Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 9 Issue 10, October - 2022

A Brief Overview Of Electric Vehicle Research

Jacob Dick
Electro-Mechanical Engineering Technology,
Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601

Dr. Sohail Anwar
Department of Engineering,
Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601

Abstract— The growing popularity of electric vehicles has really impacted the way people look at modern vehicles. In the recent years, we have witnessed significant advances in electric vehicle technology. There is so much opportunity to make vehicles that are better for the environment and more technically advanced. The main goal of this research paper is to highlight some of the improvements being made in electric vehicles now, as well as look into the future of electric vehicles and what they are capable of.

Keywords- Electric Vehicle, charging, battery, energy management

I. Introduction

In the United States, the first electric vehicle was produced in 1890. The creator was William Morrison, who was a chemist from Iowa. He made an electric vehicle that could reach a top speed of 14 miles per hour and could carry 6 people. It is hard to attach the creation of the electric vehicle just to one country or inventor. Instead, inventors were able to make different breakthroughs in the electric vehicle technology, such as, development of battery and electric motor.

Fig. 1- William Morrison's Electric Vehicle [11]

Electric vehicles became very popular, because they were so much quieter than early internal combustion vehicles, and they were a lot more reliable than steam engine vehicles. Other things that helped the growth of the electric vehicle, was gas shortages and environmental concerns. When gas shortages happen, gas becomes more expensive. This makes owning an internal combustion car harder because it is very expensive to fill up. Also, the fumes that an internal combustion car gives off are harmful to the environment. These issues helped research move forward on electric vehicles.

Now, electric vehicles have come a long way. There are three main types of electric vehicles, hybrid electric, plug-in hybrid electric, and all electric. The hybrid electric vehicle runs only on liquid fuel but has an electric drive system and battery. The plug-in hybrid vehicle can operate using a battery that can be plugged in, or through the use of liquid fuel. Lastly, the all-electric vehicle operates completely off of a battery that must be plugged in to be recharged [1].

Looking more into the operation of a fully electric car, it is very different from an internal combustion vehicle. Electric cars accelerate much faster, store electricity in batteries instead of using liquid fuel, and are much simpler compared to internal combustion vehicles. For the car to store electricity in its batteries, it must be plugged in and take electricity from the grid. The most common way an electric vehicle can be charged is at home, or at a public charging station. Once the batteries are charged, they power an electric motor. This motor then turns the wheels allowing the car to move. Electric vehicles can only go a certain distance before they need to be charged again. This distance depends on the cars range, battery size, and efficiency. When looking at the battery size, the higher the kilowatt rating, the further the car will go.

As stated previously, electric vehicles have a much simpler design compared to internal combustion vehicles. The main parts on an electric vehicle are the electric motor, the inverter, the drive train, the batteries, and the charging system. The electric motor is what that rotates the wheels and can be either AC or DC current. They are mostly AC powered and use the inverter to convert the DC current from the battery to AC current. The drive train of an electric vehicle is a single speed transmission that allows the vehicle to go faster based on the amount of power being sent to it. Lastly, the batteries and the charging system are the mechanisms that allow the vehicle to acquire electricity that ultimately runs the vehicle. [2]

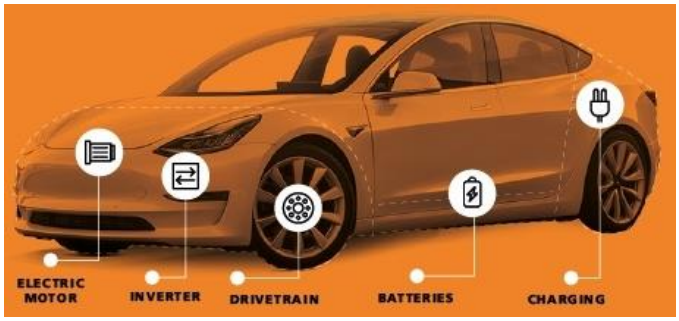

Fig. 1- Main parts of an electric vehicle [2]

II. Literature Review

a. Fast Charging

A problem with electric vehicles, is how long they take to charge. For example, right now, it takes an electric vehicle about 10 hours to charge at a house. At a fast-charging station, it takes around 30 minutes. This is not very practical, and research is in progress to find ways to make charging faster. One possibility is the use of quantum physics. This research has investigated the development of a quantum battery that allows all the battery cells to be charged simultaneously. This cannot be done in classic batteries because they are in parallel. For this battery to work, the quantum charging advantage ratio has been investigated. One source for this quantum advantage is global operation. Global operation allows all the cells in the battery to work together simultaneously. A group from the institute for Basic Science in South Korea, found that Global operation was the only system that could be used in the quantum advantage. [3] In comparison to a conventional 200 cell battery, this global operation battery would cut at-home charging times from 10 hours to 3 minutes. At fast charging stations, it would take a couple seconds to fully charge [4].

b. Battery Management

Electric vehicles have different batteries that preform different functions. They have a traction battery and an auxiliary battery. The traction battery is the primary battery. It is the one that drives the electric motor. The auxiliary battery is a smaller battery that powers the vehicles accessories.

The main type of battery used in an electric vehicle, is the lithium-ion battery. These batteries have a higher energy per unit mass compared to other batteries. They also have a high power to weight ratio, low self-discharge, and better energy efficiency.

There are also different types of lithium-ion batteries. Some common examples of these are nickel-manganese-cobalt, lithium cobalt oxide, nickel-cobalt-aluminum, lithium-iron-phosphate, lithium-manganese-oxide and lithium titanate. The nickel-manganese-cobalt and nickel-cobalt-aluminum batteries have the best performance; therefore, they have a high cost. These batteries are found in very high-performance electric vehicles. Lithium-iron-phosphate batteries are less expensive and not as efficient. They are more stable, so they are used in more affordable electric vehicles. [5]

Fig. 2- Lithium Ion Battery [5]

Lithium-air batteries are a new type of battery being researched. These batteries have a metallic lithium anode, and a porous carbon cathode [6]. They use oxygen taken from the atmosphere and create a reaction with the lithium ions from the anode. This reaction provides electrical energy, which is then used to power the vehicle. The energy density of Lithium-ion batteries is much higher than a normal battery.

When charging a lithium air battery, the reverse reaction happens. Oxygen is disconnected from the lithium ions and is sent back out into the atmosphere. This allows the lithium ions to be ready to react with new oxygen molecules one the battery is put back into use [7].

c. Optimization of energy management

When looking at a hybrid vehicle, it is much more complicated to try to optimize its energy management. This is because of the more complicated system that it uses, compared to a standard internal combustion vehicle. Some of the main issues that arise when it comes to energy management in hybrid vehicles include real time optimization, battery durability, computation load, and multiple energy sources.

The issue with real time optimization, is that the current technology pertaining to hybrid vehicles does not allow the vehicle to predict future driving conditions and make changes to optimize its energy usage. With battery durability, the battery in a hybrid vehicle is constantly charging, discharging, and switching voltages. This is very hard on the battery and causes it to age at a faster rate. Also, the computational load of a hybrid vehicle is very low compared to the amount of data it would need to compute so that appropriate strategy can be developed to make optimal changes in its energy use. Some of these strategies include, dynamic programming, genetic algorithm, particle swarm optimization, fuzzy control, equivalent cost minimization strategy, and reinforced learning. Lastly, because of the vehicle having multiple energy sources, it is much more complicated for the electric motor and the internal combustion engine to cooperate with each other [8].

III. Future Developments

There is a bright and broad future for electric vehicles, especially when it comes to sales. In 2016, plug-in electric vehicle sales were very low, only 1% of the global auto sales. It is estimated that by 2025, electric vehicle sales will be around 30% of the global auto sales. [9]

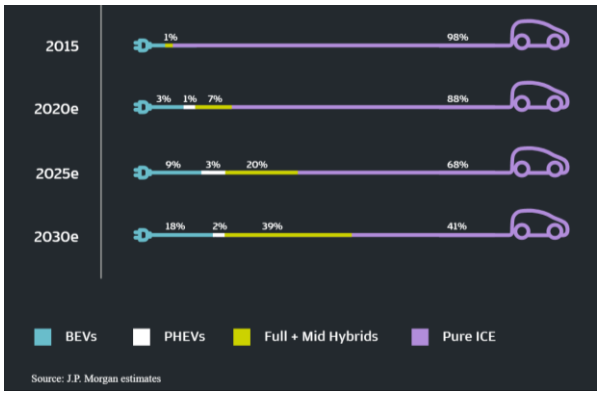

Fig. 3- Global Electric Vehicle Forecast [9]

There have been lots of new developments being researched in the electric vehicle world. One of them is electric trucks and SUV's. Some major companies such as Ford, Chevrolet, GMC, Dodge, and Tesla, have all been looking into producing trucks. Also, many more of the major car companies have been looking at producing SUV's. Another major development for electric vehicles, is the ability for their batteries to power homes. During long term power outages, the batteries in the electric vehicle could be used as a power source to power the home. Also, they could be used to send power back into the grid when electricity is in peak demand. One great thing to look forward to in the future is the range of the electric vehicle battery. For example, in 2013 the Nissan Leaf only had a range of 75 miles. Fast forward to 2022, and the Tesla Model S Long Range has a range of 450 miles. This is a huge difference, and the battery technology is still growing. Last, there will be more charging stations. In 2011, there were only 2,100 charging stations and 5,000 ports. In 2021, there were 50,000 charging stations and 130,000 ports. There are many groups looking to grow these numbers as well. The Biden Administration has a goal to have 500,000 charging stations by 2030. Also, there is a group of 50 power companies that is looking to create an electric vehicle fast charging network by 2023. [10]

IV. Conclusion

In conclusion, this report gives an overview of electric vehicles. As previously stated, the creation of the electric vehicle can't be pinned to one person, but rather multiple people who invented the things necessary to create an electric vehicle. Along with that, there are three main types of electric vehicles. The comparison of these vehicles with the internal combustion vehicles has been described in this manuscript.

This manuscript also highlights research on the future of electric vehicles. The key points of this research include faster charging methods, new types of batteries, ways to make the vehicles more efficient, and ways that electric vehicles will become more and more common. There is a great future for electric vehicles, because there is a lot of research going on that is finding ways to make these vehicles more practical. Soon electric vehicles will be capable of having the same range, same refueling time, and same affordability as internal combustion vehicles. They will be able to do this all while using a source that will not run out and is not harmful for the environment. **References** "The History of the Electric Car." *Energy.gov*, The History of the Electric Car | Department of Energy

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