IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 8, June 2022

Comparative Analysis of Battery with Lithium-Ion Battery for Renewable Energy Storage

Mrs. Priyanka Chawhan[1], Prof. A. V. Harkut[2], Prof. P. R. Jawale[3]
PG Scholar, Department of Electrical (Electronics & Power) Engineering, PLIT&MS, Buldana, India [1]
Assistant Professor, Department of Electrical (Electronics & Power) Engineering, PLIT&MS, Buldana, India[2,3]

Abstract: *A battery is essential for the renewable and sustainable development of electrical and electronic technology. This Lithium-ion has been focused and described based on a comparative analysis of various types of batteries such as Lithium-ion batteries, electro-chemical batteries, fuel cells batteries, and solar cells batteries. In contrast, electrochemical batteries are widely used in the current scenario for renewable and sustainable development, but they have some drawbacks such as limited life, leakage, and environmental concerns. Fuel cell batteries, on the other hand, are expensive and not portable in size. Similarly, solar cell batteries are not adaptable and versatile in emergency power backup. To address emergency power backup issues, It required an auxiliary power backup battery, which increased the overall system size. While a lithium-ion battery is an ultra-thin, flexible energy storage device that has advantages over other batteries such as being light in weight, rechargeable, biodegradable, non-toxic, having no leakage, no overheating, having a long life, being easily reusable, and recyclable. This battery description and comparison will be followed and evaluated by a discussion on the ethical issues surrounding the Lithium-ion battery, particularly for renewable and sustainable development.*

Keywords: Battery, Lithium-Ion Battery, Renewable Energy, etc.

I. INTRODUCTION

A battery is used in a variety of electrical and electronic devices in everyday life, including clocks, cellular phones, computers, laptops, and automobiles. Electrical energy can be stored in a battery in the form of chemical energy and then converted back into electrical energy as needed. The traditional battery is composed of two chemical metals, an anode (negative electrode) and a cathode (positive electrode), which are separated by a chemical medium known as electrolyte [1]. When an electrical circuit device is connected to a battery, chemical reactions occur on the electrolyte as a result of which atoms with electrically positive charges begin to flow towards the cathode from the anode via the electrolyte. [2] Electrolyte medium at the same time, electrons with an electrically negative charge move to the positive cathode, but due to electrolyte blockage, it begins to build an electrical current for an external circuit device, and in rechargeable type batteries, an exchange of electricity from an external source can also be done [3-4].

At renewable energy sites, the battery can store excess energy and release it when generation is low or when there are blackouts and demand is high. Recently, the battery has been used in domestic and industrial applications for power backup and fluctuation handling because its response is comparatively quick and does not require time to ramp up [5]. The characteristics and features of batteries can vary. The charge and discharge times of any battery determine its performance [6]. In terms of applications, the energy density, weight, size, and recyclability are all important considerations. Temperature range, maintenance, safety, and cost are all important factors to consider. Because of efficiency, performance, regulatory barriers, safety concerns, and cost, batteries are not widely used or fully integrated into power systems. However, for better developments, an environmentally friendly, reliable, and less expensive battery is required of future technology, which is why researchers around the world are constantly working to build less expensive and more efficient batteries [7]. There are various types of batteries available today, including electro-chemical batteries, fuel cells batteries, solar cells batteries, and lithium-ion batteries.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 8, June 2022

II. ELECTRO-CHEMICAL BATTERY

The electro-chemical battery is made up of one or more electrochemical cells that store energy in the form of chemical energy and then convert it to electrical energy and vice versa. The battery contains at least one electrochemical cell for electricity storage and generation. There are many different types of electrochemical cells batteries available, but they all contain at least one voltaic cell or one electrolytic cell. In electrochemical cells, oxidation and reduction reactions occur; oxidation occurs at the negative electrode (anode), and reduction occurs at the positive electrode (cathode). As shown in Fig. 1(a), the spontaneous redox reactions (converting chemical energy into electrical) occur in a voltaic cell, whereas the nonspontaneous redox reactions (converting electrical energy into chemical energy) occur in an electrolytic cell.

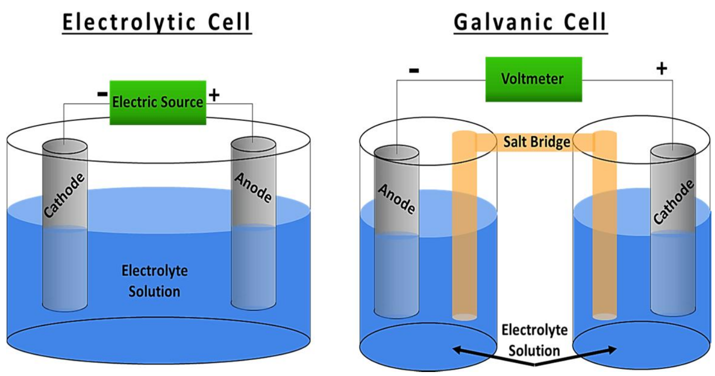

Figure 1: Operational diagram of electrochemical battery

These batteries are either rechargeable or not. Because the react components are not completely used up and the battery requires an external electrical source to recharge them after they have expended their energy, rechargeable batteries undergo electrochemical reactions that can be easily reversed. Non-rechargeable batteries undergo irreversible electrochemical reactions because the materials in the electrodes are completely depleted and thus unable to regenerate electricity, and this battery is primarily used for long-term requirements due to their significantly lower discharge ratio [8]. A battery can be wet cell or dry cell depending on the electrolyte electrochemical. Electrolyte is a liquid found in wet cell batteries. As a result, insulator sheets are used to separate the anode and cathode. The dry battery contains no electrolyte as a liquid, only enough moisture to allow current flow. As a result, the dry cell could be used in any position without fear of spilling its contents.

The current electrochemical batteries have the following limitations: (a) Short life time: The non-rechargeable and disposable battery has a practically limit of irreversibly converting chemical energy to electrical energy. Chemical reactions in rechargeable batteries reverse their supply of electrical energy to the cell and can restore their original arrangement. However, it is more expensive than rechargeable batteries. (b) Leakage issues: This occurs primarily as a result of spontaneous heating or an accident in which dangerous chemicals may be released, and leakage can also damage the equipment connected to it. (c) Environmental issues: The widespread use of electrochemical batteries has resulted in a variety of environmental and health-related pollution caused by poisonous metals such as zinc, lead, cadmium, mercury, and lithium.

III. FUEL CELL BATTERY

A fuel cell battery is a chemical device that uses hydrogen fuel and oxygen to generate electricity, heat, and water. These batteries are similar to electrochemical batteries in that an electrochemical reaction occurs as long as fuel is present and the anode and cathode contain catalysts, which cause the fuel to undergo oxidation reactions. The hydrogen used as a fuel receiver collects air or oxygen at the negative electrode (anode) and positive electrode (cathode) sides. It has the property of continuously producing dc electricity to a given external load as long as these input fuels are supplied, and the reaction is spontaneous and exothermic, as shown in Figure 2.

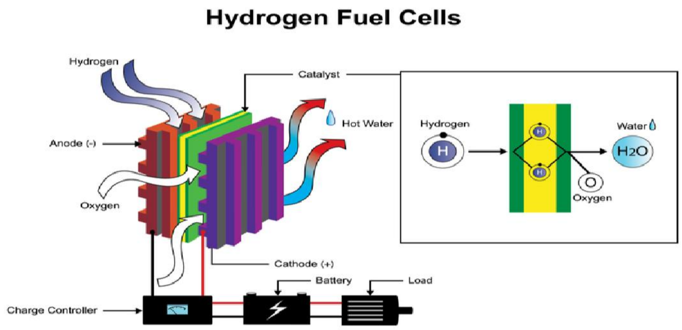

Figure 2: Operational diagram of fuel cell battery

Because there is no combustion operation in these batteries, no harmful emissions are produced, and the only by-product is water. It is thought to be an environmentally friendly battery with high efficiency, fuel flexibility, long-term stability, and low emissions [9]. Proton exchange membrane, molten carbonate, solid oxide, direct methanol, phosphoric acid, alkaline, and other types of fuel cell batteries can be used depending on the application.

The current fuel cell batteries have the following limitations:

- **a)** High cost: For general consumer use, hydrogen-based fuel cells are still prohibitively expensive. Because hydrogen peroxide and liquid hydrogen are required components, they are costly. As a result, it is primarily limited to large commercial and research applications.
- **b)** Combustible: The fact that hydrogen is highly flammable adds to the dangers in the area.
- **c)** Size and portability: Fuel cell batteries are still large, making portability difficult for use in desired applications.

IV. SOLAR CELL BATTERY

Because N-type material is usually thin, the operation of a solar cell battery is based on PN junction with solar plates of large surface area to allow sunlight. When light strikes the PN junction, electricity is generated in the depletion area. Silicon atom lattices are commonly used to create PN junctions. Doping is used to create excess holes and extra electrons in P-type and N-type materials, respectively [10]. When light is absorbed, holes in the P region try to diffuse electrons in the N region and vice versa, resulting in a charge in the junction that can produce an electric field. The free hole and electron have sufficient energy to escape the depletion zone. If an external load is connected to the PN junction via wire. As a result of electrons being drawn to the positive charge of the P-type material and holes being drawn to the negative charge of the N-type material, current flows through the external load as shown in Figure 3.

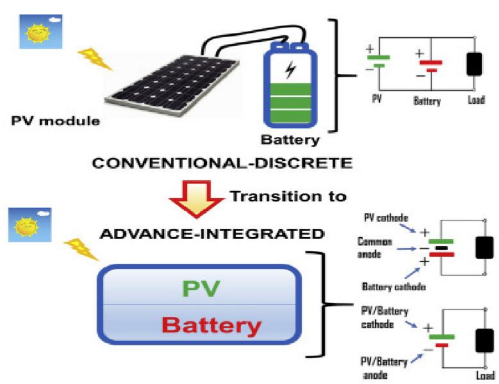

Figure 3: Operational diagram of solar cell battery

The solar cells batteries fully generate renewable energy because this free and unlimited available solar energy is converted into electrical energy without emitting harmful toxins, making it environmentally friendly.

The following are the limitations of current solar cell batteries: (a) Initial Cost: The cost of purchasing and installing the plant to store energy in batteries is still high. (b) Versatility and adaptability: Solar cell systems cannot be used in all conditions, such as cloudy, stormy, and rainy days, as well as in most battery-powered equipment because failure requires an auxiliary backup. (c) Portability and space: The system is no longer portable and should be located in an area where sunlight is abundant

V. LITHIUM-ION BATTERY

A lithium-ion battery is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode and back during discharge and charging. The chemistry, performance, cost, and safety characteristics of lithium-ion batteries differ. Lithium-ion batteries, as opposed to lithium primary batteries (which are disposable), use an intercalated lithium compound as the electrode material rather than metallic lithium.

In consumer electronics, lithium-ion batteries are common. They have one of the best energy-to-weight ratios, a high open circuit voltage, a low self-discharge rate, no memory effect, and a slow loss of charge when not in use, making them one of the most popular types of rechargeable battery for portable electronics. Because of their high energy density, lithium-ion batteries are becoming increasingly popular for military, electric vehicle, and aerospace applications in addition to consumer electronics.

M. S. Whittingham of Binghamton University was the first to propose lithium-ion batteries in the 1970s. 1 Whittingham's cathode was titanium (II) sulphide, and the anode was lithium metal. Rachid Yazami et al. discovered the electrochemical properties of lithium intercalation in graphite in 1980, demonstrating the reversible intercalation of lithium into graphite in a lithium/polymer electrolyte/graphite half-cell. 2 Bell Labs created a workable graphite anode in 1981 as an alternative to the lithium metal battery. Sony released the first commercial lithium-ion battery in 1991, following cathode research conducted by a team led by John Goodenough. Layered oxide chemistry was used in their cells, in particular lithium cobalt oxide. Dr. Michael Thackeray, Goodenough, and colleagues identified manganese spinel as a cathode material in 1983. 3 Spinel showed great promise because of its low cost, good electronic and lithium-ion conductivity, and three-dimensional structure, which provides structural stability. Although a pure manganese spinel fades with cycling, this can be overcome by chemically altering the material. In commercial cells, a manganese spinel is currently used.

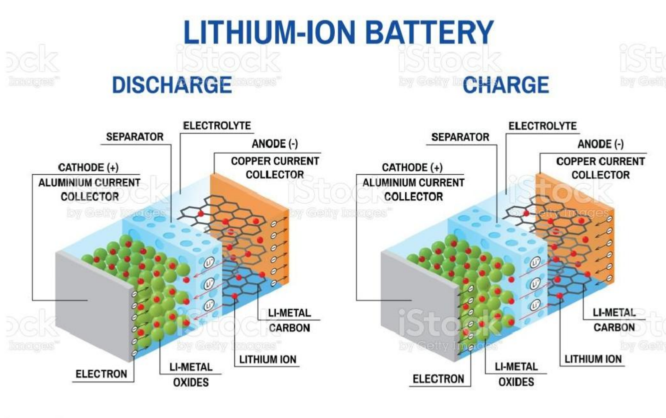

Figure 4: Operational diagram of Lithium-ion battery

Lithium-ion batteries are rechargeable batteries with extremely high-power densities. Such batteries are now widely used in everything from everyday electronic devices like cell phones to electric vehicles. What is not widely recognized is that voids play a critical role in such batteries. The void structure in a material does not always have to be spherical, as this example will demonstrate. Let us first briefly describe the main characteristics of a lithium-ion battery before discussing the critical role of voids in it.

A lithium-ion cell is made up of four parts: anode, cathode, separator, and nonaqueous electrolyte. The anode is graphite, the cathode is an oxide ($LiCoO_2$), and the alternating layers of anode and cathode are separated by a porous polymer separator, which is typically made of polypropylene (PP), polyethylene (PE), or a PP/PE laminate. A controlled amount and uniform size of porosity in the separator is a critical feature in all cases. The electrolyte, which is made up of an organic solvent and dissolved lithium salt, serves as the medium for Li ion transport. During discharge, lithium ions move from the anode to the cathode and are intercalated, or inserted into, open spaces in the cathode voids. During charging, the Li ions reverse their path. A lithium-ion battery (or battery pack) is constructed from one or more individual cells packaged with their associated protection electronics.

VI. RESULTS

The different important properties which desired for success of Lithium-ion battery are comparing with battery (electrochemical cell, solar cell and fuel cell) as shown in table 1.

These lithium-ion battery properties have proven useful in all future applications involving energy storage in batteries. As shown in Figure 5, one proposed model for renewable energy storage system application using Lithium-ion battery in which electricity is generated by the wind energy system and stored in a roll of Lithium-ion battery before being delivered to the loads.

Table 1: Technical comparison of battery storage technologies

Technology	Development	Energy Density (Wh/kg)	Cycle Efficiency (%)	Lifetime (full equivalent cycle)	Capital Costs	Special Features
Lead-Acid	Mature	20-35	60-90	200-2000	50-400	Low cost
Nickel-cadmium	Commercialized	40-120	60-83	500-2500	800-2400	Memory effect
Nickel-metal hydride	Commercialized	60-80	66	3000	300	Poor efficiency
Lithium-ion	Commercialized	100-200	90-100	1000-6000	450-3800	High cost
Sodium-sulfur	Developing	150-240	>86	2000	280	High temperature
Zinc-Bromine Flow	Developing	37	75	>2000	900	Low energy density
Vanadium-Flow	Developing	25	85	Unlimited no. of cycle	1280	Low energy density

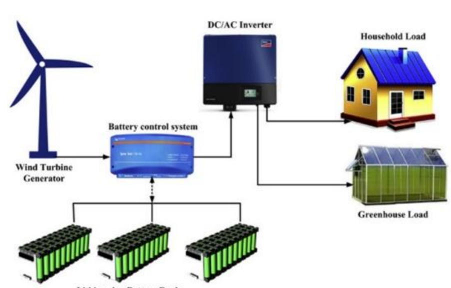

Figure 5: Renewable energy-based Lithium-ion battery system

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 8, June 2022

Impact Factor: 6.252

VII. CONCLUSION

In this paper, conventional batteries (electrochemical cells, solar cells, and fuel cells) are compared to lithium-ion batteries in terms of operational mechanisms, limitations, and various properties such as flexibility, biodegradable & non-toxic, recyclable & reusable, biocompatible, rechargeable, leakage & overheating, electrical conductivity, durability, size & shape, tensile strength, weight, cost, and efficiency. Following an overall analysis, it was discovered that the Lithium-ion battery is superior to other batteries in terms of renewable and sustainable development of the battery in the sector of renewable energy storage system, and thus, one of the plan models for renewable energy-based Lithium-ion battery system proposed and shown in Lithium-ion. However, there is still a need for extra-ordinary research to improve the manufacturing problems of the Lithium-ion battery, so it can easily be implemented on desired applications.

REFERENCES

[1] Ravikant K. Nanwatkar, Dr. Depak S. Watvisave, (2021). Analysis and Simulation of Hybrid Energy Storage System for Electric Vehicle, IJIRT, Volume 8 Issue 2, ISSN: 2349-6002

[2] Akhyar, A., Hasanuddin, I., & Ahmad, F. (2019). Structural simulations of bicycle frame behaviour under various load conditions. Paper presented at the Materials science forum.

[3] Balzani, V., Credi, A., & Venturi, M. (2008). Photochemical conversion of solar energy. ChemSusChem: Chemistry & Sustainability Energy & Materials, 1(1□2), 26-58.

[4] Bilgic, B., Gelisin, O., Guerreiro, R., Lohmann, E., Hanagasi, H. A., Gurvit, H., & Emre, M. P1-287 NEUROIMAGING FINDINGS OF NASU-HAKOLA.

[5] Colombo Zefinetti, F., Rossoni, M., Martinelli, C., & Regazzoni, D. (2021). Design Innovation of Bicycle Frames Exploiting Topology Optimization. Paper presented at the ASME International Mechanical Engineering Congress and Exposition.

[6] Demirbas, A. (2005). Potential applications of renewable energy sources, biomass combustion problems in boiler power systems and combustion related environmental issues. Progress in energy and combustion science, 31(2), 171-192.

[7] Ekblad, H., Svensson, Å., & Koglin, T. (2016). Bicycle planning–A literature review.

[8] Faria, R., Moura, P., Delgado, J., & De Almeida, A. T. (2012). A sustainability assessment of electric vehicles as a personal mobility system. Energy Conversion and Management, 61, 19-30. Hung, N. B., & Lim, O. (2020). A review of history, development, design and research of electric bicycles. Applied Energy.

[9] Karden, E., Ploumen, S., Fricke, B., Miller, T., & Snyder, K. (2007). Energy storage devices for future hybrid electric vehicles. Journal of Power Sources, 168(1), 2-11.

[10] Kumar, J., Garg, N., & Ali, A. (2016). Energy generation using paddling system with solar system. MIT Int J Mech Eng, 6(1), 5-8.

[11] Lakomy, H. (1986). Measurement of work and power output using friction-loaded cycle ergometers. Ergonomics, 29(4), 509-517.

[12] Liu, K., Liu, Y., Lin, D., Pei, A., & Cui, Y. (2018). Materials for lithium-ion battery safety. Science advances, 4(6), eaas9820.

[13] Malppan, G. J., & Sunny, T. (2015). A Review on Design Developments in Bicycle. In: IRJET.

[14] Manthiram, A. (2017). An outlook on lithium ion battery technology. ACS central science, 1063-1069.

[15] Nielsen, T., Palmatier, S. M., & Proffitt, A. (2019). Recreation conflicts focused on emerging e-bike technology. In: Boulder County Parks & Open Space, Boulder, CO.

[16] Panwar, N., Kaushik, S., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. Renewable and sustainable energy reviews, 15(3), 1513-1524.

[17] Pardeshi, S., & Desle, P. (2014). Design and Development of Effective Low Weight Racing Bicycle Frame. International Journal of Innovative Research in Science, Engineering and Technology, 18215-18221.

[18] Popovich, N., Gordon, E., Shao, Z., Xing, Y., Wang, Y., & Handy, S. (2014). Experiences of electric bicycle users in the Sacramento, California area. Travel Behaviour and Society, 1(2), 37-44.