 142203- 142213.

[2] Liu, Huaqiang, Zhongbao Wei, Weidong He, and Jiyun Zhao. "Thermal issues about Li-ion batteries and recent progress in battery thermal management systems: A review." Energy conversion and management 150 (2017): 304-330

[3] Xia, Guodong, Lei Cao, and Guanglong Bi. "A review of battery thermal management in an electric vehicle application." Journal of power sources 367 (2017): 90-105.

[4] May, Geoffrey J., Alistair Davidson, and Boris Monahov. "Lead batteries for utility energy storage: A review." Journal of Energy Storage 15 (2018): 145-157.

[5] Murnane, Martin, and Adel Ghazel. "A closer look at the state of charge (SOC) and state of health (SOH) estimation techniques for batteries." Analog Devices (2017): 2. Applications 54, no. 1 (2017): 426-436.

[6] C.Nagarajan and M.Madheswaran - ‘Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter’ - Journal of ELECTRICAL ENGINEERING, Vol.63 (6), pp.365-372, Dec.2012.

[7] C.Nagarajan and M.Madheswaran - ‘Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis’- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011.

[8] C.Nagarajan and M.Madheswaran - ‘Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques’- Taylor & Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011.

[9] C.Nagarajan and M.Madheswaran - ‘Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis’- Iranian Journal of Electrical & Electronic Engineering, Vol.8 (3), pp.259-267, September 2012.

[10] Nagarajan C., Neelakrishnan G., Akila P., Fathima U., Sneha S. “Performance Analysis and Implementation of 89C51 Controller Based Solar Tracking System with Boost Converter” Journal of VLSI Design Tools & Technology. 2022; 12(2): 34–41p.

[11] C. Nagarajan, G.Neelakrishnan, R. Janani, S.Maithili, G. Ramya “Investigation on Fault Analysis for Power Transformers Using Adaptive Differential Relay” Asian Journal of Electrical Science, Vol.11 No.1, pp: 1-8, 2022.

[12] G.Neelakrishnan, K.Anandhakumar, A.Prathap, S.Prakash “Performance Estimation of cascaded h-bridge MLI for HEV using SVPWM” Suraj Punj Journal for Multidisciplinary Research, 2021, Volume 11, Issue 4, pp:750-756

[13] G.Neelakrishnan, S.N.Pruthika, P.T.Shalini, S.Soniya, “Perfromance Investigation of T-Source Inverter fed with Solar Cell” Suraj Punj Journal for Multidisciplinary Research, 2021, Volume 11, Issue 4, pp:744-749

[14] C.Nagarajan and M.Madheswaran, “Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation” has been presented in ICTES’08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007

[15] M Suganthi, N Ramesh, “Treatment of water using natural zeolite as membrane filter”, Journal of Environmental Protection and Ecology, Volume 23, Issue 2, pp: 520-530,2022

[16] M Suganthi, N Ramesh

[17] Xiong, Rui, Jiayi Cao, Quanqing Yu, Hongwen He, and Fengchun Sun. "Critical review on the battery state of charge estimation methods for electric vehicles." Ieee Access 6 (2017): 1832-1843.

[18] Xiong, Rui, Linlin Li, and Jinpeng Tian. "Towards a smarter battery management system: A critical review on battery state of health monitoring methods." Journal of Power Sources 405 (2018): 18-29

[19] Dubarry, Matthieu, M. Berecibar, A. Devie, D. Anseán, N. Omar, and I. Villarreal. "State of health battery estimator enabling degradation diagnosis: Model and algorithm description." Journal of Power Sources 360 (2017): 59-69.

[20] .Lipu, MS Hossain, M. A. Hannan, Aini Hussain, M. M. Hoque, Pin J. Ker, Mohamad Hanif Md Saad, and Afida Ayob. "A review of the state of health and remaining useful life estimation methods for lithium-ion battery in electric vehicles: Challenges and recommendations." Journal of cleaner production 205 (2018): 115-133.