



A Comparative Study Between Electric and ICE Vehicles on Pollution Emission

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August 25, 2023

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**Submission of Research Paper
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ABSTRACT

The current Indian automobile industry is the 5th largest globally and is expected to become the 3rd largest by 2030. The Indian government has committed to solving the country's air pollution issues through an ambitious policy of switching 100% of light-duty consumer vehicles to electric vehicles by 2030.

Over the last 9 years, more than 10 lacs of Electrical Vehicles were registered in India. A further goal of NITI Aayog is to achieve EV sales penetration of 70% for all commercial vehicles, 30% for private, 40% for Buses, and 80% for Two-wheelers by 2030.

Due to the continuous focus of Govt. of India to enhance the charging infrastructure, the demand for Electric Vehicles is growing over conventional vehicles and is bound to increase because of low operating costs, price reduction due to mass production (scale of economies), and consumer's awareness of the environmental pollution caused by ICE vehicles. While the EV industry is witnessing all-time high demand, new players are entering the segment, resulting in mushrooming of multiple assembling/manufacturing units across India.

But EVs are really environmentally friendly? Do they really produce less emissions than conventional IC vehicles?

World leaders are claiming that electric vehicles (EVs) are the cleanest and the future. However, a recent study conducted by IIT Kanpur, revealed that this may not be entirely true. Even the Swedish automaker VOLVO is claiming that building an EV produces 70% more emissions than ICE.

This ongoing debate surrounding whether or not EVs are any greener and environment-friendly to manufacturers compared to ICE vehicles will likely continue and there are arguments to support both sides.

OBJECTIVES:

In this research paper, we are trying to analyze a comparative study on the emission of pollution between ICE vehicles and EVs during all the stages of their lifecycle.

This paper also highlights the environmental sustainability issues by analyzing different stages of the lifecycle of ICE & EVs and collecting research-based data to support the outcomes.

This research paper is also very helpful for the end users to clear their doubts while making a decision to procure ICE or Electric Vehicles in keeping view of the impact on the environment.

RESEARCH METHODOLOGIES:

A detailed literature review has been conducted at regular intervals to get a better understanding and deeper knowledge about the factors responsible for polluting the environment during the lifecycle of ICE & Electric Vehicles at all stages.

- Data collection: Gather emission data from various reliable sources, including research studies, government reports, and industry data.
- Parameters for comparison: CO₂ (Carbon dioxide) emissions, NO_x (Nitrogen oxide), Sox (sulphur oxides) PM (particulate matter), and other relevant pollutants.
- Consideration of lifecycle emissions: Include manufacturing, operation, and disposal stages for a comprehensive analysis.

MAJOR FINDINGS:

- 1) EVs or ICE Vehicles, which one are worse for the climate?
- 2) EVs are really a sustainable solution or we are just delaying the climate crisis issues?
- 3) Different lifecycle stages of ICE & Electric Vehicles in which they produce particle pollution.

FUTURE SCOPE OF THE RESEARCH:

Researchers across the globe are continuously working hard to invent better and more advanced technology that will help us in reducing the pollution and emission of greenhouse gases. With unlimited scope and boundless opportunities, extensive research and experiments will be carried on and we would witness a number of newer products to be introduced in the coming days.

As research on EV technology is a never-ending process, more and more inventions are bound to happen and thus there would always be a need to conduct more research keeping in view of environmental safety and sustainability.

There has long been a reputation for diesel cars' fuel efficiency, and they are generally considered to be more efficient than electric cars powered by fossil fuels. However, it is important to conduct further investigations to fully examine the life cycle emissions of both systems. The term "life cycle emissions" refers to the total emissions produced from the extraction of raw materials, manufacturing processes, vehicle operation, and eventual disposal or recycling.

When comparing diesel cars to electric cars powered by fossil fuels, it is crucial to consider not only the emissions produced during the operation of the vehicles but also the emissions associated with the production of the electricity or fuel used to power these cars. This includes the emissions generated during the extraction and refining of fossil fuels, as well as the emissions from the power plants that generate electricity.

Although diesel cars may have higher fuel efficiency, the emissions produced during the extraction and refining of diesel fuel can be significant. Additionally, diesel-powered vehicles emit pollutants such as nitrogen oxides and particulate matter, which have been linked to various health issues.

On the other hand, electric cars powered by fossil fuels also have their own set of emissions. When coal or natural gas is burned to generate electricity, it releases greenhouse gases and other pollutants into the atmosphere. However, it is worth noting that the overall efficiency of gasoline cars is similar to electric cars powered by coal and diesel power plants.

To accurately assess the environmental impact of diesel cars and electric cars powered by fossil fuels, a comprehensive analysis of their life cycle emissions is necessary. This analysis should consider factors such as the extraction and refining of raw materials, manufacturing processes, vehicle operation, and end-of-life disposal or recycling.

In conclusion, while diesel cars may be more fuel-efficient than electric cars powered by fossil fuels, it is important to conduct further investigations to fully understand the life cycle emissions of both systems. Examining the emissions from cradle to grave will provide a more comprehensive understanding of the environmental impact of these vehicles. Moreover, it is essential to consider the overall efficiency of gasoline cars, which is comparable to electric cars powered by coal and diesel power plants.

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1. INTRODUCTION

The demand for Electric Vehicles is growing exponentially over conventional vehicles due to their low operating cost, increasing EV charging infrastructure across the country, launching of new models with more advanced technology, price reduction due to mass production, and consumer awareness regarding the environment.

But a recent study done by IIT Kanpur claims that EVs are more polluting than conventional cars. A Germany-based major car manufacturer has also supported the claim that EV produces 70% more emission than ICE vehicles if all lifecycle stages are taken into consideration.

Thus, this has become an important question “Are EVs more polluting than conventional vehicles?”

Are we really solving the environmental issues by switching to EVs or we are just delaying the inevitable?

2. THEORETICAL BACKGROUND

In this research paper, a brief comparative study has been conducted to compare the emission of pollutant particles at various stages of the lifecycle of ICE and conventional vehicles.

A detailed survey has also been conducted by designing a questionnaire on various factors measuring customer behaviour on environmental issues while purchasing a vehicle. We have received 180+ online and 220+ offline responses till 30th May’22.

In this research paper, we have tried to explain major issues associated with the ICE & EVs related to the emission of pollutant particles.

We have also explained key measures required to be taken to deal with the current issues and steps to reduce pollution and make EVs a sustainable solution for the future.

a) Emissions from ICE Vehicles:

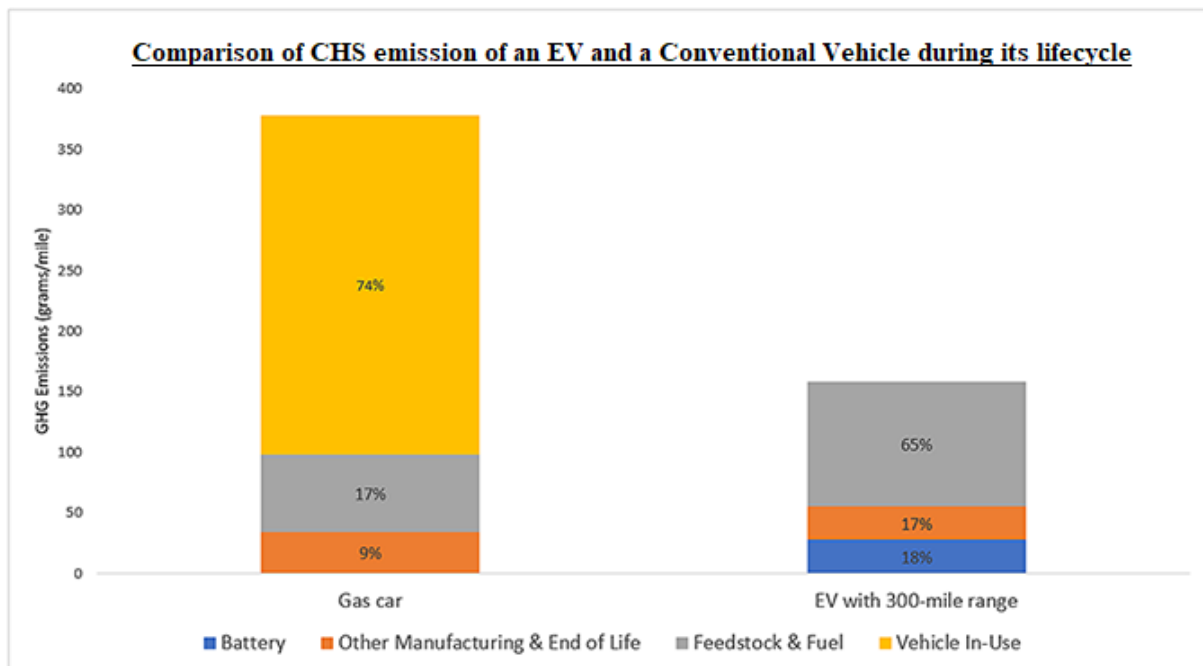
- Primarily ICE vehicles are run on fossil fuels, such as diesel or gasoline, diesel, which release carbon dioxide (CO₂), a greenhouse gas responsible for climate change.
- ICE Vehicles also emit sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter (PM), and other pollutants harmful to human health and the environment.
- The emissions from ICE vehicles contribute to air pollution, smog formation, and respiratory illnesses which are causing environmental issues at global levels.

b) Emissions from Electric Vehicles:

- EVs have zero tailpipe emissions as they run on electricity stored in batteries, meaning they do not emit any pollutants during operation.
- However, the emissions associated with EVs depend on the source of electricity used for charging. If the electricity comes from renewable sources like solar or wind, EVs have almost no indirect emissions.
- If the electricity is generated from fossil fuels, EVs can indirectly contribute to emissions based on the carbon intensity of the electricity grid.

c) Comparing Emissions:

- Numerous studies have compared the overall emissions of ICE vehicles and EVs, considering both direct and indirect emissions.
- The Union of Concerned Scientists (UCS) conducted an analysis and found that, on average, EVs produce lower emissions than comparable gasoline-powered vehicles across the United States.
- The exact emissions reduction depends on factors such as the electricity grid mix, driving patterns, and vehicle efficiency.
- In regions with a high proportion of renewable energy, the emissions reduction potential of EVs is even more significant.



d) Lifecycle Analysis:

- To gain a comprehensive understanding, it's essential to consider the lifecycle emissions of vehicles, including manufacturing, operation, and disposal stages.
- Manufacturing batteries for EVs can have higher upfront emissions compared to producing conventional vehicles.
- However, as EVs are driven, their lower operational emissions and potential for grid decarbonization can offset the initial manufacturing emissions.
- Recycling and proper disposal of batteries are critical to minimize environmental impact.
- According to the research conducted by scientists, it has been observed that gasoline cars release an average of more than 350 grams of carbon dioxide (CO₂) per mile driven throughout their lifetime. In comparison, the hybrid and plug-in hybrid models demonstrated a lower emission rate, approximately around 260 grams of CO₂ per mile. The fully battery-electric vehicles, on the other hand, exhibited the lowest emission rate with just 200 grams of CO₂ per mile.

- According to statistics provided by the U.S. Department of Energy (DOE), it is clear that electric vehicles (EVs) have a significantly lower carbon footprint compared to other types of vehicles. The DOE has calculated the amount of CO2 equivalent emissions produced per year by different energy sources used in vehicles.
- On average, EVs produce approximately 3,932 pounds (lbs.) of CO2 equivalent emissions per year. This is significantly lower than the emissions generated by other types of vehicles. For instance, plug-in hybrids emit around 5,772 lbs. of CO2 equivalent per year, typical hybrids emit approximately 6,258 lbs., and gasoline vehicles emit a staggering 11,435 lbs.
- The carbon emissions of electric vehicles (EVs) compared to hybrid cars can vary significantly depending on specific factors. One crucial factor is the carbon intensity of the power grid in a given region.
- When researchers considered the average carbon intensity of America's power grid, they discovered that a fully electric vehicle emits approximately 25 percent less carbon compared to a comparable hybrid car. This reduction in emissions can be attributed to the cleaner energy sources used to generate electricity for EVs.

e) Manufacturing of EVs & components

- This is the major part of EV pollution caused in the manufacturing battery contributes 31-46% of the total pollution caused. Batteries of electric vehicle batteries contain many rare and toxic metals like cobalt which are difficult to mine. In research, it is found that 30 to 494 kg CO2-equivalent per kWh is produced in the manufacturing of batteries. This is further narrowed to 61–106 kg/kWh CO2-equivalent due to more clear data.
- Li-ion batteries are mainly used in EVs that consist of anode active material, cathode, electrolyte, separators, and binders. For the same capacity of Li-ion battery, LFP-based-Li-ion battery produces more GHG than NMC and LMO-based-Li-ion batteries. The production of cathode materials and wrought aluminum significantly contributes to greenhouse gas (GHG) emissions. These two industries play a dominant role in the emission of GHGs, which are responsible for global warming and climate change. It is essential to address and reduce these emissions to mitigate the impacts on our environment. The battery's component mass percentage required in the manufacturing is as follows in the below table:

Battery Component	LFP	NMC	LMO
Anode materials	24.5%	28.2%	33.6%
Wrought Aluminium	20.3%	19.7%	18.7%
Copper	12.4%	11.4%	10.9%
Graphite	15.2%	18.3%	14.7%
Binder	2.1%	2.4%	2.5%
Electrolyte	17 %	12.8%	11.6%

About 50% of the battery lifetime emissions come from the source of electricity used in its manufacturing and assembling. So, batteries produced from a plant that is powered by renewable energy add a lesser amount of GHG emissions from EVs running. So many Li-ion battery manufacturing gigafactories are installing renewable energy sources to meet the power required by the plant, e.g. Tesla Gigafactory.

3. RESEARCH FINDINGS

Electric vehicles (EVs) do not generate more pollution than conventional vehicles. In fact, EVs are generally considered to be more environmentally friendly than internal combustion engine (ICE) vehicles. Here's why:

It is now clear that EVs do not generate more pollution than conventional vehicles. We may further elaborate on it in the below-given headings:

Zero tailpipe emissions: EVs produce zero tailpipe emissions because they run on electric motors powered by batteries. On the other hand, ICE vehicles burn fossil fuels, such as gasoline or diesel, which emit pollutants like CO₂, NO_x, and particulate matter into the atmosphere.

Lower lifecycle emissions: While it is true that the manufacturing process of EVs can have a higher carbon footprint due to the production of batteries, studies have shown that EVs still have lower lifecycle emissions compared to ICE vehicles. This is primarily because the emissions generated during the manufacturing phase are offset by the lower emissions during the vehicle's operational phase.

Renewable energy integration: EVs have the potential to utilize renewable energy sources for charging. When powered by renewable energy, such as solar or wind power, EVs can be effectively zero-emission vehicles throughout their lifecycle.

Improving grid emissions: As the electricity grid becomes cleaner over time with the increased adoption of renewable energy, the environmental benefits of EVs will continue to improve. EVs can help shift energy demand away from fossil fuel-powered plants and contribute to reducing overall greenhouse gas emissions.

It is worth noting that the environmental impact of any vehicle depends on various factors, such as the source of electricity, driving patterns, and the efficiency of the vehicle itself. However, in general, EVs have the potential to significantly reduce greenhouse gas emissions and contribute to a cleaner and more sustainable transportation system.

4. CONCLUSION

Electric Vehicles' popularity is growing continuously because of their unique features as compared to IC engines like less operating cost and being eco-friendly. The amount of pollution caused by EVs is highly debatable. The large emission of greenhouse gases during the manufacturing of EVs is a matter of concern for engineers and scientists. But it can be reduced largely in the future because of advancements in technologies involved in manufacturing and the fast acceptance of renewable energy sources in society. After studying several reports, I am sure to write EVs are causing less pollution even in the worst case of electricity generation (opting for more thermal-based power plants). A report found that in 95% of the world, driving an electric car is better for the climate than a petrol car. Therefore, in the future, the electric

vehicle is meeting the requirements of environmental concerns and will help in achieving a net zero economy.

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