A Comprehensive Review on Battery Electric Cars: Architectures, Emissions and Safety

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Abstract—In today's fast moving world with the development of new technologies, there has been shoot up in usage of Oil and Gas leading to problems like Global Warming, climate change, shortage of crude oil, etc. Due to these reasons Automobile Companies have started doing research for making Electric Technology usable into the daily life. Electric vehicle drives offer a number of advantages over conventional internal combustion engines, especially in terms of lower local emissions, higher energy efficiency, and decreased dependency upon oil. Yet there are significant barriers to the rapid adoption of electric cars, including the limitations of battery technology, high purchase costs, and the lack of recharging infrastructure. Our Paper is based on the explanation of such technology, architecture, efficiency and safety of Electric Cars. Paper concludes on the advantages and dis-advantages of Electric Cars and how this technology will take over the world in future and would become the alternative for Petrol and Diesel Cars.

Keywords— Battery, Architecture, Safety, Emission.

I. INTRODUCTION

With the invention of Internal Combustion Engine by Nicolas Otto, there was revolution in Automobile field. Later on, Petrol and Diesel became the main source of fuel for these vehicles. This technology made Human Efforts very easy through commercializing in the market. As, the world went through 20th Century, there happened many advancements for making this technology efficient and cost-effective. Due, to which it became the commercial success and its use in the day to day period increased. People could reach thousands of kilometers/miles in hours with the help of this technology. As we know everything has its own positive and negative side. In today's fast developing world, air pollution is rapidly increasing and affecting most of the major cities of the world. These increased is mainly due to the emission of carbon dioxide and other toxic gases from the vehicles which leads to gradual increasing in global warming. And also demand for utilization of fossil fuels is increasing at a greater rate as the use of vehicles is fast growing.

An electric car is an automobile that is propelled by one or more electric motors, using energy stored in rechargeable batteries. Electric cars are commonly powered by on-board battery packs, and as such are battery electric vehicles (BEVs). Although electric cars often give good acceleration and have generally acceptable top speed, the poorer energy capacity of batteries compared to that of fossil fuels means that electric cars have relatively poor range between charges, and recharging can take significant lengths of time. However, for everyday use, rather than long journeys, electric cars are very practical forms of transportation and can be inexpensively recharged overnight. Cars are dangerous machines. What makes them dangerous is their size, their weight, their speed, their momentum and fuel (gasoline), a substance that can potentially catch fire and explode. This is one way in which purely electric cars are distinctly safer than cars with internal combustion engines: They don't carry any gasoline. But they add an entirely new factor to the safety equation.

II. TECHNOLOGY

A battery electric vehicle (BEV), pure electric vehicle, only- electric vehicle or all-electric vehicle is a type of electric vehicle (EV) that exclusively uses chemical energy stored in rechargeable battery packs, with no secondary source of propulsion (e.g. hydrogen fuel cell, internal combustion engine, etc.). BEVs use electric motors and motor controllers instead of internal combustion engines (ICEs) for propulsion. They derive all power from battery packs and thus have no internal combustion engine, fuel cell, or fuel tank. BEVs include – but are not limited to – motorcycles, bicycles, scooters, skateboards, railcars, watercraft, forklifts, buses, trucks, and cars.

Specific Characteristics: Pure electric power train. Battery recharging at the power grid. Alternatives: additional serial combustion engine (range extender) or switchable batteries.

Battery Storage Capacity in Kilowatt Hours: 15 to 20 for city cars, up to 60 for large cars

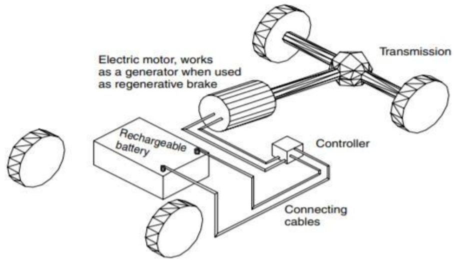

Figure 1: Layout of BEV

III. ARCHITECTURE AND COMPONENTS

The vehicle consists of an electric battery for energy storage, an electric motor, and a controller. The battery is normally recharged from mains electricity via a plug and a battery charging unit that can either be carried onboard or fitted at the charging point. The controller will normally control the power supplied to the motor, and hence the vehicle speed, in forward and reverse. This is normally known as a 2 quadrant controller, forwards and backwards. It is usually desirable to use regenerative braking both to recoup energy and as a convenient form of frictionless braking. When in addition the controller allows regenerative braking in forward and reverse directions it is known as a 4 quadrant controller.

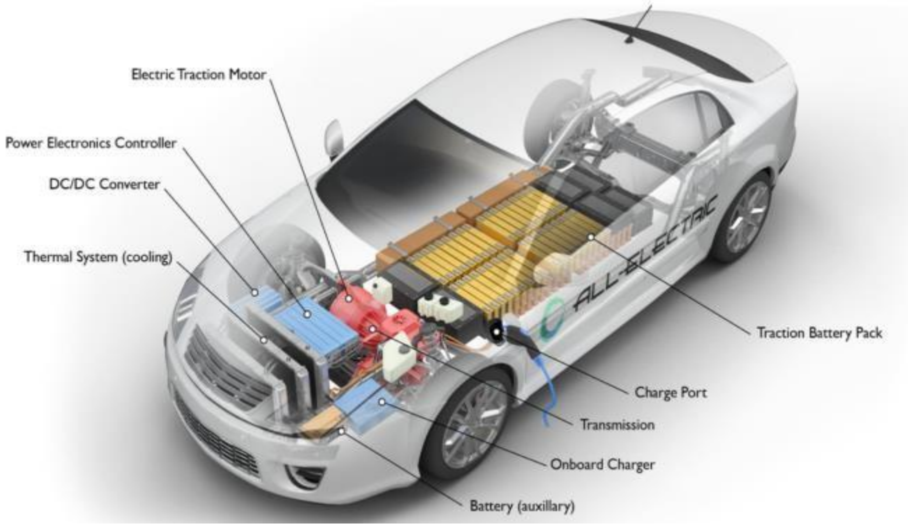

Figure 2: Components of BEV

Electric cars need 6 main components to operate:

- Battery Pack: This is the energy reservoir that contains the energy the car will use to drive, operate the heating and cooling, and run all of the other lights and accessories. Typically, batteries use direct current electricity that must be converted to AC, or alternating current, before being used in the electric motor. Sometimes, you will find direct current motors, but these are not common in mass produced electric vehicles. DC charging is faster because it charges the batteries directly. The battery pack makes up a significant cost of a BEV or a HEV.

  ➢ 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. Other types of rechargeable batteries used in electric vehicles include lead–acid ("flooded", deep-cycle, and valve regulated lead acid), nickel-cadmium, nickel–metal hydride, and, less commonly, zinc–air, and sodium nickel chloride ("zebra") batteries. The amount of electricity (i.e. electric charge) stored in batteries is measured in ampere hours or in coulombs, with the total energy often measured in kilowatt-hours.

- Power Inverter: An inverter is a device that converts DC power to the AC power used in an electric vehicle motor. The inverter can change the speed at which the motor rotates by adjusting the frequency of the alternating current. It can also increase or decrease the power or torque of the motor by adjusting the amplitude of the signal.

- Electric Motor. The component of an electric vehicle that transforms the electrical energy from the battery into rotation that can be used to move the vehicle. There are many types of electrical motors and, even though the basic technology hasn't changed over the last 100yrs or so, there have been many improvements in motor design and efficiency.

- Onboard Battery Charger. On board charger takes 230 V single phase mains supply and converts to DC in order to store in the battery. The charger is there to limit the power to the battery to prevent overheating of the battery and overheating of the supply system (I.e. home charger)

- Controller: The controller is like the brain of a vehicle, managing all of its parameters. It controls the rate of charge using information from the battery. It also translates pressure on the accelerator pedal to adjust speed in the motor inverter.

- Charging port. Much like the access port for the gas tank in an internal combustion engine car, the charge port is the location where energy enters the car.

Other components that are included in EVs that help them operate are:

Thermal System – Cooling: This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
Electrically driven accessories: Unlike in a gas or diesel vehicle using accessory belts, the air conditioning, power steering, and other components us electricity from the battery pack to operate. The lights, radio, and other components typically use traditional 12 volt direct current.

IV. EFFECT ON ENVIRONMENT

Electric cars are ever more appealing in a world where reducing carbon emissions and pollution is a growing concern for many people. Research has shown that electric cars are better for the environment. They emit less greenhouse gases and air pollutants over their life than a petrol or diesel car. This is even after the production of the vehicle and the generation of the electricity required to fuel them is considered.

The major benefit of electric cars is the contribution that they can make towards improving air quality in towns and cities. With no tailpipe, pure electric cars produce no carbon dioxide emissions when driving. This reduces air pollution considerably. Put simply, electric cars give us cleaner streets making our towns and cities a better place to be for pedestrians and cyclists. Over a year, just one electric car on the roads can save an average 1.5 million grams of CO2.

A. THE CARBON EMISSIONS OF ELECTRIC CARS

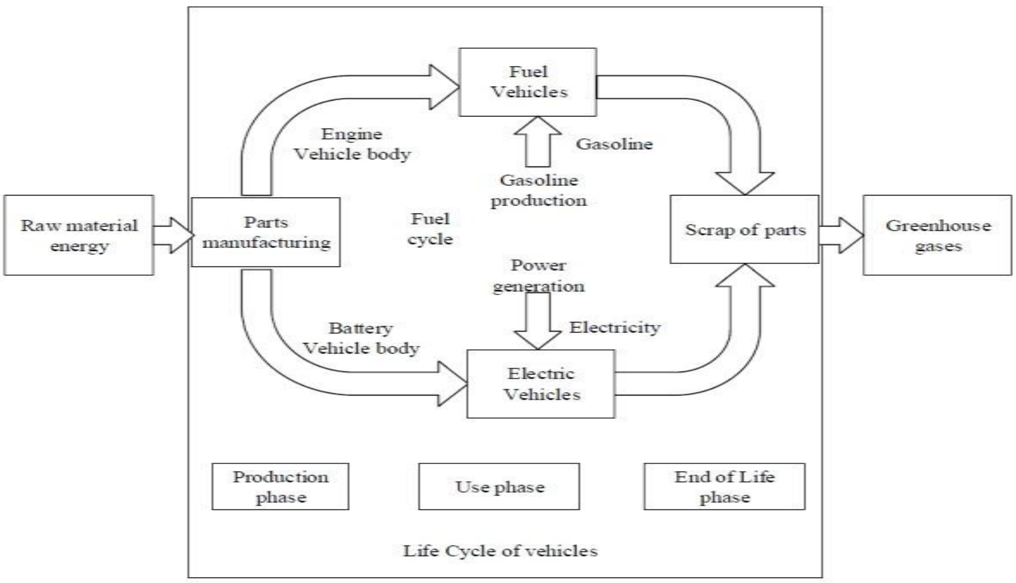

Figure 3: Life cycle of vehicle

It is quite well understood that electric cars have the potential to reduce carbon emissions, but important to realize this potential is dependent on the type of electricity that charges the battery. Given that the vast majority of power generation around the world is grid-tied, where a car is charged plays a large role in determining its carbon emissions.

By considering the full scope of emissions that occur in both electricity supply and vehicle manufacturing this analysis compares the carbon emissions of electric cars in twenty of the world's leading countries.

Electric cars' carbon emissions can be four times greater in places with coal dominated generation than in those with low carbon power.

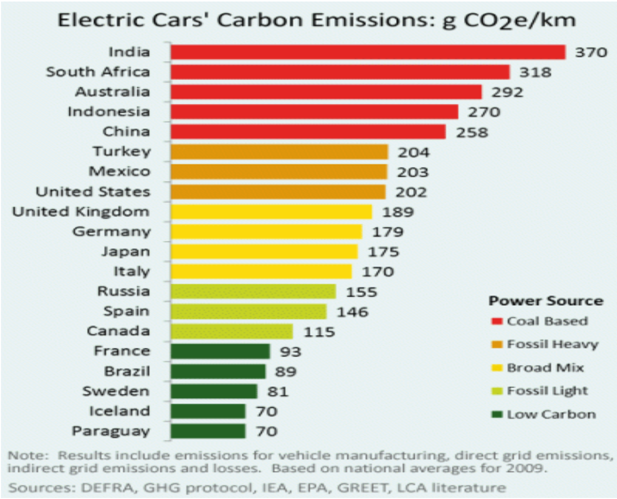

Figure 4: Carbon Emissions

The legend to the right of this chart helps explain what is driving the variation between countries. All the difference between Paraguay and India is a result of changes in the fuel mix, from low carbon hydro at the bottom to high carbon coal at the top.

In India, Australia and China coal's dominance in the fuel mix means that grid powered electric cars produce emissions ranging from 370-258 g CO_2e/km, many multiples of those using low carbon sources.

Contrast this to hydroelectric exporter Paraguay where virtually all of the 70 g CO_2e/km results from vehicle manufacturing, and electric driving is significantly lower carbon than using solar power.

V. COMPARISON OF BEVS AND ICEVS

There is relatively little controversy surrounding how to measure the global warming potential (GWP) of ICEVs. Tailpipe emissions from gasoline combustion in an internal combustion engine combined with the upstream emissions associated with gasoline production and distribution contribute the majority of greenhouse gas emissions from an ICEV. A reliable range for such lifecycle emissions has been established by a preponderance of studies.

By contrast, BEVs present a unique challenge – though the vehicles produce no tailpipe emissions, BEVs do rely on regional power plants and grids to charge their batteries. Furthermore, R&D and manufacturing for BEVs relies heavily on a variety of different inputs – such as heavy metal mining and purification, and battery cell manufacture (which includes organic solvents and various chemical processes) – and these inputs generate different adverse environmental impacts as compared with those used in the R&D and manufacturing for ICEVs.

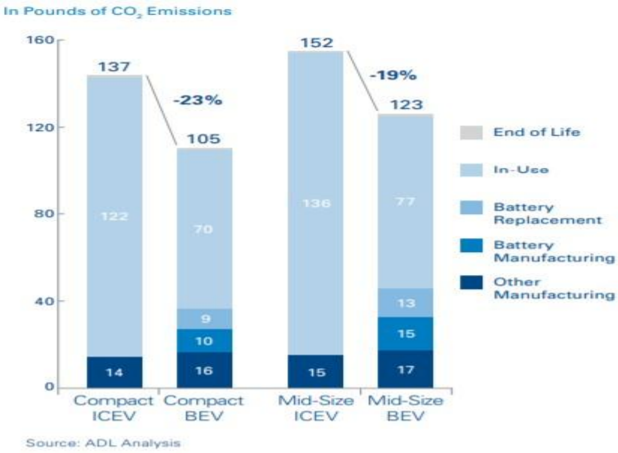

Figure 5: Emissions over a 20-Year Lifetime for a 2015 ICEV versus an Equivalent EV

VI. SAFETY

Plug-in electric vehicles (also known as electric cars or EVs) are as safe and easy to maintain as conventional vehicles. It seems no matter how you look at it, EVs have opened up a safer transport future than with the internal combustion engine. And let's not forget the harm done by ICE's antiquated, inefficient, opposing piston system, which struggled to climb above a dismally low 33% fuel efficiency. Two-thirds of the average car gas tank is lost due to friction and heat escaping, causing harm to humans in various ways.

EVs must undergo the same rigorous safety testing and meet the same safety standards as conventional vehicles.

However there are some problems related to EVs but can be tackled by doing these practices.

Here are some problems listed below

- Limiting chemical spillage from batteries
- Securing batteries during a crash
- Isolating the chassis from the high-voltage system to prevent electric shock
- Batteries catching fires during crash

the occupants of a heavy vehicle will on average, suffer fewer than the cost of gasoline. In many parts of the world, also promised a speed of 400 miles per charge for its next launch. These numbers will only improve with passing time.

The weight of the batteries themselves usually makes an EV heavier than a comparable gasoline vehicle, in a collision,

IV. Cheaper to operate – Electric cars are much cheaper to operate especially in parts of the world where electricity prices are falling. It is estimated that the cost to fuel an EV per mile is almost 25%-30% lower the price of fuel (petrol and diesel) is very high thus making electric cars a smart and pocket-friendly choice.

V. Improved Safety – An electric car is safer to use given their lower center of gravity which makes them much more stable on road in case of a collision. They are even less likely to explode since there is no combustible fuel or gas used.

and less serious injuries than the occupants of a lighter vehicle; therefore, the additional weight brings safety benefits (to the occupant) despite having a negative effect on the car's performance. Depending on where the battery is located, it may lower the center of gravity, increasing driving stability, lowering the risk of an accident through loss of control. The flexibility of placing batteries and packs almost anywhere in a car that you want means that EV safety can be taken into consideration earlier in the design stages than with an ICE car. An accident in a 2,000 lb. (900 kg) vehicle will on average cause about 50% more injuries to its occupants than a 3,000 lb. (1,400 kg) vehicle.

By protecting the battery pack with a quarter-inch-thick plate of hardened aluminum for preventing major damages during crashes. To prevent thermal runaway, the vehicle's batteries are typically surrounded by a protective cooling shroud filled with chilled liquid coolant from a traditional- style automotive radiator. In the event the batteries do overheat despite their external cooling, batteries in all models of electric vehicles are installed in an array rather than as one large battery pack. These battery clusters are further divided by firewalls that limit the amount of damage each is capable of causing if it were to malfunction.

One safety concern specific to EVs is their silent operation; pedestrians may be less likely to hear an EV than a conventional vehicle. So automobile companies are building EVs such that it emits audible sounds at low speeds. This option is already available on many EVs, including the Chevrolet Volt and Nissan Leaf.

VII. ADDVANTAGES AND DISADVANTAGES

Advantages:

I. Environment-Friendly – The biggest and the best reason to use an electric vehicle is that it is environment-friendly. They do not release vicious gases that lead to air pollution as against the fossil fuel powered cars.

II. No Fuel or Gas Cost – Since electric vehicles need no fuel or gas to power them, a user can escape the steep rise in prices of these commodities. All it needs is to be plugged in and ready to go another 100 miles.

III. Wide range of speed – An electric car can easily run at 100 miles to 200 miles per charge. The new Tesla electric car model is estimated to run at a speed of more than 300 miles per charge. Volkswagen has

Disadvantage:

I. Lack of Charging Stations – One of the major advantages of using an EV is the fact that it does not need any petrol or diesel to run. Instead, it just needs a charging station where the vehicle can be plugged and ready to go. However, one of the major challenges that are hindering its adoption is the lack of a sufficient number of charging stations.

II. Expensive – Buying an electric vehicle is still expensive. There are many fossil fuel cars available in the market at different price points. However, electric vehicles offer lesser options to choose from, and the better ones are highly priced. It is absolutely necessary for governments to promote the usage of EVs through subsidies and incentives – both to buyers and manufacturers. Even the batteries that are used are still costly, though their prices are estimated to drop in near future.

III. Lack of Power And Reduced Range – Fossil fuel based cars offer better acceleration when compared to electric vehicles. Though Tesla and Volkswagen are making EVs with better range, an average electric car can easily run at 100 miles to 200 miles per charge. Hence people are still skeptical is using electric vehicles for long journeys/ highway drives.

IV. Minimal Amount of Pollution – Electric vehicles is not 100% emission free. Even they cause a little amount of pollution indirectly. The batteries and electricity used for charging are not necessarily generated from renewable energy sources.

VIII. CONCLUSION

The advancement that the electric vehicle industry has seen in recent years is not only accepted, but highly necessary in light of the increment in global greenhouse gas levels. The biggest hurdle to the widespread adoption of electric-powered transportation is cost related, as fossil fuel and the vehicles that run on it are readily available, convenient, and less costly. 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.

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