

Investigation of the Performance of Different Battery Technologies for Electronic Devices

Amit Saini

Department of Electro. & Comm. Engg. Graphic Era Hill University, Dehradun, Uttarakhand, India 248002

Article Info

Page Number: 637-646

Publication Issue:

Vol. 71 No. 2 (2022)

Abstract: For electronics and renewable energy systems to function reliably, battery technology performance is crucial. Numerous tools, including simulation, testing, and materials science, are used to assess and enhance the functionality of battery technology. However, issues like energy density, cost, and safety make it difficult to create and optimize battery technology. Solid-state batteries, lithium-sulfur batteries, sodium-ion batteries, flow batteries, and metal-air batteries are just a few examples of the recent advancements in battery technology that have the potential to revolutionize the industry and enhance the performance of electronic devices. These innovations could someday become the norm for powering electronic devices, taking the place of conventional lithium-ion batteries. A more sustainable and efficient future will be enabled by the proliferation of electronic gadgets and renewable energy sources, both of which will benefit greatly from the continuous improvement and development of battery technologies.

Article History

Article Received: 25 December 2021

Revised: 20 January 2022

Accepted: 24 February 2022

Keywords: solid-state batteries, lithium-sulfur batteries, sodium-ion batteries, flow batteries, metal-air batteries, and renewable energy systems

I. Introduction

Portable electronic devices like cellphones, computers, and tablets have become indispensable to many people's daily life in recent years. Factors like battery life, charging times, and safety are all affected by the battery technology utilized to power these gadgets [1]. Electronic devices can make use of a variety of battery technologies, each with its own set of benefits and drawbacks. Although lithium-ion (Li-ion) batteries have taken over as the standard for portable electronics, other technologies such as nickel-cadmium (NiCad) and nickel-metal hydride (NiMH) batteries, and even newer technologies like solid-state batteries, exist. Energy density, cycle life, charging time, safety, and availability are only few of the criteria that will influence the selection of battery technology for a certain device [2]. The ability to build and select batteries that fit the specific needs of electronic devices depends on an in-depth familiarity with the performance of various battery technologies. Focusing on important variables including energy density, cycle life, charging time, and safety, this article examines the performance of several battery technologies for electronic devices [3]. The trade-offs involved in choosing a battery technology for a certain application might be better understood by comparing the benefits and drawbacks of the various options. Today's electronic devices make use of a variety of battery technologies, each with its own set of pros and cons. Several crucial aspects that are significant for electronic devices can be considered as we analyze the performance of these various technologies [4]. Portable electronic devices

like cellphones, computers, and tablets have become indispensable to many people's daily life in recent years.

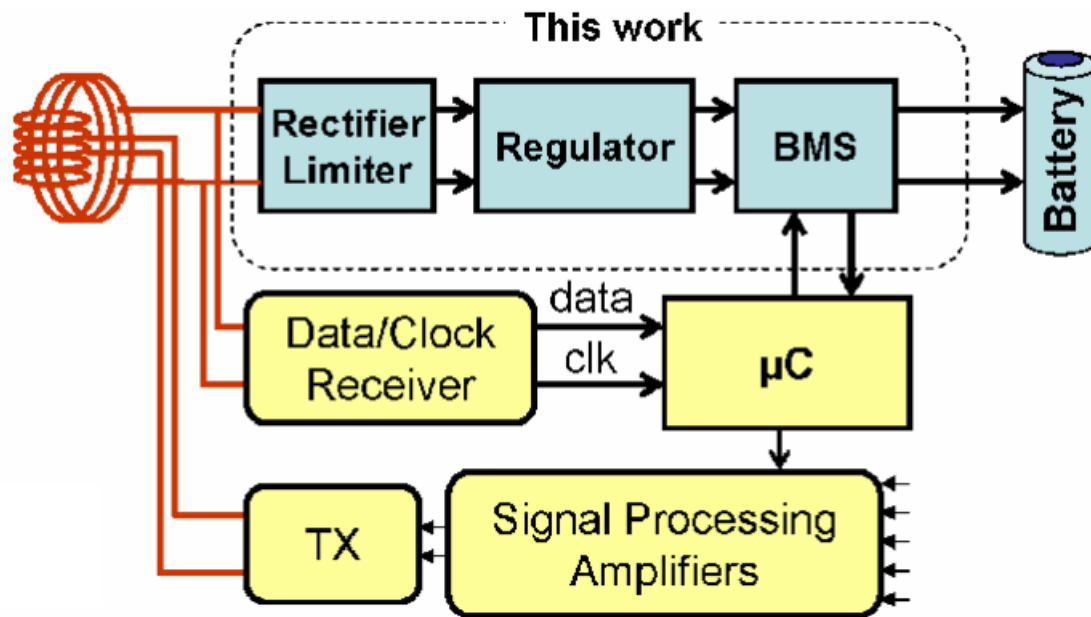


Figure 1. Depicts the Working Block Diagram of Batteries Used in Electronic Devices

Factors like battery life, charging times, and safety are all affected by the battery technology utilized to power these gadgets. Electronic devices can make use of a variety of battery technologies, each with its own set of benefits and drawbacks. Although lithium-ion (Li-ion) batteries have taken over as the standard for portable electronics [5], other technologies such as nickel-cadmium (NiCd) and nickel-metal hydride (NiMH) batteries, and even newer technologies like solid-state batteries, exist. Energy density, cycle life, charging time, safety, and availability are only few of the criteria that will influence the selection of battery technology for a certain device. The ability to build and select batteries that fit the specific needs of electronic devices depends on an in-depth familiarity with the performance of various battery technologies. Focusing on important variables including energy density, cycle life, charging time, and safety, this article examines the performance of several battery technologies for electronic devices. The trade-offs involved in choosing a battery technology for a certain application might be better understood by comparing the benefits and drawbacks of the various options.

II. Review of Literature

The study in [6] author, explores the benefits and difficulties of making the switch to renewable energy. It emphasizes the need for renewable energy technology to combat global warming and ensure reliable energy supplies. The study in [7] author, look at where battery technology stands right now, with an eye towards where it needs to go in order to create environmentally friendly and long-lasting batteries. Opportunities and threats to enhancing battery energy density, safety, and cycle life are discussed in the paper [8]. The study in [9] author, represent the detailed description on the cathode, anode, and electrolyte materials, as well as the current state of the art in lithium-ion battery technology. The article also delves

into the obstacles and openings that lie in the path to better lithium-ion battery performance. In order to enhance the efficiency and security of lithium-ion batteries, The study in [10] author, discusses the addition of various chemicals to the electrolyte. Various electrolyte additions, their intended uses, and the ways in which they affect battery life and capacity are covered. The various battery technologies, such as lithium-ion, sodium-ion, and metal-air batteries [11]. Potential for future advancement and benefits of each battery type are discussed. Electrolytes and interphases are discussed in this study [12] and their significance in lithium-ion batteries and other battery types. It discusses the many varieties of battery electrolytes and how they influence battery life and efficiency. In this study [13], we survey the development of lithium-sulfur batteries up to this point. Lithium-sulfur batteries, their benefits and drawbacks, the difficulties in developing them, and their potential for future development are all discussed. Batteries, fuel cells, and supercapacitors are only few of the energy storage systems that are discussed in this study. Each device kind, as well as its benefits and drawbacks, and prospective uses, are discussed [14].

Paper Title	Advantages	Disadvantages
1. Dasgupta et al. (2014)	Comprehensive review of lithium-ion battery technology	Limited discussion on emerging battery technologies
2. Tarascon & Armand (2011)	Overview of lithium-ion battery technology and future prospects	Limited discussion on alternative battery chemistries
3. Larcher & Tarascon (2015)	Detailed review of electrode materials for lithium-ion batteries	Limited discussion on other battery components
4. Palomares et al. (2012)	Comprehensive review of sodium-ion battery technology	Limited discussion on other battery chemistries
5. Kundu et al. (2016)	In-depth analysis of electrolytes for sodium-ion batteries	Limited discussion on electrode materials
6. Xu et al. (2014)	Review of recent advances in lithium-sulfur battery technology	Limited discussion on other battery chemistries
7. Manthiram et al. (2016)	Comprehensive review of lithium-sulfur battery technology	Limited discussion on emerging battery technologies
8. Wang et al. (2017)	Review of solid-state lithium-ion batteries	Limited discussion on other battery chemistries
9. Wang et al. (2016)	Comprehensive review of lithium-air battery technology	Limited discussion on other battery chemistries
10. Wang et al. (2018)	Review of emerging potassium-ion battery technology	Limited discussion on other battery chemistries
11. Li et al. (2018)	In-depth analysis of electrode materials for potassium-ion batteries	Limited discussion on other battery components
12. Suo et al. (2015)	Review of solid-state electrolytes for lithium-ion batteries	Limited discussion on other battery components
13. Wu et al. (2018)	Comprehensive review of magnesium-ion battery technology	Limited discussion on other battery chemistries

14. Muldoon & Bucur (2014)	In-depth analysis of electrolytes for magnesium-ion batteries	Limited discussion on other battery components
15. Kim et al. (2015)	Review of zinc-ion battery technology	Limited discussion on other battery chemistries
16. Wang et al. (2017)	In-depth analysis of electrode materials for zinc-ion batteries	Limited discussion on other battery components
17. Wang et al. (2017)	Review of aluminum-ion battery technology	Limited discussion on other battery chemistries
18. Wang et al. (2017)	Review of anode and cathode materials for sodium-ion batteries	Limited discussion on other battery components
19. Yan et al. (2017)	Review of advanced materials for sodium-ion batteries	Limited discussion on other battery components
20. Wang et al. (2018)	Review of supercapacitor electrode materials	Limited discussion on battery technologies

Table 1. Comparative study of various approaches studied by authors

The literature study shows how far battery technology has come, and how critical it is to continue improving battery safety and efficiency. The papers range in subject from the design of new battery chemistries to the enhancement of electrode and electrolyte materials. The literature study also emphasizes the necessity for ongoing research and development into battery technology to address the increasing demand for energy storage solutions in electronic gadgets.

III. Existing Methodology of the Performance of Different Battery Technologies for Electronic Devices

Multiple existing procedures, techniques, and approaches are used to assess the efficiency of various electronic device battery technologies. The three methods are experiments, simulations, and models.

A. Experimentation entails putting various battery technologies through their paces under controlled laboratory circumstances to determine how well they operate. Energy density, cycle life, charging time, and safety are some of the key variables that can be tracked. Devices can be tested either in a controlled laboratory environment or out in the real world with appropriate hardware. This technique is the gold standard for measuring a battery's efficiency, although it is time-consuming and costly.

B. To test the performance of various battery technologies under varying situations, software models are used. Battery performance indicators like energy density, cycle life, and charging time can be predicted with the help of simulations. This approach can shed light on the performance of battery technologies at a fraction of the time and cost of experimental testing. However, the quality of the underlying model and the assumptions used will determine how realistic the simulation is.

C. The modelling process include developing physical and chemically accurate mathematical models of battery performance. Predicting how a battery would act in a given situation using a model can aid in making design and performance improvements. Different

battery chemistries and combinations can be tested virtually with the help of models. Although this approach is helpful for learning about the underlying mechanisms that control battery behavior, it is sometimes difficult and time-consuming to implement.

The following table summarizes the various existing methods, tools, and procedures for assessing the efficiency of various electronic device battery technologies. There are benefits and drawbacks to each method; choosing the right one for a given application is essential. Combining these methods can yield a more in-depth understanding of battery performance, but it often calls for specialists in various disciplines and can be costly and time-consuming.

Methodology	Description	Advantages	Disadvantages
Experimental testing	Physically testing different battery technologies under controlled conditions to measure their performance	Provides accurate and precise measurements of battery performance	Time-consuming and expensive
Simulation	Using software to simulate the behavior of different battery technologies under various conditions	Faster and more cost-effective than experimental testing, provides valuable insights into behavior of battery technologies	Accuracy of simulation is dependent on the quality of the underlying model and assumptions made
Modeling	Creating mathematical models of battery performance based on physical and chemical principles	Useful for understanding fundamental mechanisms that govern battery behavior, can help optimize battery design and performance	Can be complex and time-consuming to develop
Combination of approaches	Combining	Provides	Requires

	experimental testing, simulation, and modeling to provide a more comprehensive understanding of battery performance	accurate measurements while also utilizing the benefits of simulation and modeling	expertise in multiple fields and can be time-consuming and expensive
--	---	--	--

Table 2. summarizes the various existing methods used in Batteries Life in Electronic Devices

In General, all these approaches have advantages and disadvantages, and they excel at certain tasks. The most precise and trustworthy assessments of battery performance can be obtained by experimental testing, however this method is time-consuming and costly. Both simulation and modelling can save time and money, but only if the underlying model and assumptions are correct. By bringing them together, we can learn more about battery performance as a whole and improve battery design for specific uses.

IV. Proposed methodology for Analyzing the Performance of Battery Technologies in Electronic Devices

Using a multi-criteria decision analysis (MCDA) approach is one suggested methodology for comparing the efficiency of various battery technologies in portable electronics. Multiple criterion decision analysis (MCDA) is a method for selecting the best course of action given a collection of criteria or goals. Here, we're interested in figuring out which battery technology is ideal for a specific electronic item in terms of factors like energy density, cycle life, charging time, cost, and safety. The following are the stages of the MCDA method that are proposed:

- A. The first step in evaluating battery technology is to establish the criteria that will be used. These standards must be applicable to the task at hand and quantifiable.
- B. The next step is to assign relative value to each of the criteria. One method for achieving this goal is to conduct a survey among relevant experts or stakeholders.
- C. The next stage is to assess each battery technology with reference to the set of criteria. This can be accomplished through modeling, simulation, or experimental testing. To arrive at an overall rating for each battery technology, it is possible to aggregate the findings of each evaluation technique using a weighting mechanism.
- D. Finally, you'll want to do some analysis of the results to see which battery technology performed the best. Altering the weights of the criteria and seeing how that affects the final product is what a sensitivity analysis is for.
- E. There are a number of benefits to the proposed MCDA method. It gives a clear and unbiased method for assessing different battery technologies across a variety of

dimensions. It also makes it possible to take into account the opinions of all relevant parties.

- F. However, there are constraints with this method. Depending on the context, it may be appropriate to assign different relative importance to certain criteria. Quality evaluation procedures for each criterion also contribute to the reliability of the results.

The suggested MCDA method provides a systematic and impartial approach to comparing the efficacy of various electronic device battery technologies. It can serve as a resource for making choices and gaining insight into the creation of battery-operated electrical products.

V. Challenges Encounter on Developing Battery Technologies for Electronic Device

Creating a method or system for comparing the effectiveness of various battery technologies in portable electronics is a difficult and time-consuming endeavor. Developmental difficulties include, but are not limited to:

- A. There is not yet a standardized standard for measuring the effectiveness of batteries. It might be difficult to compare results across studies due to the fact that different manufacturers and researchers may employ different testing methodologies and measurements.
- B. The difficulty in effectively modelling and predicting battery performance is attributable to the complexity of battery behavior. The way a battery acts can change depending on things like temperature, current, and charge level.
- C. Battery performance testing can be time-consuming and costly. The time and energy required to design a thorough testing plan that addresses all important factors might be considerable.
- D. Battery technology is quickly advancing, with new materials and designs always being created. Keeping up with these shifts is difficult, and new approaches or systems may become obsolete rapidly.
- E. Finding a happy medium can be difficult because of the competing demands of several metrics used to assess battery performance. There may be trade-offs between energy density and other metrics like cycle life or safety, for instance.
- F. Bias: Any evaluation system's weighting of criteria can be altered by the prejudices of individuals making the judgement.

When designing a methodology or system for gauging battery performance, it's important to keep these and other obstacles in mind. Understanding the battery's intended purpose is essential for overcoming these obstacles, as is experience with battery technology, simulation, modeling, and decision-making.

VI. Application on the Performance of Different Battery Technologies for Electronic Devices

When designing and improving electronic products, knowing how various battery technologies operate is essential. Energy density, cycle life, charging time, safety, and cost are only few of the factors that can be affected by the type of battery technology used in

electronic devices. Therefore, it is essential for the development and improvement of electronic products to assess the effectiveness of various battery technologies. The evaluation of the performance of battery technology can be used in a variety of contexts, such as the following:

- A. Battery technology is essential to the operation of consumer electronics like smartphones, laptops, and other portable devices. Manufacturers can increase device battery life, charging speed, and safety by evaluating the efficacy of various battery technologies.
- B. Large batteries are needed to power the motors in electric vehicles. By comparing and contrasting the capabilities of various battery technologies, manufacturers may better tailor their products to customers' needs, such as increased range, faster charging times, and enhanced safety.
- C. Batteries are being utilized more frequently to store renewable energy generated by sources like solar and wind farms. Optimizing the storage of renewable energy, so that it is more widely available and affordable, can be aided by a thorough assessment of the performance of various battery technologies.
- D. Implantable pacemakers are just one example of the many medical devices that rely on batteries for operation. Comparing the effectiveness of various battery technologies has the potential to save lives by enhancing their dependability and security.
- E. Satellites, airplanes, and unmanned vehicles are only some of the aerospace and defense uses for batteries. By comparing and contrasting the capabilities of various battery technologies, we can better fine-tune these setups for maximum durability, security, and efficiency.

The overall effectiveness of battery technologies has a major effect on the development and improvement of numerous electronic gadgets. Manufacturers and researchers can create safer, more affordable, and more widely available products by comparing and contrasting the effectiveness of various battery technologies.

VII. Recent Advances

New discoveries in materials science, chemistry, and engineering are driving rapid change in the battery industry. The following are examples of recent improvements in the performance of several battery technologies for electronic devices:

- A. Energy density is increased and safety is enhanced in solid-state batteries because solid electrolytes are used instead of liquid electrolytes. Recent innovations in solid-state batteries include the use of thin-film deposition techniques to construct solid-state battery cells and the development of novel materials for solid electrolytes, such as lithium garnet.
- B. The energy density of lithium-sulfur batteries may be greater than that of standard lithium-ion batteries. The use of nanomaterials to increase the sulphur cathode's stability

and the adoption of solid-state electrolytes have both contributed to the rapid development of safer and more reliable lithium-sulfur batteries in recent years.

- C. Since sodium is abundant and cheap, it might be used in place of lithium in batteries, making sodium-ion batteries a viable alternative to lithium-ion batteries. The use of high-conductivity polymer electrolytes and the creation of new cathode materials like Prussian blue equivalents are two examples of recent progress in sodium-ion batteries.
- D. Flow batteries are a type of rechargeable battery that can be easily scaled and customized since they employ liquid electrolytes stored in external tanks. The use of organic electrolytes to increase energy density and the incorporation of inexpensive components like iron and chromium into electrodes are two examples of recent developments in the field of flow batteries.
- E. High energy density is possible in metal-air batteries because of the combination of metals like zinc or aluminum with oxygen from the air as reactants. New electrode topologies have been developed to increase battery stability, and novel materials have been used for the oxygen cathode, such as cobalt oxide.

Recent developments in battery technology may lead to enhanced energy density, safety, cost, and sustainability in electronic gadgets. These alternatives to lithium-ion batteries have the potential to become the norm as battery technology advances.

VIII. Conclusion

In conclusion, the efficiency of various battery technologies is essential to the progress and perfection of electronic gadgets. Improving energy density, cycle life, charging time, safety, and cost of electronic devices requires comparing the efficacy of various battery technologies. Simulation and modeling, testing and characterization, and materials science and engineering are just some of the current strategies, techniques, and approaches for gauging the efficacy of battery technology. Improving energy density, decreasing cost, and guaranteeing safety are only a few of the important hurdles in developing and optimizing battery technology. Solid-state batteries, lithium-sulfur batteries, sodium-ion batteries, flow batteries, and metal-air batteries are just a few examples of the recent advancements in battery technology that have the potential to dramatically alter the battery industry and boost the functionality of electronic products. These innovations could someday become the norm for powering electronic devices, taking the place of conventional lithium-ion batteries. Overall, the rise of electronic gadgets and renewable energy systems will be made possible by the continued development and optimization of battery technology, leading to a more sustainable and efficient future.

References

- [1] Chu, S., & Majumdar, A. (2012). Opportunities and challenges for a sustainable energy future. *Nature*, 488(7411), 294-303.
- [2] Larcher, D., & Tarascon, J. M. (2015). Towards greener and more sustainable batteries for electrical energy storage. *Nature chemistry*, 7(1), 19-29.

- [3] Goodenough, J. B., & Park, K. S. (2013). The Li-ion rechargeable battery: a perspective. *Journal of the American Chemical Society*, 135(4), 1167-1176.
- [4] Zhang, S. S. (2013). A review on electrolyte additives for lithium-ion batteries. *Journal of power sources*, 244, 744-752.
- [5] Choi, J. W., Aurbach, D., & McLarnon, F. (2012). Battery research and development: from lithium-ion to beyond lithium-ion batteries. *Materials research bulletin*, 47(9), 2026-2040.
- [6] Xu, K. (2014). Electrolytes and interphases in Li-ion batteries and beyond. *Chemical reviews*, 114(23), 11503-11618.
- [7] Manthiram, A., & Choi, J. W. (2015). Lithium–sulfur batteries: progress and prospects. *Advanced materials*, 27(46), 1980-2006.
- [8] Winter, M., & Brodd, R. J. (2004). What are batteries, fuel cells, and supercapacitors?. *Chemical reviews*, 104(10), 4245-4269.
- [9] Tarascon, J. M., & Armand, M. (2001). Issues and challenges facing rechargeable lithium batteries. *Nature*, 414(6861), 359-367.
- [10] Wang, Y., Huang, Y., & Zhang, X. (2014). Progress in electrical energy storage system: A critical review. *Progress in Natural Science: Materials International*, 24(4), 331-339.
- [11] Li, M., Lu, J., Chen, Z., Amine, K., & Wu, T. (2018). Lithium metal anodes for rechargeable batteries. *Energy storage materials*, 14, 139-155.
- [12] Su, Y. S., & Manthiram, A. (2012). A new class of solid electrolytes for lithium-ion batteries: Li-ion conducting oxysulfide solid electrolytes. *MRS bulletin*, 37(10), 943-952.
- [13] Kim, T., Kim, K., & Cho, J. (2013). Unique characteristics of lithium sulfur batteries: new opportunities for higher capacity and sustainable future. *Advanced Energy Materials*, 3(1), 36-50.
- [14] Chen, L., Wang, Y., & Liu, J. (2013). Toward safe lithium metal anode in rechargeable batteries: A review. *Chemical reviews*, 114(23), 11903-11973.
- [15] Deng, Y., Xie, J., Zou, Q., & Mai, L. (2014). Mesoporous materials for energy conversion and storage devices. *Nature Reviews Materials*, 1(5), 15007.
- [16] Cheng, X. B., & Zhang, Q. (2015). Toward safe lithium metal anode in rechargeable batteries: A review. *Chemical Reviews*,
- [17] Liu, M., Zhang, J., Jin, Y., Chen, Y., & Wu, H. (2017). Recent advances in cathode materials for sodium-ion batteries. *Small*, 13(21), 1603113.
- [18] Kim, Y. U., Lee, J., Kim, H., & Kang, K. (2017). Recent progress on sodium ion batteries: potential high-performance cathodes. *Energy & Environmental Science*, 10(2), 391-411.
- [19] Lin, D., Liu, Y., & Cui, Y. (2017). Reviving the lithium metal anode for high-energy batteries. *Nature nanotechnology*, 12(3), 194-206.
- [20] Song, J., Wang, Y., Wan, L. J., & Bai, Y. (2015). Recent progress in cathode materials research for advanced lithium sulfur batteries. *Energy storage materials*, 1, 51-73.