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Comprehensive Review on Various Batteries and Energy Storage Systems for Electric Vehicles

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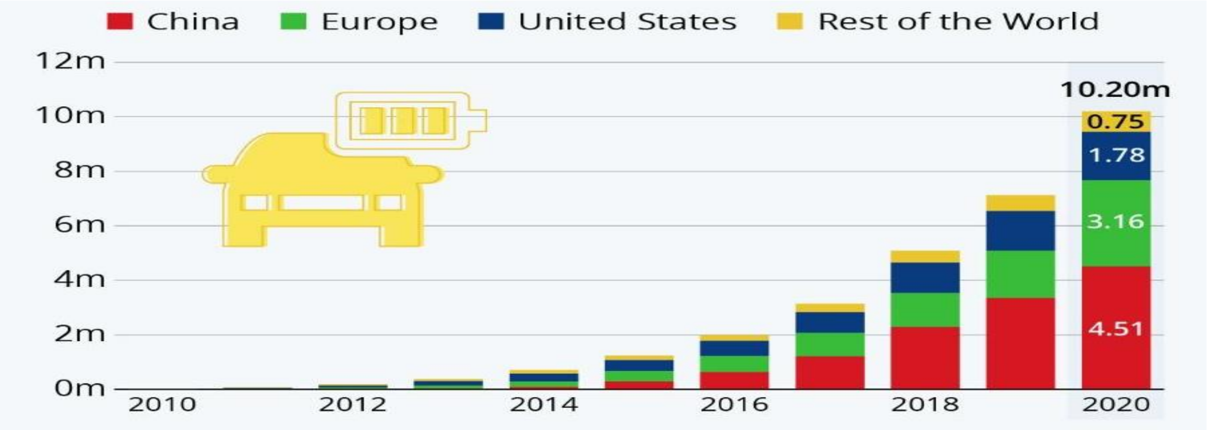
Abstract. The decreases in pollutants resulting from the use of the latest tech in transport are reliant innovation emissions in relation to replaced technology. The number of electric cars has steadily increased over the last few decades. However over past few decades. The expanded usage of electric vehicles might bring radical changes for society not just in terms of technology used to move individuals, as well as in terms of removing our economies from petroleum and reducing the environmental imprint of mobility. Electric cars use energy stashed in the battery pack to drive and spin wheels on electric motors. The cells are refilled by energy from a wall outlet or a special charging equipment if they are exhausted. However, there are various type of cell chemistries and batteries which can be utilized for generated the vehicles power, but at present Li-ion Batteries are used. This review comprehends all types of batteries, their advantages & disadvantages and their possible cause for not practical applications.

Keywords – Electric Vehicles, Eco-friendly, Batteries, Reviews, Li-ion batteries

1. Introduction

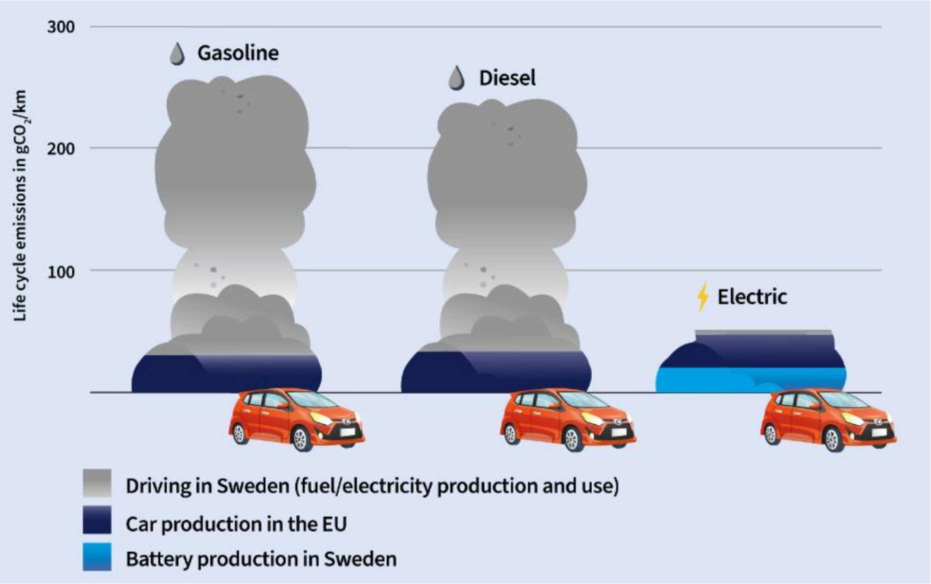
Transportation, which generally represent 30-35% of the overall fuel demands of most industrialised nations, is one of the industries with the greatest fuel use per process. Private transportation worldwide was 95 percent oil-dependent, representing over 50% of the world's petroleum consumption in 2007. Transport is the fastest increasing user of energy in the world and consumes 49 percent of its oil resources in a 2010 assessment report. The first requirement to save energy is to address the energy problem of the transport industry. Savings in energy eliminate needless final energy use that is not the same as convenience and commodities output. [1]

Figure 1. Increase in global electric car stock from 2010 to 2020 [2]



Due to the significant social effects of environmental pollution, car manufacturing companies are obliged to transfer part of their manufacturing from pure IC engine systems to new eco-friendly systems. Poor air quality is contributed by the vapours when the petrol is evaporated and by the chemicals which are made when petrol is combusted (carbon monoxide, nitrogen oxides, particulates, and unburned hydrocarbons). [3] Combustion of petrol ultimately creates a greenhouse gas called carbon dioxide. The pollutants causing harm to lungs and can lead to and exacerbate respiratory illnesses, such as that of asthma, in motor emissions from automobiles and yard machinery. Pollution from motor vehicles also adds to acid rain production. Greenhouse gases causing climate change are also emitted through pollution. [4]

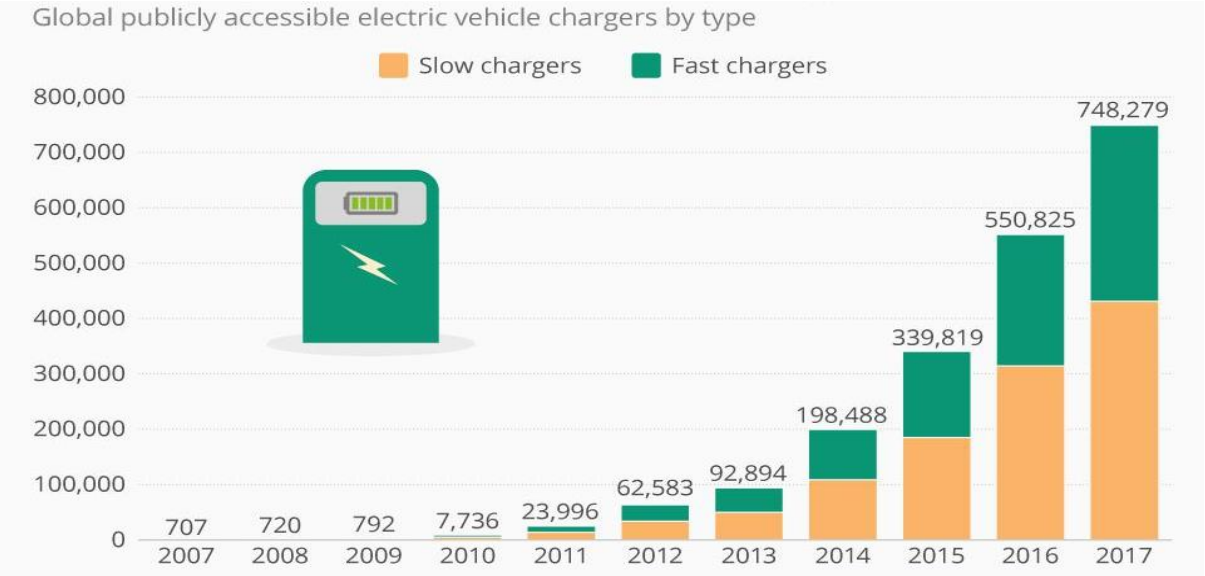
Figure 2. Emissions from Electric Vehicles and Gasoline fuelled Vehicles [5]



In addition to the sudden switch to electric transportation, EVs are keen to provide extended operating distance, quicker load times, and more security. Because of the high energy, power density, lifetime and excellent stability, rechargeable lithium-ion battery has been widely utilised to accelerate electric powered vehicles. [6] The primary difficulty which prevents appliances from coping with Li-ion batteries in electric vehicles, however, is the security worry created by an unavoidable heat generated during chargeable operations. The heat collected in the battery pack might lead to unsafe local temperature, resulting in failure or perhaps even catastrophic events of the whole battery pack. [7]

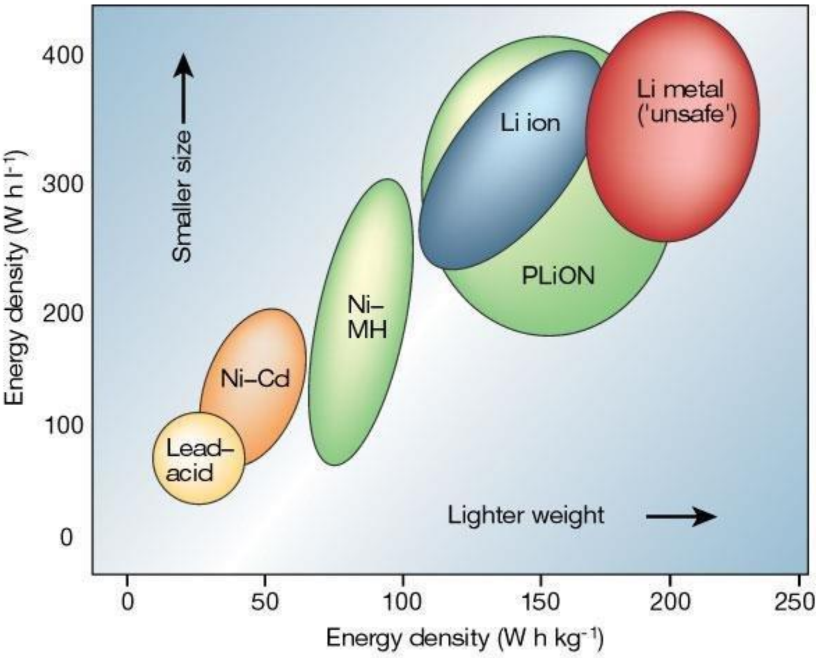
The charging stations infrastructure is still expanding. In 2019, there have been around 7.3 million loaders in the globe, roughly 6.5 million of them in household, multi-dwelling, workplaces. The major factors behind the predominance of private charges are ease, cost-efficiency and a number of measures of assistance (like concessionary rates, subsidies to acquire equipment and refunds). Likewise electrifying are ways to travel besides the automobiles. [8]

Figure 3. Expansion of Charging Infrastructure for Electric Vehicles over a decade [9]



Having electric scooters (e-scooters), electric bicycles (e-bikes) and electric mobile phones accessible today in much more over 600 cities across about 50 countries globally, electrical mobility option have been expanding quickly. While driving and once the car is connected, Energy storage systems undergoes cycles of 'discharge.'[10] The repetition of this action over time impacts the battery charge. This reduces the time and distance between the trips. Most vendors provide a 5- to 8-year battery guarantee. Furthermore, the current forecast would be that the battery of an electric automobile would last between 10 to 20 years before it can be renewed. The battery links to one or more wheels driving electric motors. When the accelerator is pressed, the automobile immediately power the engine, which progressively drains the battery energy. [11,12]

Figure 4. Energy density of various batteries for EVs [13]

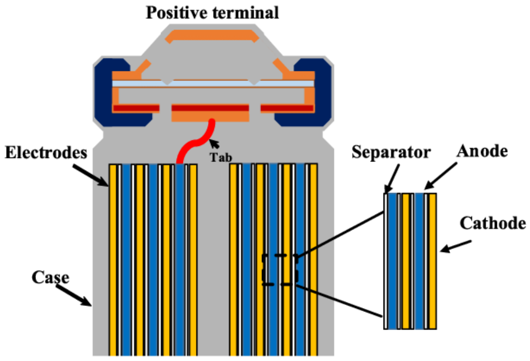


The battery is indeed the main resource and integral ingredient of the electric cars. Their performance is strongly linked to the driving range of the car, its output power, power consumption and efficient recharging. Lithium-ion battery operating temperatures are 10-40˚C, while a maximum variation in temperature is best regulated on the battery or battery system within 5˚C. Rising temperatures, cold temperatures or larger changes in temperature can impact storage capacity, lifespan and reliability. Various batteries are available for reusable EVs and HEVs, including lead-acid, nickel-based, zinc-halogen, metal-air, sodium-ion and Li-ion. The power battery is still the biggest expensive component and a significant impediment to its feasibility. Because of its potential costs and power characteristics, the lead acid battery was used in electric cars in the early 1990s.Because lead-acid battery has a relatively poor life span, some approaches and financing have been explored to increase cycle lives. [14,15]

2. Types of Batteries

It is perhaps a form of electrically charged battery and a range of mobile electrical products. These get a higher capacity than that of the conventional rechargeable batteries for lead acid or nickel cadmium. This allows battery makers to conserve space and reduce the battery pack size. Furthermore, lithium-ion batteries are friendlier than several choices. Battery makers must guarantee that safety precautions are taken to help protect in the case of a power failures which is improbable. For example, producers include charging protections for electric vehicles to preserve batteries for multiple rapid charge cycles in a brief duration. [16]

Figure 5. Internal Structure of Battery Cell [17]

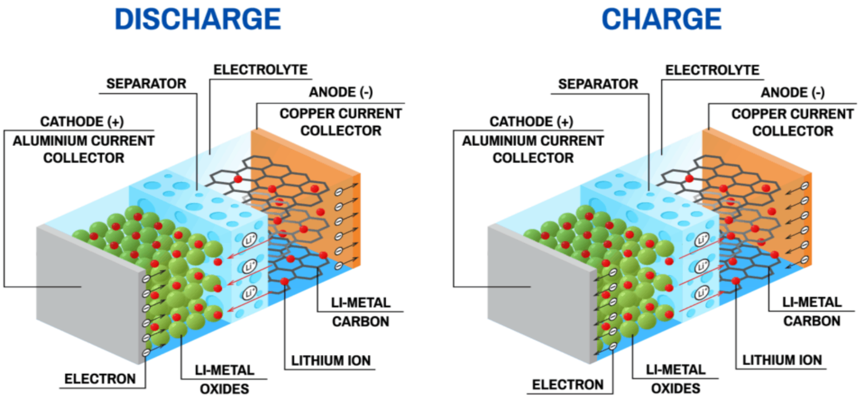


This section discusses on the major Li-ion elements, analyses related battery management systems and methods to battery efficiency, capacity & battery life. Battery endurance is critically affected by the composition and thermal properties. Every variety of electrode material, cost, availability, safety, transit of li-ion and electron products, volumetry growth, breakdown of materials and surface interactions are detailed. The fundamental and particular techniques are addressed and categorised to solve current difficulties. Different types of Li-ion batteries are listed below in detail. [18]

2.1 Lithium-Ion Batteries

Li-ion batteries combine high energy and power density in such an unrivalled way and make it the technological option for mobile devices, power instruments and electric/hybrid vehicles. Whereas if most of petrol-powered cars (EVs) replace the Li-ion battery, emissions of greenhouse gases will be substantially reduced. The great energy efficiency of Li-ion batteries may also raise the effectiveness of energy collected from solar and wind, geothermal or other renewable power in many uses in the electric grid, therefore helping to generate more popular distribution and to establish a viable energy economy. [19]

Figure 6. Illustration of Charge and Discharge of Lithium-Ion Battery [20]



Although Li-ion batteries are the key cause of mobile electrical energy storage, reducing their cost by improving energy efficiency can considerably extend their usage and allow new energy-dependent technologies. To date, there have been a significant deal of study in electrode materials for Li-ion batteries. Increased electrodes, better charging capacity and high voltages (for cathodes), can increase Li battery energy and power densities and enable it less expensive and affordable. [21]

The substances for the positive and negative electrode materials, the electrolyte as well as the separator are consequently quite different. The technical limits of the different materials depend on their purpose. Under circumstances of usage, the electrolyte shall give the maximum transit of lithium ion feasible. In the general environment, the batteries should function, presumably from −30 °C for a parked vehicle in an extreme cooling for a duration of time, to +60 °C, because of the combined surroundings plus charging temperatures, for an accumulation of heat that is heated. There should be a compatible mobile of negative and good electrode materials leading to a low-cost larger storage battery. [22]

2.1.1 Positive Electrodes

electrodes are usually ionic compounds that allow Lithium-ions to spread out. Illustrations of utilised materials are well recognised. Material properties will be briefly addressed following table. Generally, material selection depends on the requirement for energy, power, cycle life, security and cost-effectiveness. [23]

Table 1. Positive Electrodes for Li-ion Batteries for EV Applications

S.NO	POSITIVE ELECTRODE	FORMULA
1	Lithium Cobalt Oxide	LiCoO2
2	Lithium Nickel Oxide	LiNiO2
3	Lithium Manganese Oxide	LiMn2O4
4	Lithium Iron Phosphate	LiFePO4
5	Lithium Nickel Manganese Cobalt Oxide	Li (NixMnyCo1-x-y) O2
6	Lithium Nickel Cobalt Aluminium Oxide	Li (NixCoyAl1-x-y) O2

Table 2. Advantages & Disadvantages of various Positive electrodes

POSITIVE ELECTRODE	PROS	CONS
Lithium Cobalt Oxide	● Good chemical stability ● High energy density ● Good performance	● Low thermal stability ● Load capacity is less ● Short life cycle
Lithium Nickel Oxide	● Low cost ● Longer cell life ● Weight to volume ratios is high	● Lower voltage ● If silicon is added, it makes the anode to shrink
Lithium Manganese Oxide	● Reliable ● Fast charging – due to low internal cell resistance ● Better thermal stability	● Easy to explode ● Prone to leaks ● Lower capacity compared to $LiCoO_2$
Lithium Iron Phosphate	● High heat tolerance ● Great thermal stability	● Less energy density

	• Excellent lifecycle	• Not as portable and less weight as Li-ion battery
Lithium Nickel Manganese Cobalt Oxide	• High specific energy • Good thermal characteristic • Low cost	• Poor stability • Less life cycle
Lithium Nickel Cobalt Aluminium Oxide	• Fast charging • Energy density is high • Longer lifetime	• Expensive • Limited supply of materials

2.1.2 Negative Electrodes

The negative electrode is usually constructed of charcoal of a typical lithium-ion battery. Often, the reference electrode seems to be a metal oxide. During an organic solvent, the electrolyte is a lithium salt. Lithium titanium and nitrogen electrodes are two primary forms of negative electrodes utilised and different methods of electrodes including lithium metal and lithium metal alloys with something like a concentration on lithium silicon alloys and electrodes for transformation. [23]

Table 3. Negative Electrodes for Li-ion Batteries for EV Applications

S.NO	NEGATIVE ELECTRODE	PROS	CONS
1	Carbon Electrodes	• Good conductivity • Chemically stable • Inexpensive • High energy efficiency • Nontoxic	• Discharge rate is low • Reduced charging time • Reduction in anode resistance will reduce loss during charge and discharge cycle • Sometimes reactive to atmospheric oxygen
2	Lithium Titanate (Li4Ti5O12)	• Better cycle life • Power density is high • Safer than carbon-based anode • Good performance at low temperature	• Inherent voltage is low • Specific energy is less • Low conductivity of electrons
3	Lithium Metal	• Fast charging • Cheaper • Elevated energy density	• Highly dangerous • Mostly contains flammable electrolytes which are prone to burn when overheated • Prone to growing metallic dendrites
4	Silicon Electrodes	• High tolerance to change in volume during charge cycle. • Specific surface area is large	• Large change in volume because of lithiation • Prone to instabilities of bulk structures

2.1.3 Electrolytes

Salt, solvents and substances are composites of the electrolyte. The compounds are now the transition for the moving of lithium ions and indeed the solvents are organically liquids which are utilised to dissolve sales. The positive lithium ions between the cathode and the anode are the most significantly transported by electrolyte. Lithium salt, like LiPF6, in an organic solvent is perhaps the most often employed electrolyte. [23]

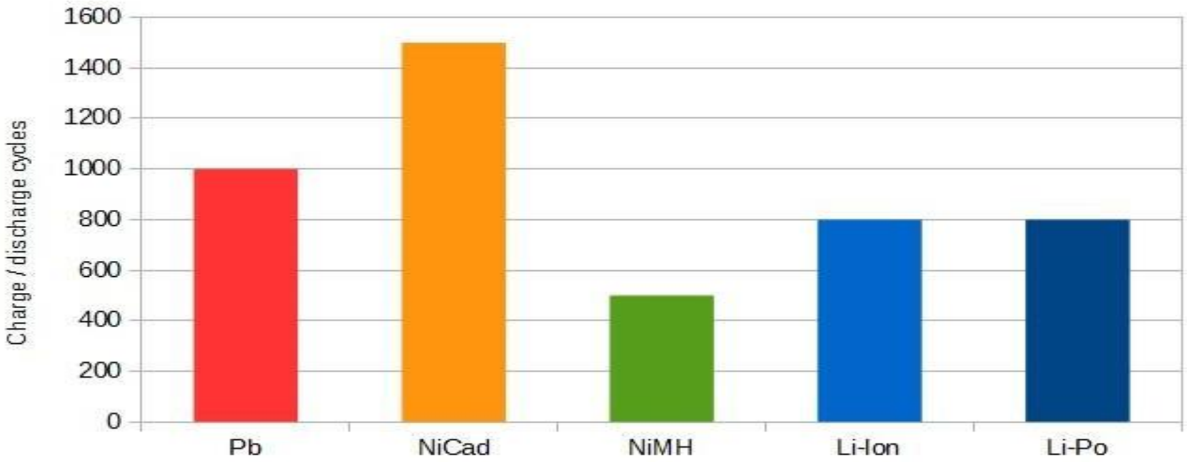
Table 4. Available electrolytes and their pros and cons

S.NO	ELECTROLYTE	PROS	CONS
1	Aqueous	● Good ionic conductivity ● Non flammable ● Inexpensive	● Restricted electrochemical voltage window ● Prone to SEI formation ● Low potential ● Concentrates aqueous solutions are expensive
2	Organic	● Absence of Leak ● Cost effective ● Electrochemically stable	● Flammable ● Not safe ● Lower ionic conductivity ● Poor life cycle
3	Polymer	● Flexible for battery design due to lower elastic moduli ● Flammability is low ● Safer	● Ionic conductivity is low ● Low Li transfer number ● Open to oxidation
4	Ceramic	● High plastic moduli ● Better ionic conductivity is found in Ceramic solid electrolyte ● Non flammable ● High Li transference number ● Well suited for high temperature uses	● Difficult to process they have high fabrication cost ● Poor electrolyte and electrode interface retention ● If there is a thermal runaway, the reaction is vigorous ● High risk of explosion
5	Solid Electrolyte Interface (SEI)	● Safer ● Not prone to leaks ● High power density ● Good thermal & mechanical stability	● Resistance at electrode & SEI is very high ● Manufacturing is difficult

3. Life Span

Regular maintenance and supervision in the usage and manipulation of lithium-ion batteries are required. Lithium-ion rechargeable batteries get a finite lifespan and are progressively losing their ability to retain a charge. This capability declines in age which is irreversible. The time it will power the product diminishes, as the battery loses capacity. When not being used or during storage, lithium-ion batteries tend to deplete (self-discharge) gradually. [24]

Figure 7. Average Life Span of Various Batteries [25]



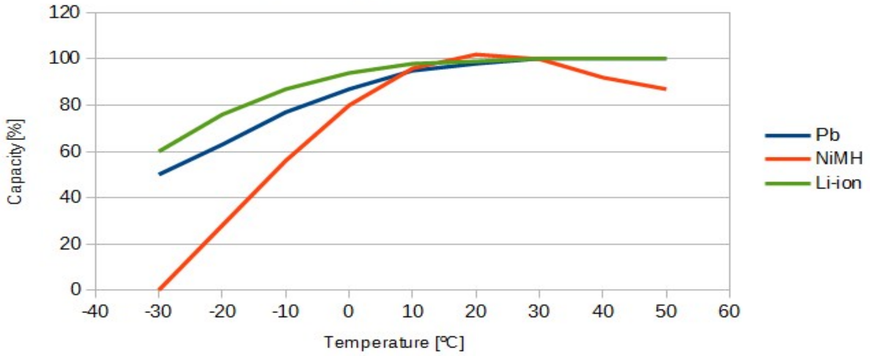
The quality and longevity of Li-ion batteries are affected by various variables. The reduction of either capability (available power) response rate can describe the efficiency deterioration of the Li-ion batteries. Capacity is wasted when the active substance is dormant as a result of parasite chemical processes, however the problem is complex and not easy to describe via fundamental techniques. Similarly, power is lowered when parasites develop which transform battery components to other compounds acting as transport barriers and increases the internal impedance of the cell, therefore reducing the voltage level at each discharge rate. [26]

The latest research emphasises the significant association between the cell fade capacity and energy efficiency also known as minimal hysteresis, perhaps resulting in low impedance of the solid interphase of the new cell with the resulting shift in interphase. This segment examines several the main factors that might influence the overall health status (SOH) of batteries, such as energy supply in relation to a new battery and analyses many current fields of study, which assist solve these difficulties. Please note, the SOH is an essential indication of the operation of the battery, which forecasts the repeatedly until its lifetime is ended. At present, batteries made of lithium-polymer are proven to achieve the maximum potential efficiency of power. This shows out to be far less resistant to lithium polymer batteries. The way they are built simply makes them placed within soft packaging, making them more mechanically vulnerable. If a cell is damaged, a short circuit is established, which leads to a large quantity of energy being released. It has a short circuit, a procedure which you cannot carry out. There is a quick, but also highly hazardous chemical reaction.

4. Temperature

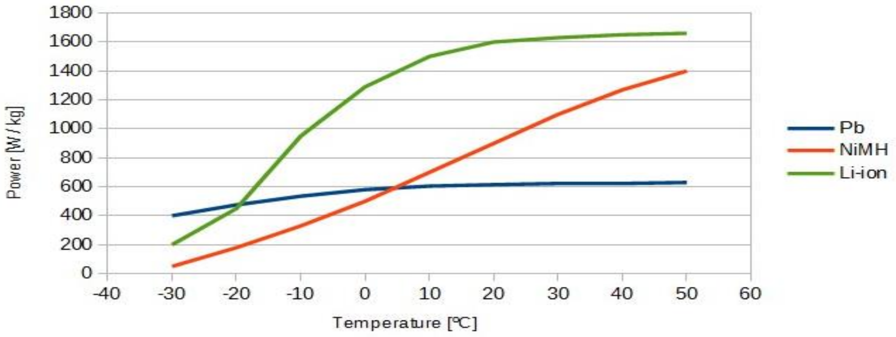
Increasing temperatures impact the electrochemical reactions within a battery. The chemical processes inside the battery also accelerate as the battery rising temperatures. At elevated temperature, excellent efficiency and enhanced battery storage are one of the consequences for lithium-ion batteries. One of several main variables affecting functionality and life duration of a Li-ion battery is the temperature of the cells, specifically while charging and unloading. Battery overheating can result in thermal fluctuations that can reach temperatures of up to 500 °C. Even a single cell's heat flow may lead to a domino effect with other cells that might escalate to fire and life loss or property. [28]

Figure 8. Impact on Battery Capacity with respect to Temperature [29]



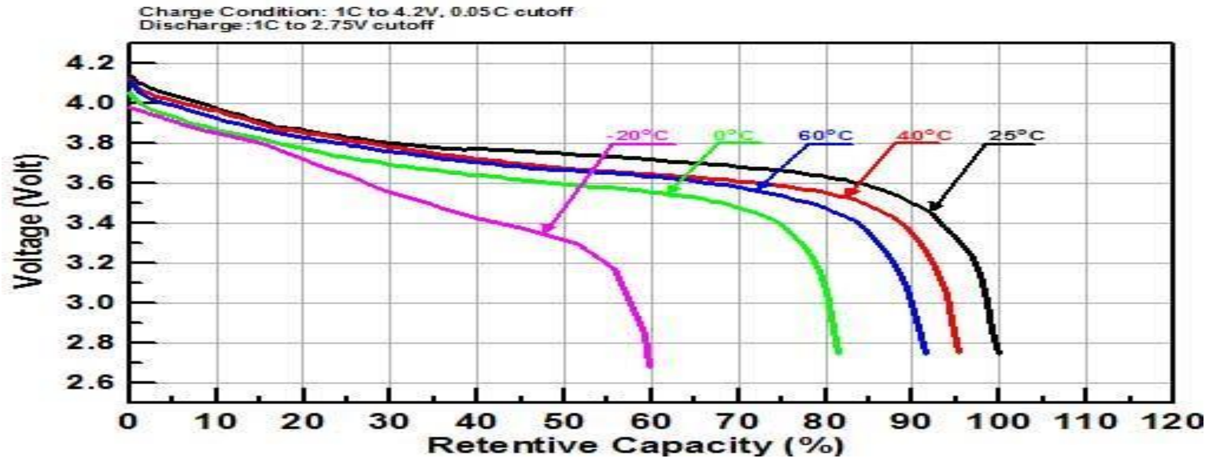
For every battery the temperature gradient varies according to the composition of the battery. If the batteries operate beyond their optimal temperature, the maximum charge capacity can be negatively affected and the total frequency a battery may provide can be reduced. Most EVs use one or even more thermal systems to minimise the dramatic temperature changes seen during charge and discharge. These systems may incorporate passive and active cooling systems, including a source of heat or more for warming batteries in colder weather conditions.

Figure 9. Impact on Battery Power with respect to Temperature [29]



Just one component of the BMS activities is cell protection. Most important duty of a BMS is to maintain the correct charging settings and balance the energy of individual cells so that the effectiveness of an entire battery is optimised. The BMS system continuously monitors and sends data like current, voltage and temperature to a channel of communication.

Figure 10. Performance of Li-battery over a range of temperatures [30]

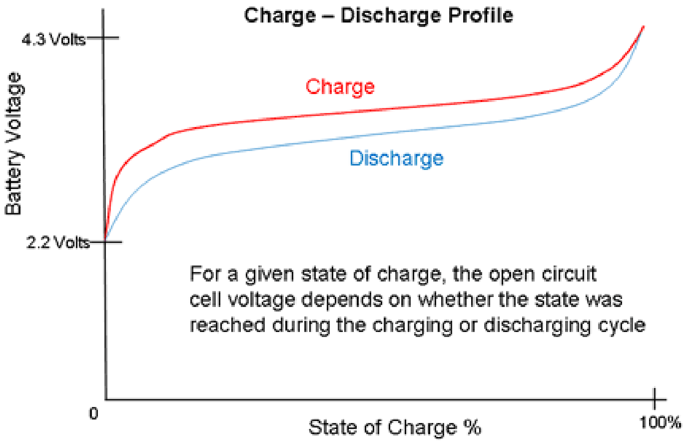


A thermal management system is intended to manage battery system temperatures but may also be used to monitor cell groups' or cells' temperature to prevent deterioration in performance, as failure of one single cell can severely affect the battery's performance. The Battery Management System (BMS) adds significant complexity and energy requirements to its batteries however the advantage far exceeds added weight and power costs. [31]

5. Charge/Discharge

The usable lifespan of an EV Li-ion battery will last until its capacity is no more than 80%. While Li-ion batteries may not be so prone to the "memory effect" of earlier types of batteries, the discharge depth (DoD) can influence the number of charging cycles a battery can accept throughout its usable lifetime. Discharge dept is an alternative way to represent the charge status of a battery (SOC). Like wear and tear on equipment and cylinders, the battery is depleted at a rate that will cut back from its life, due to the chemical reactions in the battery during the discharge period and the subsequent charging cycle. In general, producers have incorporated computer control systems to their BMS to assist preserve the life of the battery, thereby reducing the problem by preventing the battery from draining or charging beyond certain thresholds. The motorist or driver should require it but helps to regulate and extend battery life, this enables a little of an urgent "limp-home." [32]

Figure 11. Graphical Representation of Charge – Discharge Profile [33]



For a given state of charge, the open circuit cell voltage depends on whether the state was reached during the charging or discharging cycle

6. Li-ion Battery Recycling

The mound of wasted lithium-ion batteries that formerly powered such automobiles is growing explosively as the popularity of electric vehicles grows. Even while Li-ion batteries may be recycled, if present patterns for managing spent batteries continue, most of such batteries will wind up in landfills. The rich metals and other components in these popular power packs may be collected, processed, and reused. However, nowadays, virtually little recycling is done.

Lithium, graphite, and cobalt, which are all recognised as essential minerals, are used in Li-ion batteries. Critical minerals are raw resources that are strategically and economically vital with a high risk of supply disruption and no viable replacements. We lose these vital materials outright when these batteries are thrown away in the garbage.

Furthermore, if the battery or electrical device containing the battery is thrown out or placed in a municipal recycling bin alongside domestic recyclables like plastic, paper, or glass, it may be damaged or crushed during transportation or by processing and sorting machinery, posing a fire danger. Instead of being thrown away or placed in municipal recycling bins, Li-ion batteries and those found in electronic devices should be recycled at certified battery electronics recyclers that take batteries. [34]

6.1 Diagnostics of battery pack, modules and cells

Battery repurposing, which entails repurposing packs, modules, and cells in other applications like charging stations and stationary energy storage, requires a precise assessment of both the health status, which is used to determine whether battery packs are best suited for re-use, remanufacture, or recycling, and the state of charge, which is used for safety purposes in some recycling processes. The best approach for high-throughput triage and gateway testing of batteries at scale is in situ techniques for monitoring cells in service to enable advance warning of possible cell replacement, and module or pack reconditioning, rather than complete repurposing at a low level of state of health due to a few failing cells. [35]

The condition of health of cells, modules, and ageing mechanisms such as lithium plating can all be determined using electrochemical impedance spectroscopy. Such measures have the ability to inform a decision matrix for re-use, disassembly, and processing, as well as indicate potential dangers that could have downstream processing implications. Several electric-vehicle manufacturers want to employ comparable technology to manage and repair electric-vehicle battery packs in the field by identifying and replacing defective modules.

6.2 Recycling Process

Li-Ion batteries can be recycled utilizing a combination of mechanical and low-CO2 hydrometallurgical processes to make the process as environmentally friendly as feasible. At a facility, the lithium-ion batteries are first dismantled and processed mechanically. The battery's black matter, which contains key metals, is collected and sent to another factory for hydrometallurgical processing.

The black mass typically consists of a mixture of lithium, manganese, cobalt and nickel in different ratios. With cutting-edge hydrometallurgical recycling technology, able to achieve a recovery rate up to 95% of the scarce metals in battery’s black mass. The hydrometallurgical recycling process involves a chemical precipitation methodology that allows scarce minerals to be recovered and delivered to battery manufacturers for reuse in the production of new batteries. [36]

6.3 Scope of Recycling Li-ion Batteries in Future

The majority of the effort to improve Li-ion battery recycling has been concentrated in a limited number of academic research groups, most of which have worked on their own. However, things are beginning to change. Start-up businesses are commercialising novel battery-recycling technology, fueled by the massive amount of discarded Li-ion batteries coming shortly from ageing electric vehicles and ubiquitous portable electronics. Furthermore, more scientists have begun to investigate the issue, resulting in an increase in the number of graduate students and postdoctoral researchers who have been trained in battery recycling. In addition, several professionals in the fields of batteries, manufacturing, and recycling have begun to build huge, comprehensive collaborations to address the looming challenge. [37]

7. Results and Discussion

The Li-ion pack has distinct key benefits and ages of study that have led to its current high efficiency, great cycle life and high-performance battery. However, modern electrode materials are continuing to study into the limits of cost, energy density, power density, cycle life and security. There are several potential cathode and anode materials, however there is restricted electricity conductivity, sluggish li conveyance, breakdown or other adverse electrolyte reactions, low thermal stability, large expansion size and structural fragility across many cases. Numerous intercalation cathodes were marketed and converting material technology is gradually approaching mainstream marketing. In the previous several decades, Lithium-ion battery electrode materials were a thrilling research moment. With the foundation of new materials and techniques, li-ion batteries can undoubtedly influence our environment even further in the next years.

Batteries and lithium-ion cells are not as strong as every other rechargeable technology. They need protection against being charged and released excessively. Furthermore, the current must be kept below safe limits. Therefore, one drawback for the lithium-ion battery is that it requires safety circuits to guarantee that they are maintained below safe operational limits. Despite lithium-ion batteries are present for many years, they might still be seen as being an undeveloped technology, as it is an extremely developing sector. The technology does not remain consistent; thus, this may be a drawback. However, as new lithium-ion technologies are always being researched, this can also benefit from the availability of superior options.

8. Conclusion

In this review paper various types of lithium-ion batteries have been discussed along with its benefits, limitations and need for improvements. In past years the need for lithium ion, li-ion, has risen considerably. They provide some benefits over other kinds of battery technology and advancements. Lithium-ion battery has its pros and downsides, like any batteries. In order to obtain the most of LI, not just the benefits as well as the technology's limits or downsides must be understood. This allows them to be employed in a method that better fits their role. However, Li-ion batteries need to be replaced due its high cost, ageing, protection as well as availability.

9. References

[1] Yooan Kim et. al "Environmental performance of electric vehicles on regional effective factors using system dynamics", Journal of Cleaner Production, September 2021, 128892.

[2] https://www.statista.com/chart/17178/global-electric-car-ownership/.

[3] K.W.E. Cheng, "Recent development on electric vehicles", Power Electronics Systems and Applications, 2009. PESA 2009. 3rd International Conference, June 2009.

[4] Zhe Liu et. al "Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles", Energy Policy. Volume 158, November 2021, 112564.

[5] https://www.transportenvironment.org/news/does-electric-vehicle-emit-less-petrol-or-diesel.

[6] Ilker Kucukoglu, Reginald DewilDirkC attrysse “The electric vehicle routing problem and its variations: A literature review”, Computers & Industrial Engineering. August 2021, 107650.

[7] Cheng Zhang, “An optimization framework of electric vehicle (EV) batteries for product eco-design”, Procedia CIRP. Volume 90, 2020, Pages 366-371.

[8] Mohammed Hussein Saleh Mohammed Haram et al.,“Feasibility of utilising second life EV batteries: Applications, lifespan, economics, environmental impact, assessment, and challenges”, Alexandria Engineering Journal Volume 60, Issue 5, October 2021, Pages 4517-4536.

[9] https://www.statista.com/chart/14119/amount-of-electric-vehicle-chargers-by-type/.

[10] Yeonguk Son et al, “Reliable Protocols for Calculating the Specific Energy and Energy Density of Li-Ion Batteries”, Materials Today Energy, August 2021 100383.

[11] Lan Xia, “Review—recent advances in non-aqueous liquid electrolytes containing fluorinated compounds for high energy density lithium-ion batteries”, Energy Storage Materials, Volume 38, June 2021, Pages 542-570.

[12] TongZhang et al, “A rechargeable 6-electron Al–Se battery with high energy density”, Energy Storage Materials, Volume 41, October 2021, Pages 667-676.

[13] Mohammad Haris Shams, “Analysis of an electric Equivalent Circuit Model of a Li-Ion battery to develop algorithms for battery states estimation”, Battery Management System, July 2016.

[14] https://www.epectec.com/batteries/cell-comparison.html.

[15] https://www.fluxpower.com/blog/what-is-the-energy-density-of-a-lithium-ion-battery.

[16] Mohammad Rahim, “Lithium-Ion Batteries: Latest Advances and Prospects”, Batteries (7)8, 2021.

[17] Xingyan Yao, Saurabh Saxena, Lei Su, Michael Pecht “The Explosive Nature of Tab Burrs in Li-Ion Batteries” IEEE Access PP(99):1-1, April 2019.

[18] Da Deng, “Li-ion batteries: basics, progress, and challenges”, Energy Science and Engineering 3(5), September 2015.

[19] Osamu Shimamur et al, “Research and Development Work on Lithium-ion Batteries for Environmental Vehicles”, The World Electric Vehicle Association Journal, Vol. 1, 2007.

[20] https://goenergylink.com/blog/key-differences-between-lithium-ion-and-lithium-iron-batteries/ .

[21] Zhiqiang Chen et al, “Overpotential analysis of graphite-based Li-ion batteries seen from a porous electrode modeling perspective”, Journal of Power Sources, Volume 509, 15 October 2021, 230345

[22] Hari Raj, Anjan Sil, “Aqueous processing based novel composite electrode for Li-ion batteries using an environmentally benign binder”, Ceramics International, September 2021

[23] Yu Miao et al “Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for Advancements”, Energies, 2019, 12, 1074

[24] https://batteryuniversity.com/article/bu-808-how-to-prolong-lithium-based-batteries

[25] https://www.electricunicycles.eu/all_you_need_to_know_about_rechargeable_batteries-c__224

[26] https://www.fluxpower.com/blog/lithium-ion-vs.-lead-acid-battery-life

[27] https://www.newark.com/pdfs/techarticles/tektronix/LIBMG.pdf

[28] S. W. Arsri et al, "Analytical study of temperature effect on current and voltage of battery at charging and discharging condition on electric vehicle", AIP Conference Proceedings 2217(1):030068, April 2020

[29] https://optibike.com/lithium-battery-performance-in-cold-temperatures/

[30] https://optibike.com/lithium-battery-performance-in-cold-temperatures/

[31] ShuaiMa et al, "Temperature effect and thermal impact in lithium-ion batteries: A review", Progress in Natural Science: Materials International, Volume 28, Issue 6, December 2018, Pages 653-666

[32] Jie Lin et. al, "A novel underfill-SOC based charging pricing for electric vehicles in smart grid", Sustainable Energy, Grids and Networks, August 2021, 100533

[33] https://www.mpoweruk.com/chargers.htm

[34] Lívia SallesMartins et al, "Electric car battery: An overview on global demand, recycling and future approaches towards sustainability", Journal of Environmental Management, Volume 295, 1 October 2021, 113091

[35] Tsai-Hsiang Chen, "Evaluation of advantages of an energy storage system using recycled EV batteries", International Journal of Electrical Power & Energy Systems, Volume 45, Issue 1, February 2013, Pages 264-270

[36] Yanyan Tang et al, "The social-economic-environmental impacts of recycling retired EV batteries under reward-penalty mechanism", Applied Energy, Volume 251, 1 October 2019, 113313

[37] Qi Zhang, "Comparative evaluation and policy analysis for recycling retired EV batteries with different collection modes", Applied Energy, Volume 303, December 2021