ASSESSMENT OF EV’s LIFE CYCLE AND DEVELOPMENTS

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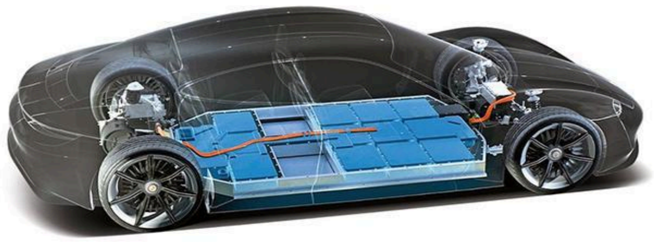
Abstract:

In the Hybrid Electric vehicles life assessment test, batteries play a very important role in determining the quality of the electric vehicle in the near future. If a customer buys an EV today then after 5 year what will be the condition of the EV. As battery plays a very important role in EV's life, the amount of years the battery of the car will work up to its full potential is depended upon the charging cycles in the past. The life of the battery of an EV is decided by the charging cycles. The lesser number of charging cycles the more is the battery life. Can you imagine? If you have an electric car and drive it for 50,000 miles in a year then the battery will have less life than if you drive it for 100,000 miles in a year. The battery of an EV is the most important part of the vehicle. The battery is the most expensive part of the vehicle. Battery technology is still a problem. The battery technology that is used in the EV is still not developed to the level of the gasoline engine. These are just the basic problems which cause the battery to degrade. Still there are many problems like, variations of average driving patterns in different geographic locations and the use of heating and cooling due to local climate conditions have an impact on the energy consumption of EVs. The Life Cycle Assessment (LCA) method is used for the quantitative ecological assessment. This Project mainly focusses on Assessment of EV's lifecycle and development.

Introduction:

As the automotive industry is on the brink of a significant electrical transition, environmental performance of EVs has become a extremely debated topic. This addresses 2 essential aspects of this dialogue, particularly the climate impact of EVs and also the use of essential metals, including rare earth minerals. The energy transition has been called the most critical challenge facing humanity today. With the majority of the world's population expected to live in cities by 2050, the demand for energy will be at an all-time high. To meet this demand, the global energy infrastructure will need to be increased. One of the biggest drivers of increasing energy demand is the need to power cars and trucks, which account for 40% of global energy use. The electric vehicle revolution has begun, but the biggest challenge is electrifying the world's fleet of vehicles and reducing the number of vehicles that are still powered by gasoline and diesel engines. In 2015, the global fleet of electric vehicles was around 4.3 million. Over the next few years, this number is expected to grow to over 300 million electric vehicles by 2040, but this will not be sufficient to meet the global energy needs of the future. This research looks at the demand and availability of critical raw materials (such as lithium, cobalt, nickel, graphite, and rare earths) used in batteries and electric motors. The analysis is based on data from the International Energy Agency (IEA), the European Energy Agency (EEA), the US Energy Information Administration (EIA), and the World Bank, and it includes the following raw materials: lithium, cobalt, nickel, graphite, and rare earths. This research also focusses on the development of every new raw material which can be used in the electric vehicles body for increasing the overall life span of the vehicle. The Life Cycle Assessment (LCA) methodology is employed for the quantitative ecological assessment. AN LCA will e.g. function a selections support tool in vehicle engineering.



What is an Electric Vehicle:

The term “EV” covers many types of vehicles, example: Hybrid EV’s and battery EV’s. Hybrid EV’s have a electric motor and a Combustion engine. This project focusses on Battery EV’s which use a electric motor and a battery which are charged externally.

EV’s are thought to be an option for replacement of vehicles which run on fossil fuels, they have a ton of advantages compared to the vehicles which have a combustion engine. Few highlighted advantages are lesser noise and zero tail pipe emission. Their ability to run on externally charged batteries ensures us a future with fossil fuel free mobility. In bigger cities with millions of vehicles with a combustion engine, introducing in electric vehicles will valuable as pollution and noise levels of the city decreases drastically. The only disadvantages the customer will face is the range of the vehicle and the price. These would be minimized in the future as their would be more charging stations with more access to fast charging, and as demand increases more companies will manufacture electric vehicles which will lead to a major price decrease. The main problem our society will face is the high demand of metals like lithium, manganese or cobalt and the rare earth metals like neodymium. Many problems arise like the range of the vehicle is very less compared to the conventional combustion engine vehicles. Even though the range is enough for daily travels many customers judge the vehicle based on range. Air conditioner and heater reduces the range drastically as these features are energy intensive. The price of a EV is comparatively higher than the conventional vehicles in the same size.

The energy consumption of the EV depends upon different parameters which can be divided into three groups: driving resistances, the use of auxiliaries and losses. Driving resistances must be overcome to achieve and maintain a certain velocity. Examples are the rolling, acceleration and aerodynamic resistance. Vehicle characteristics like weight and the frontal area influence the resistances. In addition the use of auxiliaries such as heating, air conditioning and ventilation increase the energy consumption. Also losses occur in the process of converting electric energy into mechanical energy due to the efficiencies of the different components.

Materials used in Electric Vehicles:

The EV's skeleton is made up of aluminium to be strong and lightweight. The wheels of the vehicle are even made with aluminium instead of steel as a weight saving method. The seat frames and the steering wheel are made up of magnesium, a light weight metal. The bodies are generally made up of impact resistance plastic and this material is usually recyclable.

The electric cars battery consists of plastic housings that contain metal anodes and cathodes and fluid called electrolyte. In most of the cases lead-acid batteries are used although there are many batteries in the market consisting of fluids and metals, like nickel metal hydride(NiMH) batteries, this is the second best in the market to provide a power source. These vehicles generally hold the fluid in absorbent pads to avoid leakage if punctured during an accident.

The motor or the traction system have plastics and metals inside it so they don't require any lubricants. These contain complex machines which convert the energy generated by the motor into driving power.

Plastics, foam padding, vinyl, and fabrics are been used for the dashboard, door liners and seats. The tires are made up of rubber, but, unlike standard tires, these are designed to inflate to higher pressures so the car rolls with less resistance to conserve energy. The electric car tires also contain sealant to seal any leaks automatically, also for electrical energy conservation. Self-sealing tires also eliminate the need for a spare tire, another weight- and material-saving feature.

The windshield of the car is generally made up of solar glass that keeps the interior from overheating in the sun or frost which usually form in the winter.

Materials that provide thermal conservation reduce the energy drain that the heating and air conditioning impose on the batteries.

Factors influencing the life of an electric car:

The life of the vehicle generally depends upon the driving pattern and changing behaviour as well as the intensity to use the auxiliaries. An aggressive driving style creates more loss in energy whereas a cautious driving style results in lesser consumption of electricity. Finally the heating and cooling of the car's cabin to attain the desired temperature as per needs.

The electricity mix is one of the most crucial parameters for the LCA calculation. Using a mix based entirely on renewable energies delivers a completely different result than an energy mix based on fossil fuels. Choosing the adequate mix which reflects the real world situation and leads to fair and reliable results is challenging. In many LCAs an energy mix is used which is based entirely on renewable energy. However, often it is not clear if this represents the actual grid situation or if it is a case of crediting renewable energy to the EV rather than a different use. In the latter case it must be considered if the crediting can be justified. The charging of EVs can in principle often be carried out at regular household plugs. Yet, often more sophisticated solutions are required at workplaces or in public areas to allow adequate and safe charging. Depending on the conditions of the site the installation of these charging stations demands major building activities. These activities can be significant for specific scenarios in which only one or a few vehicles use one charging station. The available charging infrastructure also influences the options of smart charging. Smart charging applications can increase the share of renewable energy used to charge the EV.

The influencing factor can also be the climate, the topography and the type of road can have a significant change in the energy consumption. The climate makes us turn on air conditioner or the heater as per customer needs. A modern heat pump can be used to reduce the energy consumption of the car as it removes the heating needs of the customer. A flat topology leads to lower energy demand than a hilly landscape topology.

The breaking recuperation can be an important factor for lesser energy usage. Regenerative braking is an energy recovery mechanism that slows down a moving vehicle or object by converting its kinetic energy into a form that can be either used immediately or stored until needed. In this mechanism, the electric traction motor uses the vehicle's momentum to recover energy that would otherwise be lost to the brake discs as heat. This contrasts with conventional braking systems, where the excess kinetic energy is converted to unwanted and wasted heat due to friction in the brakes, or with dynamic brakes, where the energy is recovered by using electric motors as generators but is immediately dissipated as heat in resistors. In addition to improving the overall efficiency of the vehicle, regeneration can significantly extend the life of the braking system as the mechanical parts will not wear out very quickly.

LCA Approach:

A life cycle assessment (or LCA) is a technique for assessing potential impacts, including the environment and human health and well-being, related to a product, system or service.

An LCA approach to the measure the environmental impacts differs from other environmental management approaches in this its focus is upon the measurement and calculation of impacts normalised per unit of output.

Commonly referred to as a “cradle-to-grave” study, an LCA reviews the full range of impacts from the beginning to the end of a product’s life by:

-Compiling an inventory of relevant inputs and outputs of a product system;

-Evaluating the potential environmental and human health impacts associated with those inputs and outputs; and

-Interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

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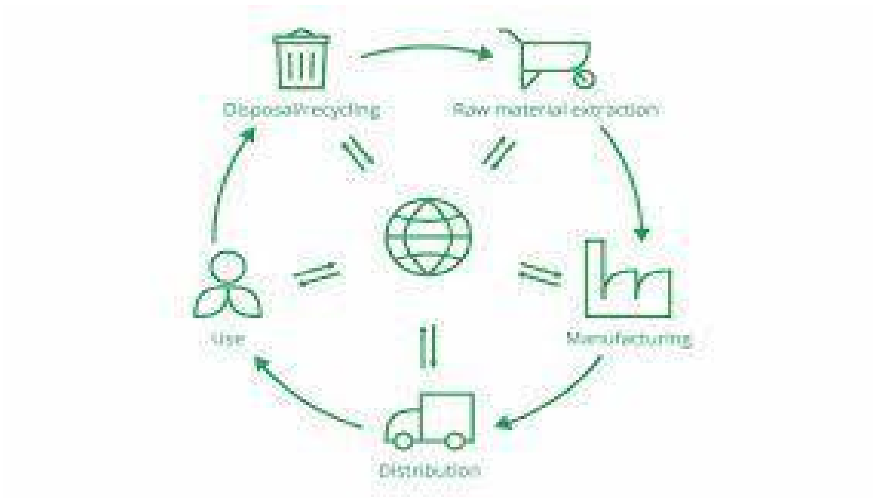


Batteries for Hybrid and Plug-In Electric Vehicles:

Lithium-ion batteries:

Lithium-ion batteries are considered the best in the market for development of electric cars as they have high energy density, cycle life, high temperature performance and low self-discharge. Most of these batteries can be recycled.

Nickel-Metal Hydride Batteries:

They are generally used in computer and medical equipment, offer reasonable specific energy and specific power capabilities. They generally have a very longer life cycle than lead-acid batteries and are safe and abuse tolerant. They have been used widely in HEV's. The main demerit of this type of battery is that they have high manufacturing costs, and high self-discharge and heat generation at high temperatures, and need to control hydrogen loss.

Lead Acid Batteries:

They can be designed to produce high power. They are generally safe, reliable and inexpensive. But have a low specific energy and bad cold temperature performance and a short life cycle.

Ultracapacitors:
They store energy in a polarized liquid between and electrode and electrolyte. Energy storage capacity increases as the liquid's surface area increases. Ultracapacitors can provide vehicles additional power during acceleration and hill climbing and help recover braking energy. They may also be useful as secondary energy-storage devices in electric-drive vehicles because they help electrochemical batteries level load power.

List of lithium-ion battery cells that are used in some well-known PEV products:

-Mitsubishi/GS Yuasa – large format prismatic (30Ah), manganese-oxide cathode (LMO)

- Nissan/AESC – large format pouch (33Ah), nickel/manganese/cobalt-oxide cathode (NMC)

- Holden/LG Chem – large format pouch (15Ah), manganese-oxide cathode (LMO)

- Honda/Toshiba – large format prismatic (20Ah), titanium-oxide cathode (LTO)

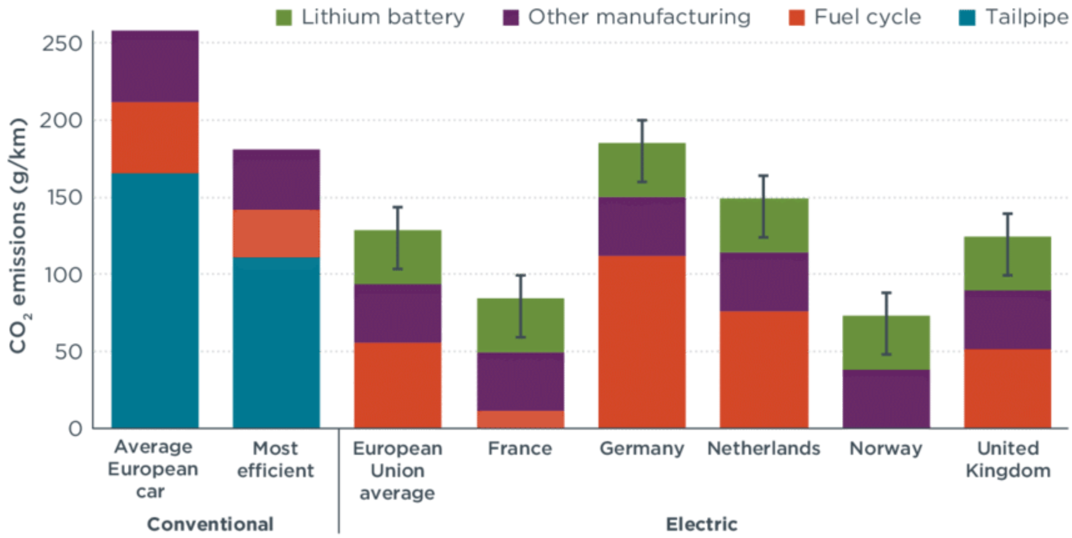
- BYD – large format prismatic (10Ah), iron-phosphate cathode (LFP)
-Tesla/Panasonic – small format cylindrical (3.3Ah), nickel/manganese/cobalt oxide (NMC)

Effects of Battery Manufacturing on electric vehicles life-cycle:

Electric vehicles have be popular in the society because of their ability to reduce energy consumption and emissions. Advancement in Li-ion battery has been the main objective for many automobile companies for increasing their sales. Due to higher sales the manufacturing cost continues to fall, making them more competitive than the internal combustion vehicles.

The manufacturing emissions of the battery in the electric vehicle have been studied extensively. Many studies state that the maximum amount of greenhouse gas emissions attribute to battery production. Studies indicate the equivalent amount of emission per Km per kWh of battery capacity (Kg CO_2/kWh) for electric vehicles. These generally find 1–2 g CO2 per Km per kWh of battery capacity. The idea of using LCA can greatly influence its conclusions about the carbon intensity of batteries.

As a result of high efficiency of the electric motor in the EV, they are able to generate electricity from low carbon sources, as the electric cars will have very low to zero emission than the internal combustion vehicles.



This figure shows the life-cycle greenhouse gas emissions of electric and conventional vehicles, detailing the contributions of lithium-ion battery manufacturing, vehicle manufacturing, tailpipe emissions, and upstream fuel cycle emissions. End-of-life emissions impacts are not included here due to the high uncertainty involved; however, this issue is discussed in the Future Outlook section. The figure compares an average new European passenger car,2 the conventional internal combustion engine vehicle with the lowest CO2 emissions available in Europe (2017 Peugeot 208 1.6 BlueHDi Active 5dr), and a battery electric vehicle (modeled on a 2017 Nissan Leaf with a 30 kWh battery enabling 107 miles of real-world range) charged using average grid electricity in different regions. Efficiency and emissions for both conventional and electric vehicles are adjusted to reflect real-world driving conditions rather than test-cycle numbers.3 The carbon intensity of battery production in this figure uses the central estimate from Romare et al. of 175 kg CO2e/kWh; this translates to approximately 35 g CO2e/km over the lifetime of the vehicle. As indicated by the error bars, other studies have found a range of battery production emission values above and below our chosen estimate. The figure shows the results for the electric vehicle use-phase emissions from five countries representing more than threequarters of European electric vehicle sales through mid-2017.

As shown in Figure, the life-cycle impact of a vehicle is the sum of the emissions impacts from all the associated vehicle’s activities: manufacturing, fuel cycle, and use. Electric vehicle manufacturing requires more energy and produces more emissions than manufacturing a conventional car because of the electric vehicles’ batteries. Lithium-ion battery production requires extracting and refining rare earth metals, and is energy intensive because of the high heat and sterile conditions involved. Most lithium-ion batteries in electric vehicles in Europe in 2016 were produced in Japan and South Korea, where approximately 25%–40% of electricity generation is from coal. On the other hand, electric vehicles travel farther with a given amount of energy and account for fewer emissions through the fuel production and vehicle use phases. Overall, electric vehicles typically have much lower life-cycle greenhouse gas emissions than a typical car in Europe, even when assuming relatively high battery manufacturing emissions. An average electric vehicle in Europe produces 50% less life-cycle greenhouse gases over the first 150,000 kilometers of driving, although the relative benefit varies from 28% to 72%, depending on local electricity production. An electric car’s higher manufacturing-phase emissions would be paid back in 2 years of driving with European average grid electricity compared to a typical vehicle.

This emissions recovery period is no more than 3 years even in countries with relatively higher-carbon electricity such as in Germany. When comparing to the most efficient internal combustion engine vehicle, a typical electric car in Europe produces 29%less greenhouse gas emissions. We do not account for different driving or charging patterns in different countries; this is a rich area for future work. We assume that the original battery will last for the lifetime of the car, 150,000 km. This is consistent with available evidence suggesting that electric vehicle battery degradation has not been a widespread problem, even among Tesla vehicles with high travel activity, and there is no evidence to suggest that a replacement is typical within this time frame. Other life-cycle analyses have used similar assumptions for battery lifetime based on available industry data. As seen in the figure, electric vehicles (using EU average electricity) have sufficient greenhouse gas “savings” over a lifetime relative to conventional vehicles that any hypothetical battery replacement rate would not affect our conclusions.

Payback period in an Electric vehicle:

The rise in the EV's will happen when the lifetime cost of ownership falls below that of a conventional vehicle. By taking a average lifetime means generally 4 years as a period of ownership. In this case I am considering a car and analysing the payback period of it. In this case just by using a method of smart meter tariff the payback period is cut by over fifth. By the time all the gasoline engine vehicles will stop production this car's payback period will be down to 2 years.

The only way to improve the payback period in an electric vehicle is with feed-in tariffs removed, and discounted VAT on all the products. Just by using this system the payback period of the car will increase by more than 20 years. This would give a return on investment of minus 3%.

A research found out that combining a 4kW residential solar rooftop system with battery storage of a similar size, and a small EV with 35 kWh capacity, would ensure a payback term of four years for the lot in Britain in 2025.

Germans get faster payback:

In Britain, with the present low VAT regime for solar products, the payback time for a standalone system is estimated at 19 years, with an annual return on investment of -2.7%. By contrast, German system owners, because of higher electricity retail prices and a better feed-in tariff regime, can expect to pay back their system price after six years, with an annual return on investment of 10.3%. The report highlights the straightforward addition of a sensible device that manages controllable loads, like heat pumps and predicament boilers, can halve the payback period in Britain and significantly reduce it in Germany..

Developments in Electric vehicles:

After a decade of continuous growth, in 2020 the total number of electric cars hit the 10 million mark, there was a whooping 43% increase in the stock compared to 2019. The BEV's accounted for two-thirds of newly bought electric cars in 2020. China has the largest fleet of 4.5 million electric cars.

Electric cars have continued their steady development over the years. With improvement in battery life and their efficiency. The increase in range of the vehicle is viable for broad range of business and personal uses.

The decline of costs in the electric vehicle will only happen if there is advancement in batteries. Since 2010 the average cost of a battery has dropped down from $1000/kWh to $227/kWh. This results in a drastic change in overall price of an EV. In addition to the battery production costs reductions, batteries themselves have become more efficient. Many electric vehicles use lithium ion battery. Tesla the leading manufacturer of electric cars has invested a lot of bucks to get new technologies due to high recharge capacities of these batteries.

An example of the development in li-ion battery is adding a protective nano layer on the battery will expand with the batteries increasing temperature. Even after these many advancement the electric vehicle market still has many hurdles to overcome to ensure widespread use.

HEV's have been promoted extensively in last 10 years. Nearly every car manufacturer has one HEV in the market. The wheels of the car can be driven using engine and electric motor. These types of cars are been divided into two types Series Hybrid and parallel hybrid. Nevertheless HEV still has emissions. The introduction of plug in HEV's would solve majority of the problem. It accepts the electric power to the battery through plug in from the mains. Therefore when easy users can charge the battery using AC from the mains.

The MOTOR:

There are many motors available in the market for electric vehicles like DC Motors, induction motor, DC brushless motor, permanent magnet synchronous motor and switched reluctance motor.

1. DC Motor:
   This is a very old motor which is been in use from a very long period of time. All the power involved in electromechanical conversion is transferred

to the rotor through stationary brushes which are in rubbing contact with the copper segments of the commutator.

2. Induction motor:
   It is one of the most popular AC Motor. It has a large share in variable speed drive application such as air conditioning, elevator.
3. DC brushless motor:
   This conventional DC motor is poor mechanically because of low power winding, the field is stationary while the main high power windings rotates. The high power winding is put on the stationary side of the motor and the field excitation is on the rotor using a permanent magnet. The motor has longer life time than the DC motor but is a few times more expensive. Most of the DC motor can be replaced by the brushless motor with suitable driver. Presently, its applications find in low power EV.
4. Permanent magnet synchronous motor:
   The stator is almost as same as an induction motor. The rotor is mounted with permanent magnets. It is equal to an induction motor but the air gap filed is produced by a permanent magnet.
5. Switched reluctance motor:
   This is a new motor and very famous recently because of the fault tolerance because of the fault tolerance because each phase is decoupled from other. Each phase winding is connected in a flyback circuit style.

The Energy Storage:

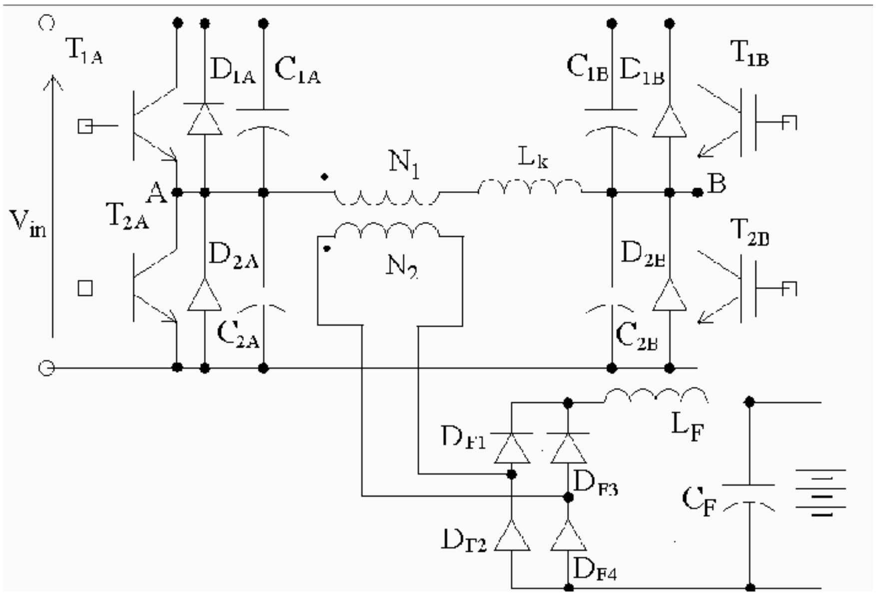
1. Batteries:
   The battery is the main energy storage in the electric vehicle. The battery is the only part which ensures the success of electric vehicles. As there are presently many ongoing developments in battery technology, advance electric vehicles with high power will be sold in the market in the next decade. Li ion battery is presently used in many electric vehicles. It seems that the LiFePO4 type is preferable because of its chemically stable and inherently safe. For low cost batteries lead acids battery has been dominant in the market. This battery has found its application in electric wheel chair, Golf cart, micro car. Now the only development left for the car companies is installation of fast charging batteries. Now the new development in the MIT research institute found out that a crystal structure technology allows

the battery to charge 100 times faster than the conventional vehicles. Other alternative is to use the ultra-capacitor.

2. Ultra-Capacitor:
   A capacitor is basically a static component. There is never a chemical reaction going to take place inside the components. Its charging and discharging speeds are very fast. The energy storage capacity is very less in this kind of battery. Almost 20% less than that of lead acid batteries. Although in the near future the storage of the ultra-capacitor is going to be drastically increased still the usage of this energy storage device remains a challenge.

Charging Systems:

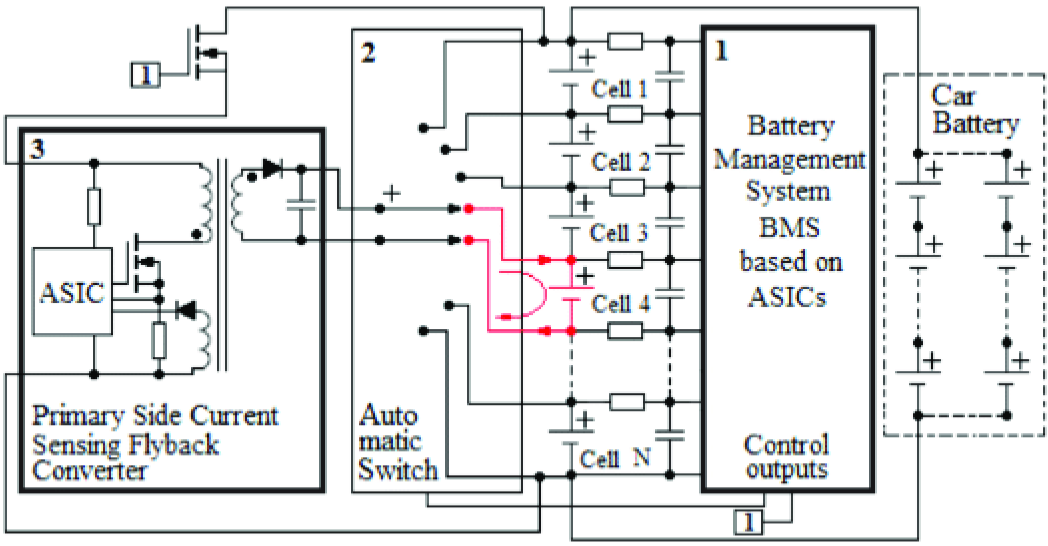
1. General charger:
   The charger which is needed for slow charging and fast charging purposes both required to handle high power. The H-bridge power converter is needed. This converter is famous for its efficiency and has found many application in chargers and DC-DC converter.



2. Ultra-capacitor charger:
   The voltage on the ultra-capacitor varied from the full-voltage to zero once nits energy storage varies from full to zero. this is often completely different from the battery as its voltage can solely varies at intervals twenty fifth. The condenser voltage is internal purpose and isn't to bear with users. The transformer isolated convertor isn't necessary. A tapped converter ought to be used because it can have higher potency for power conversion

[13]. The potency of the facility converter is more than the transformer-isolated version. The structure is straightforward.

3. Battery Management Systems:
   It is also referred to as BMS. This system is formed by a number of battery cells. They can be connected in series and parallel according to the design. Each of the cell should be viewed properly and regulated. The measured parameters are used to provide the decision parameter for the system control and protection. Two parameters are usually provided. They are the state of charge (SoC) and the State of Health (SoH). SoC is like the oil tank meter that provides the battery charging condition. It is measured by the information of voltage and current. The SoH is to record the health or aging condition. There are a few definitions but the prominent one is :
   SoH =(Nominal Capacity – Loss of Capacity)/Nominal Capacity



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