TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 9036 - 9040

Effects of Battery Manufacturing for Hybrid and Electric Vehicles: A Comparative Study

[1]Ninad Girish Aghanashini, [2]Gopal Krishna Barkur
[1]ManipalInstitute of Technology, MAHE, Manipal[2]ManipalInstitute of Technology, MAHE, Manipal
[1]ninad.girish@learner.manipal.edu,[2]gopalkrishna.b@manipal.edu

Article Info
Volume 82
Page Number: 9036 - 9040
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 09 February 2020*

Abstract:
Hybrid and electric vehicles have gained momentum in the automobile sector as these vehicles help in moving towards a cleaner and greener future when compared to their fossil fuel counterparts. They also need to adhere to the upcoming norms such as BSVI in India and EURO based compliance in the other countries. This paper highlights the various types of hybrid vehicles (HV) and electric vehicles (EV) present in the Indian market as well as in the rest of the world (parallel hybrids, series hybrids, plug-in hybrids, two mode hybrids). The study looks at the components of a standard HV and discusses the impact of the HV's and EV's to the environment and the market. The primary focus is the comparison between the amount of greenhouse gases that are produced by the manufacturing of electric vehicles or hybrid vehicles and its batteries with that of a conventional internal combustion vehicle. For this, a basic understanding the nature of electric vehicles and its necessity in the global market as well as the Indian market has been presented, finally concluding with a discussion on whether the shift to electric vehicles results in decrease of the total production of the carbon emissions in the environment.

Keywords: *Carbon emissions, Electric vehicles,Greenhouse gases, Hybrid vehicles, Lithium ion battery.*

I. INTRODUCTION

In view of the present climate crisis and global warming, searching for alternate sources of fuel has become the hotbed of research. Hybrid vehicles (HV) and Electric vehicles (EV) have been in the market for a long-time as key players in other parts of the world but in the Indian scenario it has still not well integrated. In India, the range anxiety, high cost of battery and lack of proper EV charging infrastructure has swayed the consumers away from these products. But due to the policy changes and the momentum that is being currently generated by the government, Original Equipment Manufacturers (OEMs)are set to launch their electric vehicles with an Indian portfolio, even in a price sensitive market. Stricter emission guidelines, reduction in G.S.T. and such benefits are some of the ways that the governmentis trying to persuade the Indian buyer to go electric.

Hybrid vehicles are called **hybrids** as they can use both a regular internal combustion engine and an electric motor [1][2]. Instant power and torque, as well as increased mileage with lesser emissions can easily be obtained in such vehicles. The fuel efficiency and power output show ever vary from model to model. They have regenerative braking and torque assist functionalities that would enhance the driving experience. There are mainly 4 types [1]:

A. Parallel Hybrids

The electric motor and internal combustion engine run in tandem, or it can be run by using one as primary power source with the other acting as a toque assist or a power assist when needed.

B. Series Hybrids

This uses the internal combustion engine coupled with a generator that is used to generate electricity. This electricity is the directed to the electric motor on demand. In this case the engine is not directly used to run the vehicle.

January - February 2020
ISSN: 0193 - 4120 Page No. 9036 - 9040

C. Plug in-hybrids

These have large batteries and these can be charged through any ordinary 110 colt socket and this can individually run the vehicle for about 70 kilometers on average without the help of the engine.

D. Two mode Hybrids

These use smaller batteries and electric motors inside. At lower speeds, they can either work on an internal combustion engine or electric or on both. At greater speeds, the internal combustion engine runs continuously in its higher gears.

This paper will discuss the Life cycle assessment of EVs and internal combustion engine vehicle (ICEV).Life cycle assessment (LCA) is a methodology, commonly used for the environmental assessment of vehicle technologies (or any other product/system).

II. Objective

The main objective of this paper is to analyze the entire automobile sector of established markets and come to a conclusion on the comparative amount of greenhouse gases released on to the environment by the manufacturing of electric vehicle and an internal combustion engine. As the Indian market not yet established itself a profitable electric and hybrid electric vehicle market so this paper will represent the data derived from the European market.

III. Literature Review

This paper provides the data for a comparative study on the battery manufacturing and greenhouse gases produced throughout the vehicle's life cycle in the market. LCA will be used currently for further analysis of the carbon emissions by EVs and ICEV's.

Messagie [2] explains Life Cycle Assessment (LCA) as a "methodology that is commonly used for the environmental assessment of vehicle technologies (or any other product/system)."It is important to note that several LCA studies consider raw material extraction, production of components, assembly, transport, vehicle use to the end-of-life treatment. These are essentially all the environmentally significant processes in the life cycle of vehicles.

The LCA methodology adopted here helps in conducting a comparative study between the two types of power trains driving the automobile sector, where all factors are taken into account such as say, the manufacturing of the entire car and the lithium ion battery, type of fuel used for power generation and other costs.

Various authors [3]-[5] assist in estimating the amount of carbon emission being released into the atmosphere when they conducted their experiments. These key findings provide a mechanism to better understand the carbon footprint released by the global market and subsequently give an insight on how it could potentially increase Greenhouse gases or GHG in the Indian market as well.

IV. Discussion

This section takes a broad look at the data representing the amount of carbon emission has been released into the atmosphere and is calculated in terms of kg CO2/kWh. When the focus is primarily on the manufacturing sector which includes the battery production, electric motor, interior and exterior structure of the vehicle, most countries generate their electricity by the means of coal or burning of hydro-carbon based fuels. This doesn't help with the growing need to bring down carbon emissions even with the help of transitioning from petroleum powered vehicles to battery based electric vehicles. This study mainly focuses on the "generic type of batteries" used in cars and not the "specialized batteries" that would make obtaining the readings for special batteries a more strenuous activity. Everyday new products are being released into the market but since they have not been tested for a longer period of time, they will not be taken into consideration. Additionally, the lithium-ion battery industry is changing quickly, and larger, more efficient are factories are being planned and developed for the sole purpose of lowering emissions per kWh of battery produced.

January - February 2020
ISSN: 0193 - 4120 Page No. 9036 - 9040

Ambrose and Kendal, along with Messagie [3][5] discuss experiments and the calculations conducted by them, these readings start from as low as 56 kg CO2/kWh to 494 kg CO2/kWh. This can be attributed to the various situations in which they conducted their experiments as also the types of the vehicles used by them must which must have varied and hence change in battery technology from area to area show different results. The charts made by Hall and Lutsey in their paper [4], represent the amount of carbon emission values above and below the chosen estimate produced by the cars that is from the development and manufacturing stage till the use of these vehicles for about 150,000 kilometers on road with normal driving standards taken into consideration. Results show a variation on the basis of harsh or economic driving conditions. It comprises of the data of from five countries that are currently using electric, hybrid and internal combustion engines.

Interestingly, electric vehicles manufacturing requires more energy for its production of batteries than that of ICEVs. This leads to more energy consumption and higher emission production even before the release of the vehicles into the consumer market. Hall and Lutsey [4] talk about “Lithium-ion battery production requires extracting and refining rare earth metals and is energy intensive because of the high heat and sterile conditions involved”, in their paper. As is the case in the Indian market, batteries are usually manufactured elsewhere for example, in Europe batteries of their EVs are imported from Japan and South Korea, where the generation of electricity is generated from burning of coal. However, when one considers the cost travelled per kilometers, electric vehicles look more promising. Since these donot run with the help of an engine, there are lesser moving parts, indicating a comparatively cheaper cost of service. From [4] the authors compare the most efficient internal combustion engine vehicle and it was found that a standard electric car in Europe produces 29% less greenhouse gas emissions.

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 as expressed by the authors in [3][4].

Assuming that this battery will last for the entire lifetime of the car that is, 150,000 kilometers (from the given data in Fig. 1), degradation of the battery is not likely to occur even over a considerable period of time and distance covered by the car as it has not been dealt as a widespread problem just yet as there have not been many cases to prove otherwise [4]. This, however, does not take into consideration, the changes in parts that these vehicles may have been through due to faulty equipment on board. As evident from the data in Fig. 1 [4], it is more likely for Germany to take the most amount of time to pay back the emissions from conversion of petroleum to electric since the major part of generation of electricity there comes from burning coal and other carbon-based fuels. Compared to ICEV, a typical electric car from Norway, UK and France would require the manufacturing-phase emissions to be paid back in two years of driving with average grid electricity (from the fig.1)[4]. Summarizing the above data what is noticeable is that the overall savings over a lifetime of using of electric vehicles is far more than that of internal combustion engines vehicles, considering the EU average electricity.

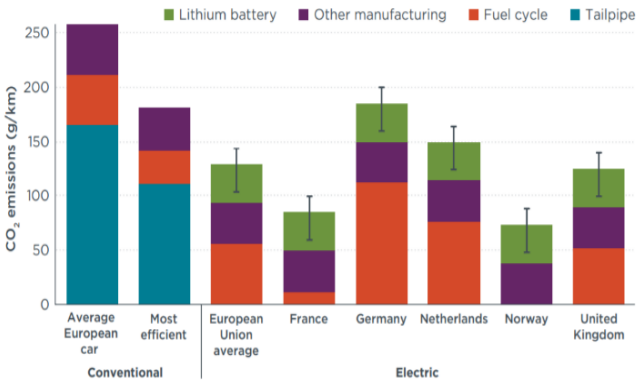

Fig. 1: Life cycle emissions (over 150,000 kilometers) of electric and conventional vehicles in Europe in 2015 [4]

January - February 2020
ISSN: 0193 - 4120 Page No. 9036 - 9040

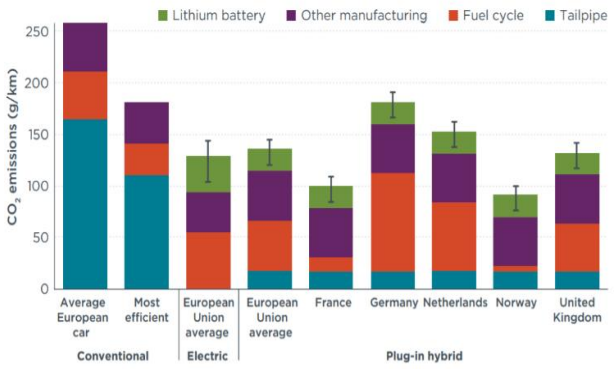

Fig. 2: Comparison of life-cycle greenhouse emissions in conventional, electric and plug-in hybrid vehicles in Europe in 2015 [4]

Figure 2 depicts that plug-in hybridsalso emit lesser greenhouse gases thaninternal combustion vehicles. Just like a battery electric vehicle, in the case of plug-in hybrids carbon emissions are low everywhere except in Germany where, as mentioned earlier, the electricity grid is generated by burning carbon-based fuels.

V. Future Outlook

The findings in this paper imply that difference in the amount of emissions produced may not be groundbreaking but is substantial enough to go ahead with the conversion from internal combustion vehicles to hybrid or electric vehicles. Although there are some shortcomings, the implementation could very well improve the state that of the industry as well as the environment. Some of areas which could improve are [4][7]:

A. Grid Decarburization

This is very important aspect of any industry that will help bring down the emissions by a huge margin when you look at the graphs. Germany is one such country whose global carbon emission will reduce significantly with better management of resources and shifting towards a more clean and green energy and future.

B. Battery Second Life

The batteries can be reused in stationary storage applications after their vehicle use phase. This, in turn, allows the initial battery production footprint to be spread across more use. When batteries are being reused after their removal from the electric vehicles, they are likely to retain significant capacity, typically 75%–80% of their original capacity. This can be very beneficial for not very high demanding tasks.

C. Battery technology

As we see that technology from yesterday is nothing but a vintage item today, technology is advancing very rapidly. Tesla is coming up with its new 1 million miles battery that is expected to last for about 1 million miles only after which the battery starts to degrade unlike the conventional Lithium batteries used in vehicles today. Lithium ion battery manufactures tend improve the battery by around 5-8% every year with the help of research and experimentation. With there being an increase in demand for electric vehicles by more and more countries, innovation and scale in terms of battery manufacturing will surely step up in the upcoming years.

VI. Conclusion

Countries across the world are working towards a cleaner and more energy-efficient and environment friendly solutions, so there is hope. It is still not too late. As the need for electric vehicles seems to be growing bigger, manufacturers can see to it that they now introduce large scale production for battery manufacturing and EVs. This paper highlights the following:

The Electric caroption is a much cleaner alternative to internal combustion engine car over its lifetime.

The other focus would be on the Battery manufacturing life-cycle emissions debt being quickly paid off. It was mentioned that an EV's carbon emissions during the manufacturing stage are usually paid off after only 2 years as compared to driving an average ICEV. The payback could decrease depending on a country's ability to generate electricity using renewable energy.

Grid decarbonization offers a significant opportunity to reduce the impact of battery manufacturing

Government policies and subsidies can go a long way in ensuring proper integration of EV's into the existing and non-existing markets.

January - February 2020
ISSN: 0193 - 4120 Page No. 9036 - 9040

India's move to EV use is realistically oriented if there is reduction in electricity generated from burning based fuels which the key bottleneck that needs to be addressed. Therefore all the key components for improvement addressed in the paper hold good in the Indian market place.

VII. REFERENCES

[1] D.Sclar, 'Auto Repair for Dummies', 2nd Edition, ISBN: 978-1-119-54361-9.
[2] Alternative Fuels Data Center. US Department of Energy. [Online]. afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work
[3] M. Messagie, "Life Cycle Analysis of the Climate Impact of Electric Vehicles," VrijeUniversiteitBrussel, Transport & Environment, 2016.[Online]https://www.transportenvironment.org/publications/electric-vehicle-life-cycle-analysis-and-raw-material-availability
[4] D. Hall and N. Lutsey, "Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions," February 2018.[Online]https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf
[5] H. Ambrose and A. Kendall, "Effects of battery chemistry and performance on the life cycle greenhouse gas intensity of electric mobility," Transportation Research Part D: Transport and Environment, 2016, 47, 182-194.[Online]. http://www.sciencedirect.com/science/article/pii/S1361920915300390
[6] D. Oberhaus, Tesla May Soon Have a Battery That Can Last a Million Miles, Wired, September 2019. [Online]https://www.wired.com/story/tesla-may-soon-have-a-battery-that-can-last-a-million-miles/
[7] K. Cheema, India Vs China Turns Electric: How The Two Markets Stack Up For Electric Vehicles, December 2019. [Online].https://inc42.com/features/india-vs-china-turns-electric-the-story-of-two-ev-markets/