REVERSE ENGINEERING OF EV BATTERIES

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Contents

Introduction

An electric vehicle battery (EVB, also known as a traction battery) is a rechargeable battery used to power the electric motors of a battery electric vehicle (BEV) or hybrid electric vehicle (HEV). Typically, lithium-ion batteries, they are specifically designed for high electric charge (or energy) capacity. The most common battery type in modern electric vehicles are lithium-ion and lithium polymer, because of their high energy density compared to their weight. Since the late 1990s, advances in lithium-ion battery technology have been driven by demands from portable electronics, laptop computers, mobile phones, and power tools. The BEV and HEV marketplace have reaped the benefits of these advances both in performance and energy density. So, in this we will be seeing the types, structure of the battery, it's pros and cons and will Brainstorm ideas to reverse-engineer the product to make it a low-cost/advanced product.

Types of EV batteries

The following four EV batteries are commonly used in battery- electric vehicles (BEV) and hybrids. Each one has its pros and cons.

- Lithium-ion batteries
- Nickel-Metal Hydride batteries
- Lead-Acid batteries
- Ultracapacitor batteries

The most common EV battery types are lithium-ion, nickel-metal hydride, lead-acid, and ultracapacitor. Each battery type has some advantages and disadvantages. Like the lead-acid batteries are economical and reliable, but they have fewer life cycles than the Nickel-metal Hydride batteries. Lithium-ion batteries offer high energy per unit mass but are not efficient in the long run. However, battery makers continue to refine these energy storage components to improve performance and reduce cost.

Lithium-ion batteries:

These are the most common type of EV batteries and are also found in consumer electronic items like smartphones, tablets, and laptops.

Figure 1: Lithium-ion battery

Lithium-ion batteries are preferred due to their high energy per unit mass compared to other batteries. They also have the advantages of a high power-to-weight ratio, energy efficiency, high-temperature performance, and low self-discharge.

Nickel-Metal Hydride batteries:

This type of EV battery offers reasonable specific energy and power performance. It is also used in computers and medical equipment. Compared to lead-acid, nickel-metal hydride batteries offer more life cycles. They are also safer under most operating conditions because they can tolerate more abuse.

Figure 2: Nickel- Metal Hydride battery

Nickel-metal hydride batteries are more often used in hybrid cars, where they are usually charged from the internal combustion engine. However, their drawbacks include high costs, high self-discharge, high heat emission at high temperatures, and hydrogen loss.

Lead-Acid batteries:

These are the oldest type of EV batteries. As a mature technology, lead acids are inexpensive, safe, and reliable. However, they suffer from high weight, low specific energy, sub-par performance during the cold, and shorter calendar and lifecycle.

Figure 3: Lead Acid Battery

Lead-acid batteries are often used in neighbourhood electric vehicles (NEVs) where high performance is not needed. In some EVs, they are also used to power secondary electrical systems.

Ultracapacitor batteries:

Ultracapacitors EV batteries use polarized liquids between electrodes and electrolytes to store energy. The more the surface area of the battery, the higher the energy stored in the capacitor.

Figure 4: Ultracapacitor battery

However, ultracapacitors are usually used to increase the power when the car accelerates and climbs a hill. They also assist in regenerative braking. Ultracapacitors also help to balance load power as a secondary energy storage system.

Lithium battery and its dominance in EV Batteries

Why Is Lithium used in Batteries?

Today we can see small, powerful computers as small as to fit in our pockets easily such as a mobile phone. This is all because lithium-ion batteries can provide immense power at a very small size. It is due to lithium-ion batteries communications and transportation has advanced so much, which includes the shrinking of computers in size and the use of electric cars being practical. These advancements were made possible by the fact that lithium-ion batteries could be more compact than the nickel-cadmium cells of the last generation while yet delivering the same amount of power. Even better, lithium-ion batteries use fewer harmful components and have a longer charge-retention time.

The energy density of lithium-ion batteries is very high, with a little memory effect and a significantly lower self-discharge rate. It is possible to construct cells that emphasize either power density or energy. However, because the solution present in these batteries can easily catch fire, these batteries can explode if damaged and pose a safety risk.

Lithium-ion Battery Working Principle:

A Lithium-ion battery for electric vehicles consists of an anode, cathode, separator, electrolyte, and two current collectors (anode and cathode). The positive and negative electrodes store the lithium. The electrolyte carries positively charged lithium ions from the anode to the cathode through the separator, and vice versa. When the battery is discharging and current is supplied, the anode releases lithium-ions to the cathode, resulting in electron flow from side to side. When charging the batteries, the situation is just the opposite: lithium-ions are released by the cathode and received by the anode. The separator prevents the flow of electrons inside the battery.

Architectural/block diagram:

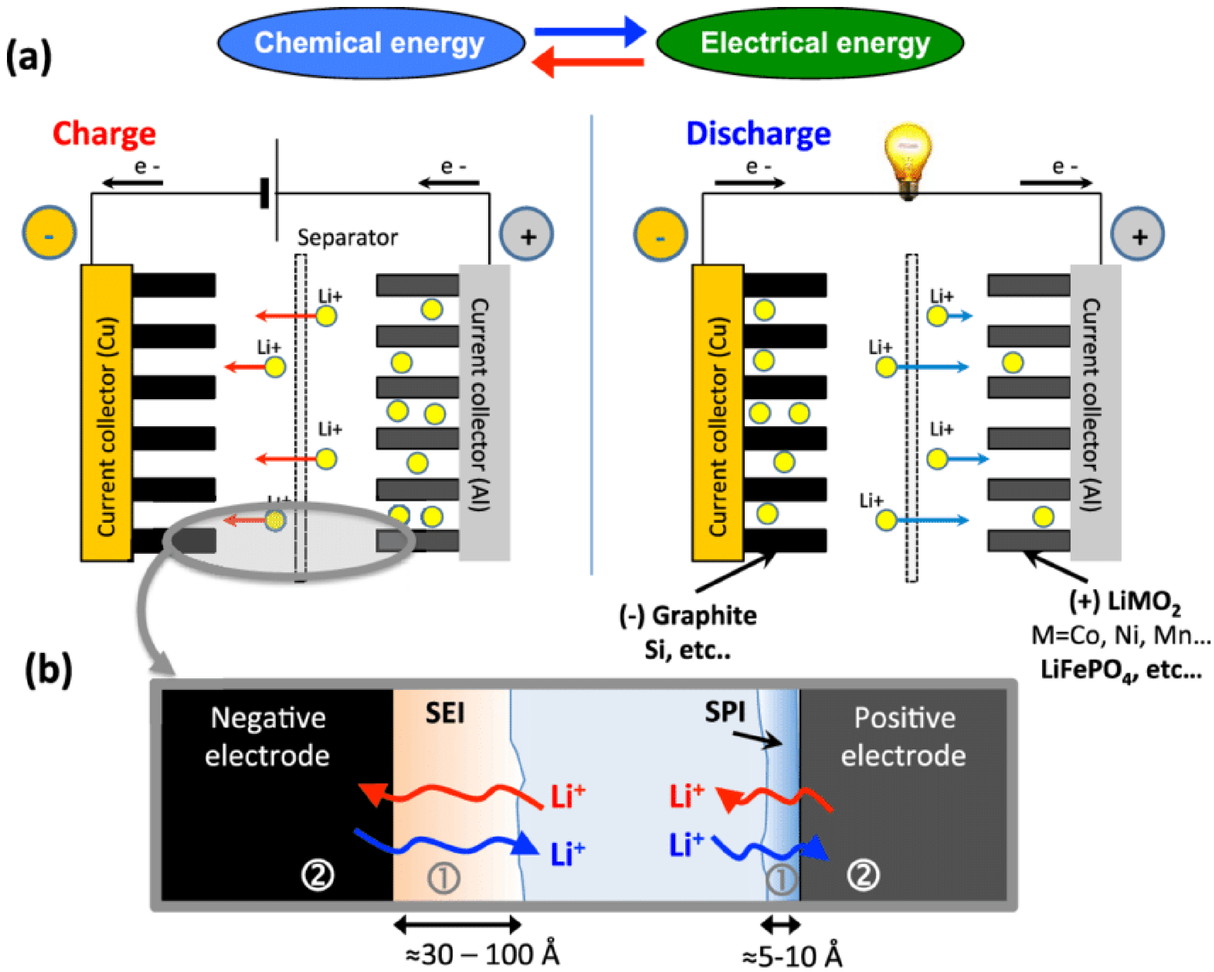

Figure 5: Block Diagram of Lithium-ion battery

To achieve the load and power capacity of traditional passenger vehicles, the batteries of electric cars are composed of a group or a group of lithium-ion batteries, which are connected by a circuit and monitored by an independent computer. Depending on the voltage required by each automobile brand or its use, the number and arrangement of lithium-ion battery is different. The battery 18650 are normally located under the rear seats inside the passenger compartment, or in the trunk. In some more modern vehicles, due to their large size, they are located in the lower part of the car. Covered by an aluminium casing and protected from moisture.

The rocking chair concept governs how lithium-ion batteries function. Here, redox processes are responsible for transforming chemical energy into electrical energy. A lithium-ion battery is made up of two or more electrochemical cells that are electrically linked.

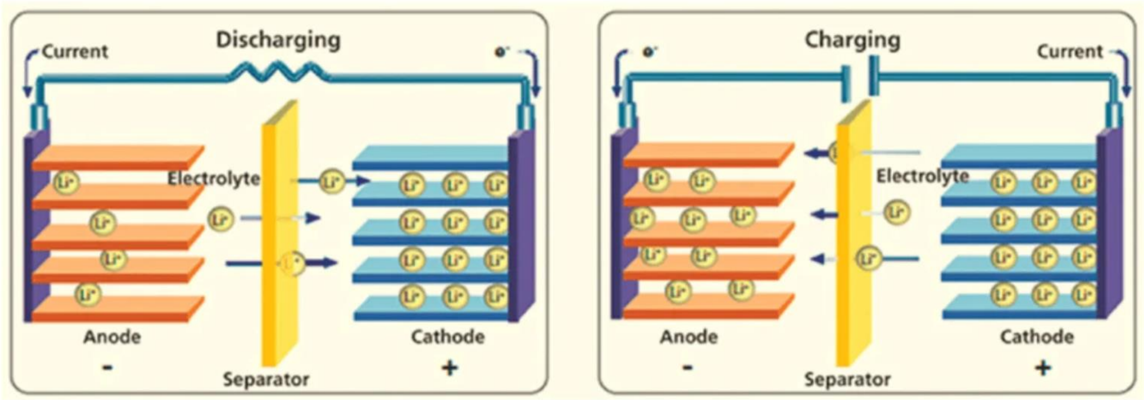

Figure 6

Ions travel toward the negative electrode, also known as the anode when the battery is fully charged. The lithium ions travel back to the top anode or cathode when the battery is fully depleted. This indicates that the lithium ions flow back and forth between the battery's two electrodes during the charge-discharge operation.

Lithium-Ion Battery Advantages:

Using a battery with a Li-ion cell has several benefits. This is the reason for the vast application of lithium-based batteries in modern electronics. Anything, including mobile phones, computers, tiny electrical gadgets, automobiles, and several other uses.

The advantages of lithium-ion batteries include:

<u>1: Greater Energy Concentration:</u>

Greater energy concentration is a great perk of lithium-based batteries. High energy density battery tech is also required for electric cars. These lithium-ion batteries are also significantly better when we talk of power density. Energy density is important for batteries because computers and smartphones require a lot of power to carry complex calculations while still requiring great battery life.

<u>2: Lesser Maintenance</u>:

Low maintenance is another great perk of a lithium-ion battery. Unlike lead acid batteries that require refilling of the electrolyte occasionally, Li-ion batteries do not require any such maintenance. One of the benefits of lithium-based batteries is that it does not require to be regularly maintained. Ni-Cad batteries have to be periodically discharged to prevent the memory effect.

<u>3: Lower Self-Discharging Rate:</u>

The self-discharge rate of many batteries that can be recharged is a problem. The advantage of lithium-ion cells over other rechargeable cell types like Ni-Cad and NiMH is that their level of self-discharging is substantially lower. In the first four hours after being fully charged, it is usually around 5 percent, but it decreases to a rate of 1 or 2 percent every month.

4: Greater Voltage Per Cell:

Every lithium-based cell generates roughly 3.6 volts of electricity. A lithium-ion cell or battery exhibits respectable load characteristics. Before dropping off when the last charge is consumed, they offer 3.6 volts per cell very steadily. The output of every lithium-ion cell is more significant, needing fewer cells for many batteries uses. 3.6 volts per cells is quite impressive when compared to 1.3 volts provided by commonly used nickel based cells and 2 volts per cell provided by alkaline batteries.

Some cells require an additional process to be applied before their use after the first charge. At the same time, you can use lithium-based batteries directly after their first charge.

5: Multiple Types:

Lithium-ion batteries come in several different varieties. This benefit of lithium-based batteries may allow for the adoption of the appropriate technology for a particular application. Some li-ion batteries have high energy densities so are perfect for use in mobile electronics. Others can supply current levels that are significantly greater and are perfect for high power requiring tools and EV cars.

Lithium-Ion Battery Disadvantages

Any technology in this world has drawbacks to its use besides all the advantages Li-ion batteries also have some disadvantages. It is important to know the disadvantages of any component that you are using in your electrical components so that you can design your products keeping in mind the shortfalls of the component. The disadvantages of Lithium-ion battery include:

1: Requirement of a Battery Protective System:

The strength of lithium-ion batteries is not as high as that of specific rechargeable systems. They need to be guarded against being overcharged and discharged excessively. In addition, they must keep the current within acceptable limits. As a result, one drawback of lithium-ion batteries is that protective circuitry must be added to guarantee that they are kept inside their safe operating ranges.

Li-ion batteries may be utilized without technical understanding, thanks to the battery-saving circuitry. When the battery is fully charged, it may be left on charge, and the charger will switch off power to the battery. Lithium-ion batteries include built-in battery-saving systems that keep an eye on several elements of their performance.

2: Lifespan:

Lithium-based batteries degrade over time is one of the main drawbacks of using them in consumer products. A lithium cobalt oxide battery or cell for an average customer should be stored with a partial charge in a cold environment. Frequently, it takes about 500 to 1000 charge-discharge cycles for any rechargeable battery before their efficiency declines.

This depends on time or the date, but it also depends on how many charge-discharge cycles the battery has been through. The number of charge-discharge cycles are being increased as the technology advances but still if a battery is fitted into the device, there might be need for its replacement sometime.

3: Transportation:

Many airlines have a cap on the quantity of lithium-based batteries they may transfer, which means they can only do so via ships. Passengers have to carry li-ion batteries such as smartphones and power banks but in most cases there are restrictions on their transportation. Any lithium-based batteries that are transported separately must have covers, and other safeguards, to prevent short circuits.

Also the efficiency level achieved by the EV car (i.e, Range) is less compared to the petrol and diesel vehicles.

4: Cost:

Costs of li-ion batteries are generally very high which is a major issue. Typically, the price of manufacturing a li-ion battery is forty percent more that the price to produce than nickel-cadmium cells. Cost of a product is very important when mass production of any technology is the purpose.

5: Prone to fire:

Battery protection systems avoid heating lithium-ion batteries and prevent the electrolyte of batteries from catching fire. So, your battery can never explode if it is not damaged physically.

Reverse Engineering Ideas to make it an advanced product:

To reduce the recharging time:

Nano Liquid Battery Could Reduce EV Charging Time to Seconds:

Charging is an essential part of the EV experience. At the moment, recharging one's EV battery takes substantially longer, compared to refuelling a conventional gas-powered car. In order to reduce charging time (and boost EV adoption), advancements in power-cell technology is pressingly needed.

Scottish chemists from the University of Glasgow understand the demanding requirements of EV batteries and have developed a cutting-edge solution to address slow charging concerns. Leveraging dense liquid components, the scientists were able to decrease EV charging time to seconds (average charging time using standard EV batteries range between 30 minutes to 3 hours).

<u>Flow Battery Model:</u>

A flow battery, or redox flow battery (after reduction–oxidation), is a type of electrochemical cell where chemical energy is provided by two chemical components dissolved in liquids that are pumped through the system on separate sides of a membrane.

The revolutionary battery uses a thick liquid consisting of nano molecules for efficient storage of either hydrogen gas or electric power.

This liquid can generate the needed energy quickly and on demand. When it's time to recharge, drivers must replace the liquid. This process requires individuals to first attach a nozzle to the EV and pump out the used matter. Afterwards, a second nozzle replenishes the car with fresh nano liquid.

The flow battery comes with other benefits for EV owners. Energy capacity using the liquid power cell increased – by a whopping 10 times. Moreover, the used matter is recyclable, allowing scientists to process and re-use the liquid for other battery-related applications.

<u>Construction principle:</u>

A flow battery is a rechargeable fuel cell in which an electrolyte containing one or more dissolved electroactive elements flows through an electrochemical cell that reversibly converts chemical energy directly to electricity. Electroactive elements are "elements in solution that can take part in an electrode reaction or that can be adsorbed on the electrode." Additional electrolyte is stored externally, generally in tanks, and is usually pumped through the cell (or cells) of the reactor, although gravity feed systems are also known. Flow batteries can be rapidly "recharged" by replacing the electrolyte liquid (in a similar way to refilling fuel tanks for internal combustion engines) while simultaneously recovering the spent material for recharging. Many flow batteries use carbon felt electrodes due to its low cost and adequate electrical conductivity, although these electrodes somewhat limit power density due to their low inherent activity toward many redox couples.

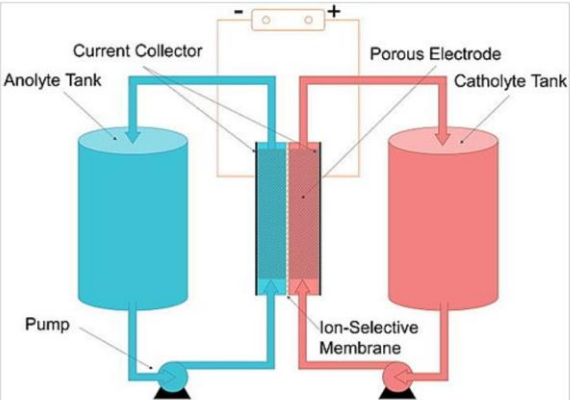

Figure 7: Construction of flow battery

In other words, a flow battery is an electrochemical cell, with the property that the ionic solution (electrolyte) is stored outside of the cell (instead of in the cell around the electrodes) and can be fed into the cell to generate electricity. The total amount of electricity that can be generated depends on the volume of electrolyte in the tanks.

Importance of Flow Batteries

The flow battery presents an industry game-changer. Significant enough to get consumers over the hump and facilitate widespread adoption of electric cars. Chemists based at Glasgow University have utilized a nano-molecule that has the capability of storing electric power or hydrogen gas in its new flow battery system. Instead of visiting charge points, cars could theoretically fill up at a gas station, as the system works on replacing fluid within the battery. An electric car owner would use the pumps to fill the battery with fresh electrolyte instead of the usual fossil fuel that is pumped into combustion engines, and the depleted electrolyte would be discarded at the same time. This means that no change to the infrastructure is required, and current gas stations could be used to support electric vehicles, eliminating the concern over ease of use due to limited charge points.

Further to this, the new system eliminates the concern over the need to wait significant periods to charge the vehicle which causes delays to journey and make the cars less convenient. As the energy is replaced through changing the electrolyte by pumping it directly into the system, recharge time is dramatically cut, meaning that filling up a regular car and recharging an electric one would take a similar time with the flow battery.

Conclusion:

With the flow battery concerns over the usability and performance of electric cars are alleviated. Because the system allows the fresh charge to be pumped directly into the system the current infrastructure can be used to support recharging, the time of which is reduced to the same as refuelling a combustion engine car. The new battery system also supports a greater amount of energy storage, meaning that cars can travel further without needing to recharge. The impact of this is that two of the main preventions of the widespread adoption of electric cars are eliminated, assisting the uptake of a renewable alternative in one of the world's biggest fossil fuel consuming sectors.

Nano silicon anodes for high performance rechargeable batteries:

The specific capacity of graphite, which is currently the material of choice for the anodes of EV batteries, is about 350 mAh/g, while pure silicon can achieve a specific capacity of 3,575 mAh/g, which is at least 10× greater than traditional graphite anodes. The new technology exploits the properties of silicon, one of the most promising anode materials, by growing and fusing silicon nanowires directly onto the particles of the commercial graphite powder already chosen by the battery manufacturer, increasing the EV range while also shortening the time required for recharging. The novel technology has two relevant key factors. The first is that this process is agnostic as to which graphite is used (synthetic or natural) and to the size of the graphite particles. The second is that the manufacturing process can use already-deployed machinery, making this solution very affordable and scalable. According to OneD Battery Sciences, the costs of SINANODE technology remain low thanks to the use of materials already common in the renewable energy industry, particularly the production of solar panels, in which inexpensive silane gas (SiH4) is used, and the very high yield and modest amount of electricity used to convert the silane into nano-silicon.
Taking advantage of an extremely high theoretical capacity of 4200 mAh g−1, silicon has been considered one of the most promising anode materials for lithium ion batteries. Nevertheless, it also has many challenging issues, such as large volume expansion, poor electrical conductivity and the formation of unstable solid electrolyte interphase layers. To address these challenges, much effort has been directed towards developing new strategies, such as designing novel nanosilicon and hybridizing with other functional materials. This

paper is dedicated to identifying the current state-of-the-art fabrication methods of nanosilicon, including ball milling, chemical vapor deposition, metal-assisted chemical etching and magnesiothermic reduction, as well as the design principles and the selection criteria for fabricating high performance Si nanostructures. The critical factors determining the electrical conductivity, structural stability and active material content are elucidated as important criteria for designing Si-based composites. The structural evolution and reaction mechanisms of nanosilicon electrodes studied by in situ experiments are discussed, offering new insights into how advanced Si electrodes can be designed. Emerging applications of Si electrodes in other rechargeable batteries, such as Li-S, Li-O2 and Na-ion batteries are also summarized. The challenges encountered for future development of reliable Si electrodes for real-world applications are proposed.

Figure 8: Nanosilicon Battery

Battery Swapping:

Battery Swaping is a process in which a drained battery is exchanged for a fully charged battery at a battery swapping station or BSS. The BSS acts as a battery aggregator that provides the infrastructure where a number of batteries are kept in charging and charged batteries are made available to EV drivers.

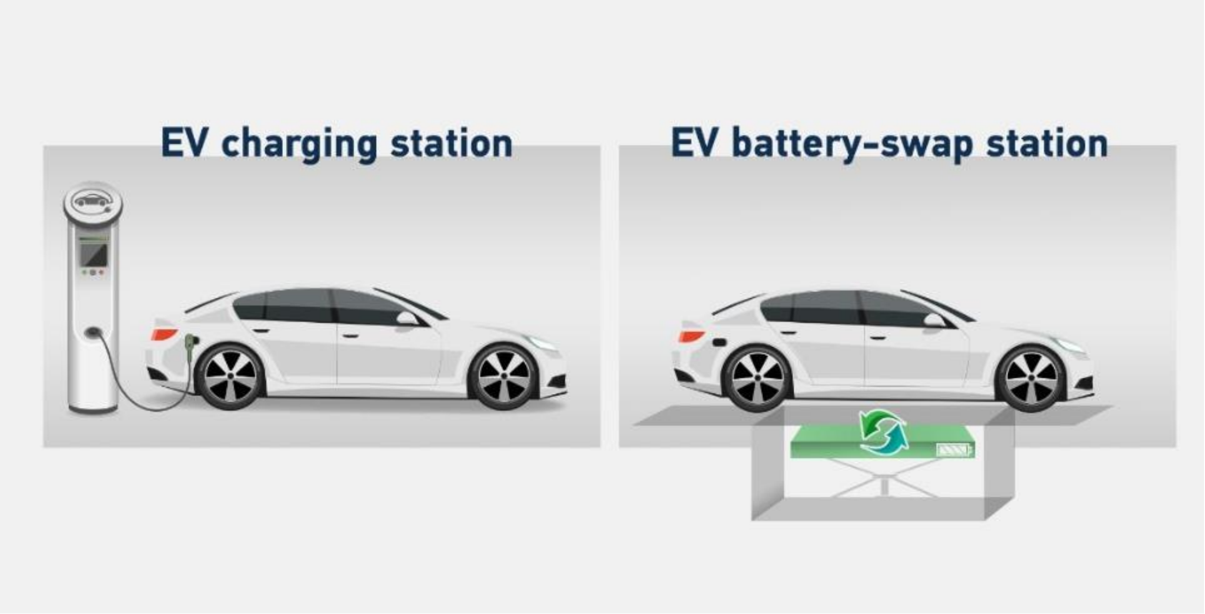

Figure 9: Battery swapping

Let us now look what are the challenges, advantages and disadvantages/barriers of battery swapping

Advantages:

- Charges battery in few minutes
- Batteries can be charged away from the swapping point, allowing more freedom in setting up swap facilities
- Reduction in the upfront cost of EV, as battery ownership is replaced by battery leasing
- Increased predictability of battery life due to controlled charging conditions

Barriers:

- Lack of standardization among EV batteries unsuitable battery pack design to enable ease of swapping
  (weight, dimensions and ergonomics)
- Greater number of batteries needed to power the same number of EVs
- The shorter commercial life of battery packs due to customer preference for new batteries with a higher range
- Slow adoption of charging method by OEMs
- Higher costs of battery leasing over the life of the EV
- Higher GST on separate battery (18%) vs battery sold with EV (5%)

Sodium ion battery as alternative to lithium:

The sodium-ion battery (NIB or SIB) is a type of rechargeable battery analogous to the lithium-ion battery but using sodium ions (Na+) as the charge carriers. Its working principle and cell construction are almost identical with those of commercially widespread lithium-ion battery types, but sodium compounds are used instead of lithium compounds.

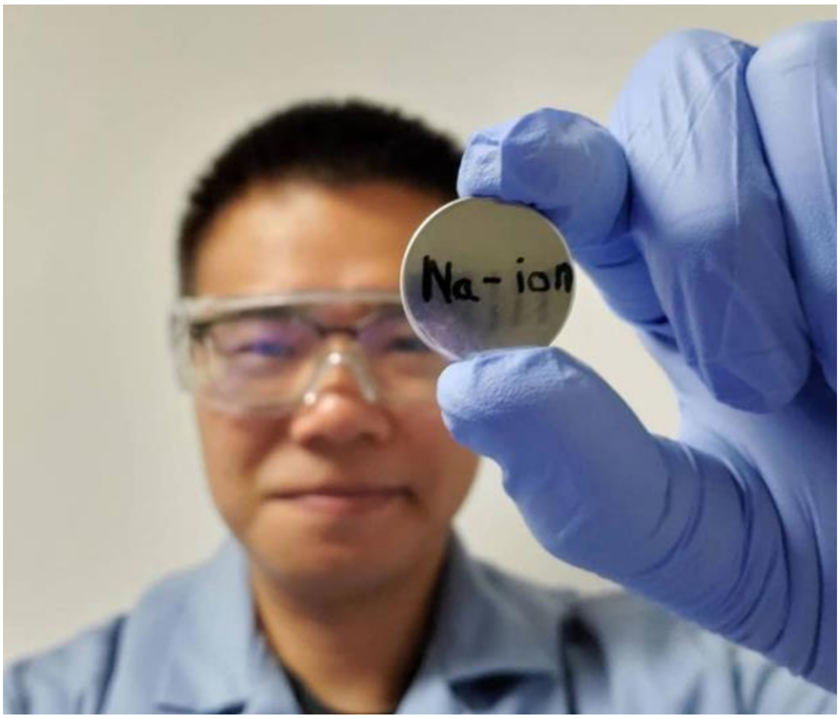

Figure 10: Sodium-ion battery

Since the physical and electrochemical properties of sodium differ from those of lithium, the materials generally used for lithium-ion batteries, or even their sodium-containing analogues, are not always suitable for sodium-ion batteries.

	Sodium-ion Battery	Lithium-ion Battery	Lead–acid battery
Cost per Kilowatt Hour of Capacity	$40–77	$137 (average in 2020).	$100–300
Volumetric Energy Density	250–375 W·h/L, based on prototypes	200–683 W·h/L	80–90 W·h/L
Gravimetric Energy Density (specific energy)	75–165 W·h/kg, based on prototypes and product announcements	120–260 W·h/kg	35–40 Wh/kg

Cycles at 80% depth of discharge	Hundreds to thousands.	3,500	900
Safety	Low risk for aqueous batteries, high risk for Na in carbon batteries	High risk	Moderate risk
Materials	Earth-abundant	Scarce	Toxic
Cycling Stability	High (negligible self-discharge)	High (negligible self-discharge)	Moderate (high self-discharge)
Direct Current Round-Trip Efficiency	up to 92%	85–95%	70–90%
Temperature Range	−20 °C to 60 °C	Acceptable: −20 °C to 60 °C. Optimal: 15 °C to 35 °C	−20 °C to 60 °C

Table 1: Comparison of Sodium-ion battery with other battery

Operating principle:

Sodium-ion battery cells consist of a cathode based on a sodium containing material, an anode (not necessarily a sodium-based material) and a liquid electrolyte containing dissociated sodium salts in polar protic or aprotic solvents. During charging, sodium ions are extracted from the cathode and inserted into the anode while the electrons travel through the external circuit; during discharging, the reverse process occurs where the sodium ions are extracted from the anode and re-inserted in the cathode with the electrons travelling through the external circuit doing useful work.

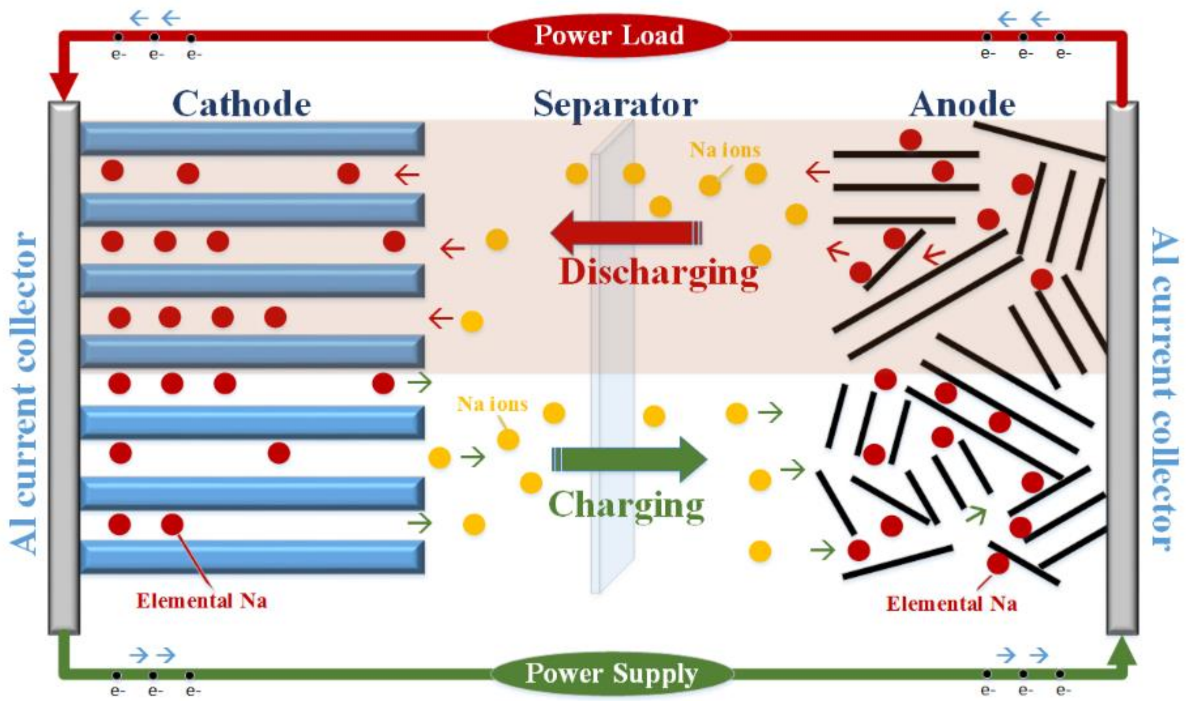

Figure 11: Operating Principle of Sodium-ion battery

Future of sodium-ion batteries:

The abundance of Sodium is thousand times more than lithium. Therefore, the supply of it is infinite. Considering the overall cost of extraction and purification of Sodium to be far lower, Na-ion cells can be 20%-40% cheaper. However, the challenge at the moment is bringing the technology to scale.

While LIBs can recharge thousands of times, SIBs have reached only a fraction of that. The reason as per the findings is believed to be the atoms suddenly realigning and facilitating that flawed phase transformation during battery charge. However, a research team from the US Department of Energy's Pacific Northwest National Laboratory (PNNL) has developed a sodium-ion battery with greatly extended longevity. The PNNL research team altered the electrolyte salt to greatly extend the number of charging cycles (300 or more) with minimal loss of capacity (>90% retained) in a coin-sized battery in lab tests. This is a promising finding that will lead to improved Na-ion battery technology to power electric vehicles and store solar energy in coming years.

Results and Discussions

Electric battery Automobiles are really important as they will prevent a major source of increased global warming and other natural problems.

So with this detailed report we have tried to reverse engineer the EV battery and have tried to provide some valuable suggestions to improve the current EV battery to an advanced product.

Conclusion and Future Work

The progress that the electric vehicle industry has seen in recent years is not only extremely welcomed, but highly necessary considering the increasing global greenhouse gas levels. As demonstrated within the economic, social, and environmental analysis sections of this webpage, the benefits of electric vehicles far surpass the costs. The biggest obstacle to the widespread adoption of electric-powered transportation is cost related, as gasoline and the vehicles that run on it are readily available, convenient, and less costly. As is demonstrated in our timeline, we hope that over the course of the next decade technological advancements and policy changes will help ease the transition from traditional fuel-powered vehicles. Additionally, the realization and success of this industry relies heavily on the global population, and it is our hope that through mass marketing and environmental education programs people will feel incentivized and empowered to drive an electric-powered vehicle.

REFERENCES

[1] Powerelectronicsnews.com Nano-silicon graphite anodes increase efficiency of next gen EV batteries.

[2] Mashable.com Battery swapping could reduce EV charging time.

[3] Hindustantimes.com Low-cost sodium-ion EV batteries

[4] Futurecar.com Nano-liquid battery could reduce charging time in EV batteries.

Market Research

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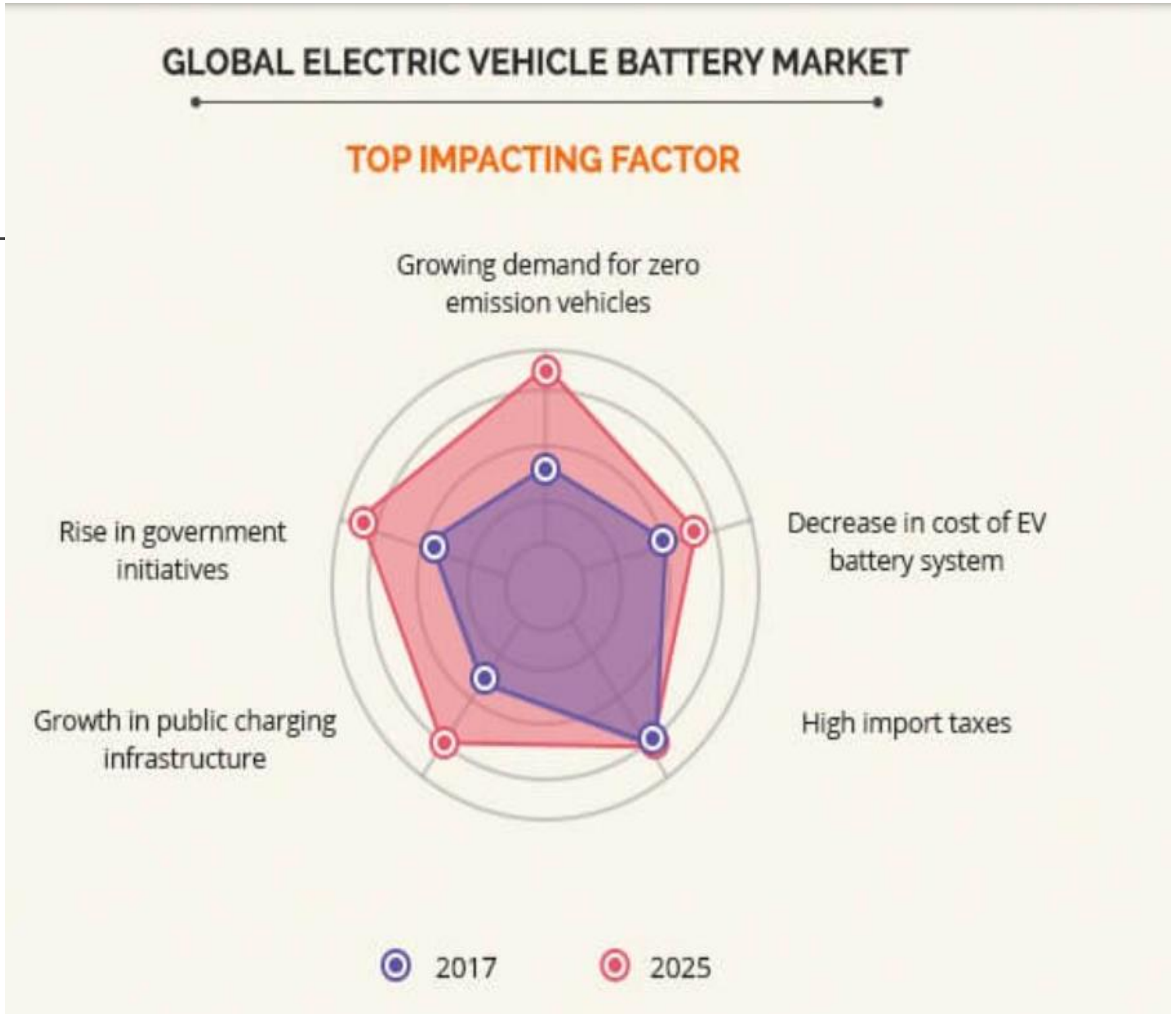
Market Overview

The electric vehicle (EV) battery market is expected to value USD 218.47 billion in 2027, from USD 34.08 billion in 2020, registering a CAGR of 31.56% during the forecast period. The outbreak of COVID-19 did have some impact on the supply chain of electric vehicles and electric vehicle batteries due to global supply chain disruption, but the impact was short-lived and had a short-term impact on the market. Electric vehicle sales eventually grew by around 41% from around 2.11 million units in 2019 to around 2.97 million units in 2020, while the electric vehicle sales growth between 2018 and 2019 was just around 5.2%. The concerns regarding the negative effect of climate change and the growing carbon emission in major cities have created a significant demand for electric vehicles. The EV30-30 Scenario targets increasing the market share for electric vehicles (EVs) to 30% by 2030 (excluding two/three-wheelers). The supportive government policies to promote electric vehicle sales are expected to increase the demand for EV batteries over the forecast period. However, the high cost of electric vehicles, the demand-supply gap of the vital raw materials such as cobalt, and the lack of charging infrastructure are expected to restrain the growth of the market.

Top Impacting factors

The soaring demand for zero emission vehicles, advancing evolution of lithium-ion technology, and rising government regulations on emission control systems are the significant factors that affect the growth of the global electric vehicle battery market. These factors are anticipated to either drive or hamper the market growth.



Enhanced demand for zero emission

Widespread global concerns regarding the negative effect of the climate change along with alarming pollution levels recorded in major cities have created a significant demand for electric vehicles. The rise in petrol and diesel prices has added to the demand for the fuel efficient vehicles. Therefore all these factors have cumulatively shot up the need for advanced fuel efficient technologies, leading to surge in demand for electrically powered vehicles for travel.

Investment Opportunities

With interest in more affordable electric vehicles rising exponentially, the market for EV batteries, now worth over $27 billion annually, is expected to sustain double digit-percentage growth over the next decade. With vehicle batteries being the most important limiting factor to growth, continued innovation and competition in this market can be expected.

Because of their growing importance, research into newer and better rechargeable batteries is gaining momentum. Lithium-air and lithium-metal batteries may prove to be the advancement that matters. If these technologies do end up paying off, investing in large companies involved in battery production, in pure-play lithium-ion manufacturers, or indirect exposure via lithium metal producers can help bolster a portfolio's future performance.

Increasing Investment by Leading Automotive OEMs

Leading players are expanding their operation in the EVs battery market. For instance, in April 2020, SK Innovation invested USD 2.5 billion in its battery business to build two plants at its site in Commerce, Georgia. Also, in April 2021, LG Chem and General Motors (U.S.) invested more than USD 2.3 billion in a second U.S. battery cell plant for electric vehicles in Tennessee. This plant supports the production of General Motor's upcoming Cadillac Lyriq Crossover and other upcoming EVs. In November 2020, SVOLT Energy planned to build the first European lithium-ion cell Gigafactory in Saarlouis, Germany. The company invested USD 2.4 billion in manufacturing capacity. In April 2020, Vehicle Energy Japan completed a new production line for lithium-ion battery cells and battery modules for hybrid vehicles in Kyoto, Japan. This production building can produce 150,000 to 200,000 batteries.

Customer expectation

- Range
- Low cost
- Faster recharge
- Safety and less prone to fire
- Longer life cycle

Cost of EV battery

According to an April 2019 report by the International Council on Clean Transportation (ICCT), the projected cost by 2025 should be $120/kWh to $135/kWh. This is less generous than the Wharton analysis, suggesting by 2025 a 100 kWh battery replacement out of warranty may cost up to $13,500. The ICCT report does note that battery cost forecasting has consistently underpredicted actual battery cost reduction. They provide a caveat that if a slightly rosier analysis is performed, battery pack-level costs could be $89/kWh by 2025 and $56/kWh by 2030.

According to the latest forecast from Bloomberg New Energy Finance (BNEF), in Dec 2020 the average price of battery capacity was $137/kWh, with an expectation of average price close to $100/kWh by 2023, seven years sooner than Bloomberg NEF models suggested in 2016. Cited within the 2019 ICCT report, the BNEF models estimate that by 2030, average battery pack level costs will be $62/kWh. A 100 kWh pack may cost at least $6,200 to replace by 2030.

Geographical wise usage and demand

Asia-Pacific Expected to Witness Significant Growth:

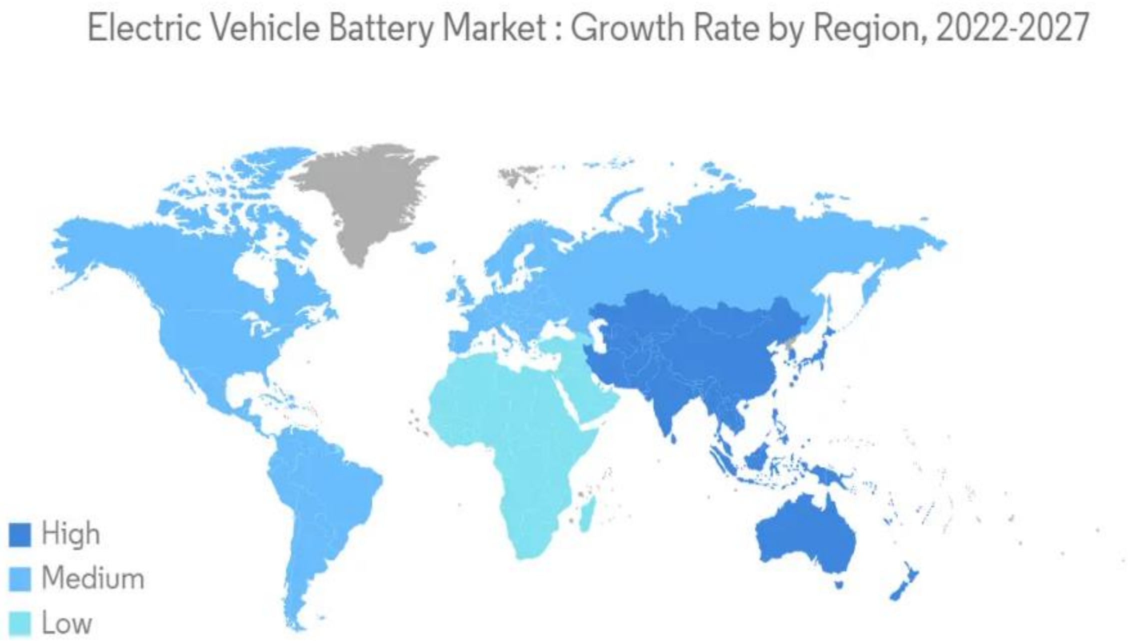
The Asia-Pacific region dominated the global market share in 2020. With the increasing deployment of electric vehicles in countries such as China, Japan, and India, and the high demand for vehicles with urbanization and increasing power purchase parity, the usage of lithium-ion batteries is expected to witness significant growth in the region.

- Favorable policies, such as the energy efficiency standards and increasing peak demand charges and technological advances, have led to the commercial and industrial (C&I) sector receiving more attention from project developers, primarily driven by strong growth in China and India, which, in turn, is expected to drive the demand for lithium-ion-based energy storage systems in the region.

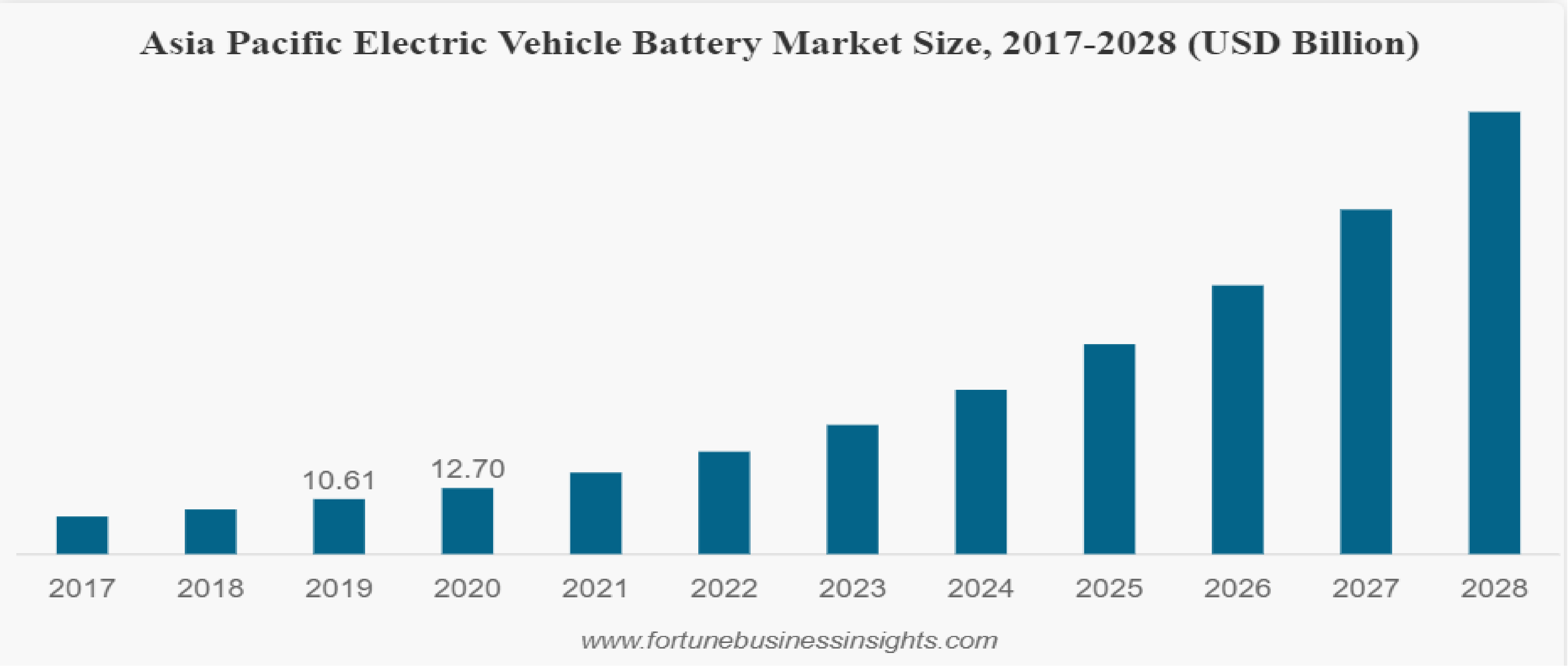
- China is one of the largest markets for electric vehicles, and the increasing adoption of electric vehicles in the country has been in line with the clean energy policy. Moreover, the Government of China has been providing both financial and non-financial incentives to promote the adoption of electric vehicles.
- However, in January 2021, China's Ministry of Finance has cut subsidies for electric vehicles (EVs) by 20% for the year 2021, as sales of so-called new energy vehicles (NEVs)—a category covering hybrids, plug-ins, and hydrogen-powered autos—regained momentum after plunging during the pandemic last year.
- In India, lithium-ion batteries are mainly used in electric vehicles. India is a major importer of lithium-ion batteries in the Asia-Pacific region and during 2019-20, the country had imported approximately 450 million units of lithium batteries used in a range of electrical equipment, products, and EVs and were valued at an estimated INR 6,600 crore (approx. USD 929.26 million), with China, Japan, and South Korea being the major trading partners.
- The government of India is targeting the conversion of two and three-wheelers into 100% electric ones and the total automotive sales to 30% into e-mobility by 2030. Currently, India is dependent on other countries for sourcing EV batteries, which has resulted in the hiked price of EVs. The penetration of EVs in the Indian automotive sector is expected to bolster indigenous manufacturing of Li-ion batteries to make them economically viable.

Asia-Pacific Expected to Witness Significant Growth

- Hence, owing to the above points, Asia-Pacific is expected to witness a significant growth in EV battery market during the forecast period.



Latest trends



Conclusion

Transition to electric vehicles is estimated to require an 87,000% increase in supply of specific metals by 2060 that need to be mined initially, with recycling covering part of the demand in future. In the UK alone, it is estimated that switching 31.5 million petrol vehicles to electric would require "207,900 tonnes of cobalt, 264,600 tonnes of lithium carbonate, 7,200 tonnes of neodymium and dysprosium, and 2,362,500 tonnes of copper", and a worldwide switch would require 40 times these amounts. So with these we clearly understand the potential market of the fast growing EV and its much increased significance in the near future.

Your best quote that reflects your approach… "It's one small step for man, one giant leap for mankind."

- NEIL ARMSTRONG