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Conventional Vehicles, Electric Vehicles, and Hybrid Vehicles; A Comparative Study

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Abstract
A significant number of comparative analyses have been conducted to assess the strengths and weaknesses of three distinct types of vehicles: conventional vehicles that utilize internal combustion engines, battery-powered electric vehicles, and hybrid vehicles that incorporate both battery power and internal combustion engines. The parameters selected for examination play a crucial role in defining the main aspects of the study as well as the criteria for comparison. The research distills essential insights into the characteristics of conventional, electric, and hybrid vehicles based on the comprehensive evaluations carried out. This article employs comparative methodologies and multi-criteria decision-making (MCDM) techniques to analyze these vehicle types. Furthermore, additional considerations and interpretations have emerged from the investigations performed.(1)
Keywords: Electric vehicle (EV); hybrid electric vehicle (HEV); internal combustion engine vehicles (ICEV); Gasoline Vehicle (GV); Carbon Dioxide (CO2)

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(1) Bibi Sadeer, N., Montesano, D., Albrizio, S., Zengin, G., &Mahomoodally, M. F. (2020). The versatility of antioxidant assays in food science and safety—Chemistry, applications, strengths, and limitations. Antioxidants, 9(8), 709.

I. Introduction

Vehicles equipped with internal combustion engines (ICEs), often termed conventional vehicles, hold a dominant position within the global automotive industry. Recent concerns surrounding carbon emissions and dependence on imported oil in numerous countries have catalyzed a heightened interest in electric vehicles (EVs). The discourse surrounding EVs has been ongoing since the inception of the first electric carriage in the 1830s. In contrast, the technology related to full hybrid electric vehicles (HEVs) has evolved at a more accelerated rate in comparison to EVs, offering a range of advantages similar to those found in EVs. Mass-produced HEVs, such as the Toyota Prius and the Honda Insight, are now readily available in the market.(1)

This chapter aims to analyze the differences between EVs, HEVs, and conventional vehicles, the rationale for the investigation of each type, their respective impacts on greenhouse gas emissions and oil dependency, the present state of these vehicle categories, recent research advancements, and the essential requirements for battery specifications.(2)

A vehicle is categorized as an Electric Vehicle (EV) if its propulsion system relies wholly on its battery. A Hybrid Electric Vehicle (HEV) is characterized by its utilization of multiple sources of traction energy, allowing it to operate solely on electric power when necessary. In contrast, a conventional vehicle is powered exclusively by an internal combustion engine. The anticipated decline in the production costs of fuel cell vehicles (FCVs) has established them as a viable fourth alternative.(3)
Nonetheless, FCVs have not yet achieved widespread mass production; thus, this chapter will primarily address Battery Electric Vehicles (BEVs), HEVs, and conventional vehicles. Our definition of a BEV aligns with the established nomenclature. The advantages of electric propulsion for both vehicles and aircraft have been acknowledged for over 130 years. This book includes a chronological account of the evolution of electric vehicles commencing in the 1830s.(4)

1- Conventional vehicles features

A conventional vehicle is characterized by its reliance on a single energy source to power its operational load. Primarily, these vehicles fulfill three main functions: the transportation of individuals, the conveyance of goods, and a hybrid service that integrates both passenger and freight transport. Typically, conventional vehicles are powered by internal combustion engines; however, exceptions exist in forms of transportation such as buses, trolleybuses, trains, and trucks, which may utilize external combustion engines, such as steam engines. Among the various vehicle types, personal cars and light vehicles are the most widely utilized by the general populace, chiefly designed for passenger transport. They also have the capacity to carry personal goods, generally with a maximum load of around 400 kg. Similarly, small covered commercial vehicles share similarities with compact cars but are specifically engineered for goods transport. These vehicles tend to have a greater mass than standard cars, typically not exceeding 2500 kg, and can also serve as personal transport for owners.(5)

The logistics of goods transport are predominantly managed by autonomous vehicles, which may draw power from diverse alternative energy sources aside from the traditional internal combustion engine. Additionally, a minor fraction of the vehicle's kinetic forces can be utilized for braking or steering assistance, thereby enhancing operational control. The driver's cabin of these vehicles does not necessitate stringent criteria regarding load capacity or compliance with stringent deadlines, unlike taxis or rideshare vehicles. In essence, conventional vehicles primarily operate on petroleum derivatives as their fuel source.(6)

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(2) Shafique, M., Azam, A., Rafiq, M., & Luo, X. (2022). Life cycle assessment of electric vehicles and internal combustion engine vehicles: A case study of Hong Kong. Research in Transportation Economics, 91, 101112.

(3) Malozyomov, B. V., Martyushev, N. V., Kukartsev, V. V., Konyukhov, V. Y., Oparina, T. A., Sevryugina, N. S., ... & Kondratiev, V. V. (2024). Determination of the Performance Characteristics of a Traction Battery in an Electric Vehicle. World Electric Vehicle Journal, 15(2), 64.

(4)Amry, Y., Elbouchikhi, E., Le Gall, F., Ghogho, M., & El Hani, S. (2022). Electric vehicle traction drives and charging station power electronics: Current status and challenges. Energies. P19.

(5) Bai, S. & Liu, C. (2021). Overview of energy harvesting and emission reduction technologies in hybrid electric vehicles. Renewable and Sustainable Energy Reviews. P119

(6)Elkelawy, M., Alm ElDin Mohamad, H., Samadony, M., Elbanna, A. M., & Safwat, A. M. (2022). A Comparative Study on Developing the Hybrid-Electric Vehicle Systems and its Future Expectation over the Conventional Engines Cars. Journal of Engineering Research, 6(5), p25.

2- Electric vehicles features

Electric vehicles (EVs) are the most popular vehicles powered solely by electricity. Compared to conventional gasoline vehicles, EVs have several advantages, such as being clean and quiet, offering great driving performance, using energy more efficiently, and having convenient supply, easy operation, and low operation and maintenance costs. At the same time, EVs also have some disadvantages, of which the main factors are the high price of EVs, limited driving range, long charging time, and the potential influence on the power grid, environmental issues, and the safety of batteries. The infrastructure for EVs is still incomplete, and it will take a longer time and require substantial investment to promote the development of vehicles and corresponding infrastructure. Therefore, the promotion of EVs still has a long way to go, and it needs to be researched and promoted by governments, enterprises, research institutes, and public opinion.(1)

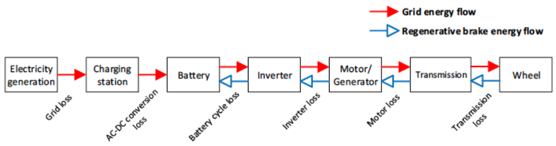

Fig.1.Energy flow and losses between different stages of typical EV

3- Hybrid vehicles features

A hybrid vehicle is a type of vehicle propelled by a two-power system: Internal Combustion Engine (ICE) and an electric motor. There are three types of HEVs based on their operational characteristics: series, parallel, and power hybrids. In series HEVs, only the electric motor operates the vehicle. The engine drives the generator that supplies an electrical charge to the battery that powers the electric motor. The engine does not drive the wheels during normal vehicle operation. The battery will only perform a few tasks and is not required to deliver the peak power.(2)

The first role is to capture energy during regeneration. During deceleration, the motor acts as a generator to produce electricity with the retarding effect. The stored energy improves vehicle dynamic performance. The second role is to assist the engine during acceleration. In gasoline or diesel-powered hybrid electric vehicles, the motor usually provides power to the wheels through a gear system.(3)

In a parallel hybrid, both the gasoline engine and an electric motor can directly drive the wheels and propel the vehicle. The electrical energy supply works in a similar way to what happens in a series hybrid. In a power hybrid, the vehicle possesses some unique features from the other two traditional hybrid vehicles. The vehicle may have a fixed mechanical power split. When specific power available to the vehicle is not needed, the engine may operate either as a source or power sink to connect or disconnect from the edge of the dual hybrid machine. When the vehicle requires higher specific power than available from any individual energy sources, the power is absorbed from the temporary energy stored. When the vehicle requires higher specific power than available from either the vehicle's single or multiple power sources, the power is provided in a balanced combination of all energy source types. Unlike the regular hybrid vehicle where the ICE can be turned off during its electric power, the power hybrid can operate with the ICE off during its electric-only power mode.(4)

II. Characteristics of conventional, electric and hybrid vehicles

There are three kinds of powertrain modes for various motor vehicles utilized nowadays: conventional vehicle, electric vehicle, and hybrid vehicle. In view of various propulsion techniques and combinations for automobiles, driving performances and emission concentrations for conventional, electric, and hybrid vehicles were experimentally compared based on the mechanics and dynamics characteristics of all three powertrain modes. It is shown that the electric vehicle produces the best

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(1) Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K. W., Islam, E., ... & Ahmed, S. (2021). Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles. Energy Policy, 158, 112564.
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(2)Zhao, F., Chen, K., Hao, H., & Liu, Z. (2020). Challenges, potential and opportunities for internal combustion engines in China. Sustainability. P11
(3) Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K. W., Islam, E., ... & Ahmed, S. (2021). Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles. Energy Policy, 158, 112564.
(4) Zhao, F., Chen, K., Hao, H., & Liu, Z. (2020). Challenges, potential and opportunities for internal combustion engines in China. Sustainability. P107

driving performance but the lowest emission concentration by employing the storage battery for the power switches. As compared with the conventional vehicle, the hybrid vehicle may provide nearly the same driving performance and a much lower emission concentration due to the not necessarily use of internal combustion engines.(1)

A hybrid vehicle is basically a conventional vehicle that relies on an electric motor on occasion to assist the internal combustion engine. The general characteristic of this type of powertrain is relatively high fuel efficiency. However, substantial investment could be required in the advanced components when more of the energy is regularly used. To produce the hybrid vehicle with better fuel economy and lower emission concentrations, two inherently attractive methods of using an electric motor have been proposed for the powertrain mode: Series Hybrid and ISG-Inner Side Guide Hybrid. Each is designed to deliver electric power from the on-board storage battery to the driven wheels, while as little engine power as possible is utilized for the internal combustion engines during the acceleration operation.(2)

To study how the driving performance and emission concentrations may vary with the power requirements during acceleration operation, the steady-state acceleration behaviors for the base motor vehicle, series hybrid vehicle, and ISG-Inner Side Guide Hybrid vehicle are analyzed.

III. Comparing of conventional, electric and hybrid vehicles:

This article discusses the potential benefits of using electric and hybrid cars, which are receiving increased attention due to developing technologies. This can play a strong supportive role for the economies and the environment, opening new areas for commercial activities. The performance of vehicles, as well as the economic and environmental benefits of electric and hybrid vehicles compared to traditional cars, is presented in this study. Electric and hybrid vehicles can use renewable and clean energy resources. Electric vehicles do not release CO_2 and are much more fuel-efficient, producing 30% less carbon dioxide than diesel vehicles. Electric vehicles require minimal maintenance and have low operating costs attributed to fewer moving parts that need replacement. The efficiency of electric vehicles is enhanced by reducing vehicle weight, drag coefficient, rolling resistance, and incorporating regenerative systems for stopping and accelerating or traveling on constant speed road grades.(3)

By considering the regeneration capabilities, hybrid vehicles have increased fuel efficiency and reduced travel costs. Hybrid vehicles are powered by an internal combustion engine with an efficient electric motor and an advanced battery that prevents wasteful engine activity. The results show that the three electric cars tested do not emit pollutants in terms of CO_2, CO, HC, and NO_x. Electric power vehicles have lower operating and maintenance costs than internal combustion vehicles. However, we have the limitation of moving only short distances. The battery also needs a long time to recharge. The design of electric cars involves reducing system weight and optimizing the drag coefficient. The efficient design of a transport vehicle requires testing mathematical and analytical models, numerical simulations, and physical tests on the value system. The driving cycles for the obtained results were the New European Driving Cycle, the extra-urban driving cycle, and the Milan urban driving cycle. Other results indicate that electric vehicles reduce fuel costs by 75% for 100 km, reduce CO_2 emissions by 70% for 100 km, reduce CO emissions by 70% for 100 km, and reduce NO_2 emissions by 60% to 70% per 100 km compared to internal combustion engines. These results show that electric vehicles with lithium-air batteries are considered a feasible and attractive solution.(4)

1. Power Source

A conventional vehicle is driven by an internal combustion engine that generally runs on petrol or diesel. Electric vehicles (EVs), in contrast, are fueled by electric energy stored in a rechargeable battery. EVs represent two types: Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs). BEVs store electric energy from an external power source into a battery package to power an electric motor that drives the vehicle. FCEVs operate on hydrogen gas stored in the tank and oxygen from the atmosphere to generate

(1) Lattanzio, R. K., & Clark, C. E. (2020). Environmental Effects of Battery Electric and Internal Combustion Engine Vehicles. Congressional Research Service (CRS) Reports and Issue Briefs, NA-NA. p435

(2) Martins, J. & Brito, F. P. (2020). Alternative fuels for internal combustion engines. Energies.

(3) Towoju, O. A. & Ishola, F. A. (2020). A case for the internal combustion engine powered vehicle. Energy Reports.p 67

(4) Santos, N. D. S. A., Roso, V. R., Malaquias, A. C. T., & Baeta, J. G. C. (2021). Internal combustion engines and biofuels: Examining why this robust combination should not be ignored for future sustainable transportation. Renewable and Sustainable Energy Reviews, 148, 111292.

electrical energy through the chemical reaction inside a fuel cell shared with the powerful electric motor.[(1)] Hybrid vehicles are capable of using power from both electric and conventional power sources. The main types of hybrids include the parallel mild hybrid, energy management parallel, micro-hybrid, conventional, full hybrid, and series-parallel. A parallel mild hybrid vehicle's electric motor only assists the gasoline engine when extra power is required. An energy management parallel hybrid provides just the necessary energy, supplying electric power to its electric motor from the battery package alone. Micro-hybrids have a unique mark-and-start system. When the driver releases the brake, the engine automatically starts and is ready to operate quickly. The conventional hybrid's engine constantly operates and recharges the battery. The full hybrid has an electric motor that can power a vehicle exclusively, drawing electric energy from the battery or from the internal combustion engine. Throughout the series-parallel, the vehicle can use electricity to get direct energy from either the electric motor or the motor connected to the engine, which can only recharge the battery.[(2)]

2. Charging

A plug-in hybrid vehicle uses two unique on-board energy sources, in our case electricity and gasoline, two direct pass-through energy inputs, and the internal combustion engine to recharge the second type. In order to make use of one of these vehicles, one must be able to recharge the electricity source. The most common method is to use a connector with a suitable cable offering a 7.2 kW single-phase or three-phase charging rate in the 36A and 480V range. Depending on the battery technology, a correctly designed and managed recharging station can also handle 80A and even 120A fast charging. Earlier PHEV vehicles did not handle fast charging. Each house can, in fact, have the usual wall box or use a domestic plug; a charging rate higher than 3 kW requires a proper triphasic 16A wall box. More advanced PHEV vehicles can also use a cable in case one must recharge in the absence of electrical networks and renewable energy sources.[(3)]

A vehicle driver schedules the times when the car will be connected to an electrical network in order to avoid peak hours or to take advantage of renewable energy source production maxima or the best kW price. When connected and in line with the local network director specifications, the vehicle will benefit from the energy available at the maximum power, and the oscillograph power is always inferior. At times, the PHEV can choose to be an energy source connected in parallel with the main line with the aim to balance the power distribution between the inputs and the home or industrial plant, but not to disrupt the general power grid. For example, the PHEV unit uses the batteries as an energy storage for smoothing out the load on the energy conversion unit. Statements are present in every current PHEV user's manual prohibiting the use of the PHEV on-board energy sources to supply electric energy to house systems in the case of emergency, or when a fault is detected during utility grid operation, so the back-feed overload protection does exist. The PHEV manufacturer describes different operation zones that establish different charging or discharging power, if the respective time schedules and general operating conditions are met. When a PHEV is charging, the energy can move from the energy source towards the house during same-tariff periods; if it is discharging in feed-in mode to support the house electricity demand, the vehicle modality changes and the energy moves from the house towards the energy source. The user adjusts voltage and current as the device has three distinctive power distribution modes.[(4)]

3. Emissions

Many health problems arise out of air pollution. Transportation is one of the most significant sources of air pollution in the world. Urban areas are usually characterized by road transport, leading to an increased concentration of pollutants. The atmosphere acts as a natural greenhouse. Each time people burn fossil fuels such as gasoline, diesel, or natural gas, they release carbon dioxide and other heat-trapping gases into the atmosphere. Air pollution is one of the factors affecting global and local climate changes. Gases, impurities, and particulate matter are emitted to

(1)Liu, X., Reddi, K., Elgowainy, A., Lohse-Busch, H., Wang, M., & Rustagi, N. (2020). Comparison of well-to-wheels energy use and emissions of a hydrogen fuel cell electric vehicle relative to a conventional gasoline-powered internal combustion engine vehicle. International Journal of Hydrogen Energy, 45(1), 972-983.
(2) Yang, Z., Wang, B., & Jiao, K. (2020). Life cycle assessment of fuel cell, electric and internal combustion engine vehicles under different fuel scenarios and driving mileages in China. Energy.p 87
(3) Zhao, F., Chen, K., Hao, H., & Liu, Z. (2020). Challenges, potential and opportunities for internal combustion engines in China. Sustainability.p17
(4) Lešnik, L., Kegl, B., Torres-Jiménez, E., & Cruz-Peragón, F. (2020). Why we should invest further in the development of internal combustion engines for road applications. Oil & Gas Science and Technology–Revue d'IFP Energies nouvelles, 75, 56.

cause air pollution originating from engines that burn fuels such as gasoline and diesel. Therefore, as part of efforts to reduce emissions from road transport, more stringent requirements have led to the development of internal combustion engines that run more efficiently with lower fuel consumption and show a reduction in emissions. [(1)]

Conventional internal combustion engine vehicles are a significant source of air pollution, especially in urban areas, where the traffic pollution levels cause air quality problems. The main pollutants in vehicle emissions are CO, NOx, VOC, SO2, CO2, and particulates. Since about three-quarters of air pollution is caused by transport, it has been widely researched. Electric and hybrid vehicles dominate discussions on the future of transport in attempts to reduce the pollution caused by current transport systems. The transportation sector is responsible for the increase in CO2 emissions into the atmosphere, which is responsible for the increase in temperature during recent years. Air pollution is responsible for increasing healthcare bills and decreasing life expectancy. It affects older people, children, and people with allergies, asthma, and other types of lung disease. By causing global warming, air pollution affects everyone. The main pollutants found in vehicle emissions are carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur dioxide (SO2), and particulates.[(2)]
The next figure shows the well to wheel CO_2emission of GV and EV[(3)]

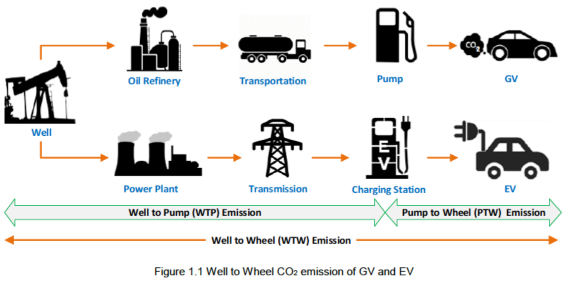

Fig.2. Well to Wheel CO_2 emission of GV and EV

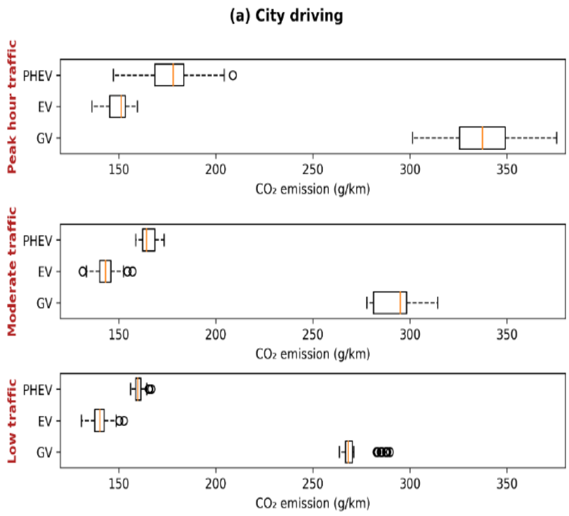

Fig.3. CO_2 emission of GV, EV and PHEV in city driving

For the city driving cycle, CO2 emission sharply increases with the level of trafficcongestion for GV. On the other hand, for EV and PHEV, CO2 emission alsoincreases with the level of traffic congestion, but the impact is comparatively low.[(4)]

(1) Zhao, F., Chen, K., Hao, H., & Liu, Z. (2020). Challenges, potential and opportunities for internal combustion engines in China. Sustainability.p19

(2) Santos, N. D. S. A., Roso, V. R., Malaquias, A. C. T., & Baeta, J. G. C. (2021). Internal combustion engines and biofuels: Examining why this robust combination should not be ignored for future sustainable transportation. Renewable and Sustainable Energy Reviews, 148, 111292.

(3)Md mamunurrahman, A comparative assessment of co2 emission between gasoline,Electric, andhybrid vehicles: a well-to-wheelPerspective using agent-based modeling, doctor of philosophyTheuniversity of texas at arlingtonAugust 2020, p4

(4)Md mamunurrahman, A comparative assessment of co2 emission between gasoline, Electric, and hybrid vehicles: a well-to-wheelPerspective using agent-based modeling, doctor of philosophyTheuniversity of texas at arlingtonAugust 2020, p44

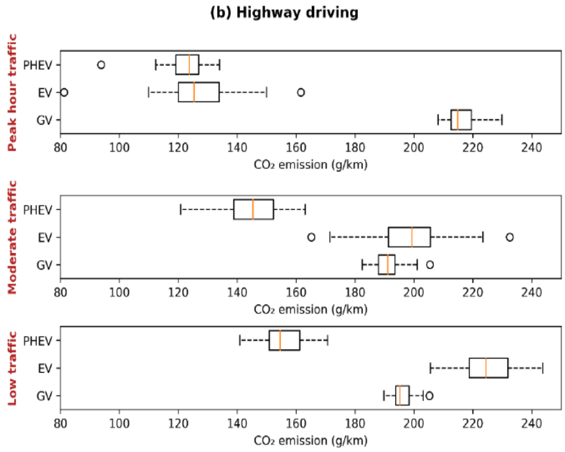

Fig.4. CO_2 emission of GV, EV and PHEV in Highway driving

For highway driving, the amount of CO2 emission from GV is a non-monotonicfunction of traffic congestion where emission is minimum for moderate traffic andmaximum for peak hour traffic. On the contrary, the amount of CO2 emission fromEV and PHEV decreases monotonically with the level of traffic congestion for thespeed range 60 to 100k/h.[(1)]

4. Range

Range is less critical or not critical if the vehicle is just used for daily commuting and is also useful for other purposes. If the vehicle is not planned as the only or main vehicle in a multi-vehicle household, it can rely on a very small all-electric range supplemented by an internal combustion engine. Therefore, it is important to understand a user's usage of the vehicle. This knowledge is useful in both battery size design and outside charging station planning. Currently, most plug-in hybrids only have 10 to 30 miles of all-electric range and therefore are not useful to many commuters. If, however, 100 miles of all-electric range can be guaranteed every day, people only have to visit a gasoline station once a month, and then the gas bill becomes almost trivial. The days of the week on which one needs to think about going to the gas station are drastically reduced. For a plug-in hybrid, the limited all-electric range does not have a significant impact. However, for a battery electric vehicle, it is critical since the user may want to use the vehicle for all purposes, from daily local commuting to out-of-state vacations. If the vehicle can only be used for one kind of purpose, the needed range changes dramatically, and therefore the battery size and the use cost in a particular dense urban environment may not be consistent with the outside charging station density. Although battery size is directly associated with all-electric range and charging speed, only the all-electric range affects revenue, which is why it is what is really important to the user.[(2)]

5. Refueling

Refueling of vehicles is important as this determines the time taken for the vehicle to get back to its routing. In general, vehicles are refueled in the morning before the start of activities. Refueling means both filling up the fluid itself as well as the act of recharging. The time taken for refueling depends on the delivery rate of the fuel, the capacity of the fluid tank, and the actual amount of fluid required for the operation of the vehicle.[(3)]

Generally, conventional vehicles are fitted with larger tanks, and electric vehicles with batteries having longer ranges are considered for longer activities. Hence, these vehicles require a lesser number of refueling breaks. Based on this perspective, conventional vehicles are the best vehicles to choose as the refueling time is less. Conventional vehicles also consume the least amount of energy compared to electric vehicles.[(4)]

Hybrid vehicles have an advantage over other vehicles in the aspect of the amount of energy consumed. Electric vehicles have the shortest refueling time depending on the electric charging system used. In the event of constant discharging, the battery will be at zero charge state. The only method for the electric vehicle to proceed after this condition is to replace the discharged battery with a charged battery. The conventional or hybrid vehicle has to wait until a certain amount of charge has been reached for it to proceed.[(5)]

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(1)Md mamunurrahman, A comparative assessment of co2 emission between gasoline, Electric, and hybrid vehicles: a well-to-wheelPerspective using agent-based modeling, doctor of philosophyTheuniversity of texas at arlingtonAugust 2020, p45

(2)Towoju, O. A. & Ishola, F. A. (2020). A case for the internal combustion engine powered vehicle. Energy Reports.p45

(3) Kirkpatrick, A. T. (2020). Internal combustion engines: applied thermosciences.

(4) Hoeft, F. (2021). Internal combustion engine to electric vehicle retrofitting: Potential customer's needs, public perception and business model implications. Transportation Research Interdisciplinary Perspectives.

(5)Towoju, O. A. & Ishola, F. A. (2020). A case for the internal combustion engine powered vehicle. Energy Reports.

6. Efficiency

Now we will examine the relative efficiency of hybrid, electric, and conventional vehicles. One important measure of the efficiency of a vehicle is the fuel economy of the vehicle. Fuel economy may be calculated in terms of miles per gallon or in other terms such as miles per 100 gallons or kilometers per liter. Since the hybrid vehicle makes use of both an internal combustion engine and an electric motor, the fuel economy of the vehicle may be calculated in terms of miles per gallon, while the electric vehicle uses only an electric motor. Therefore, the efficiency may be calculated in terms of kilowatt-hours per mile. However, hybrid vehicles and electric vehicles have the advantage of savings on fuel and the reduction of pollution in city driving compared to the conventional vehicle.(1)

Another important consideration in the efficiency of a vehicle is the total life-cycle energy consumption and greenhouse gas emissions. The energy consumption and greenhouse gas emissions generated from a vehicle may be divided into three segments: a) upstream or fuel-cycle that covers well-to-tank emissions.

b) tank-to-wheel emissions that cover emissions from the vehicle during driving.

c) vehicle production emissions.

The energy consumption in electric vehicle driving is lower than the fuel energy of a hybrid vehicle or the energy required to travel one mile with a gasoline car. However, the life-cycle energy use of an electric vehicle includes energy to produce traction batteries. Therefore, battery efficiency and vehicle production energy are key factors in reducing life-cycle outputs of electric vehicles. The greenhouse gas emissions relative to vehicle technology and the electricity grid mix also determine whether the electric vehicle is attractive for climate policy. The use of renewable energy to develop electricity could lower emissions; it is clearly intelligent to use renewable energy to charge electric vehicles.(2)

7. Maintenance

In general, you will have far fewer maintenance issues with an HEV or EV than you will with a gas car. The internal combustion engine in a hybrid vehicle has fewer parts than in a conventional vehicle, and because it is also the smaller part of the giant hybrid system, it can be expected to have even fewer defects. There are two major advantages that hybrids have from an environmental management point of view. One is the maintenance-free nature of electric motors and their controllers relative to internal combustion engines. The other gains are heat-related; the first is the fact that only a small-sized internal combustion engine has to be cooled in hybrids, and the second is the high thermal efficiency at low exhaust temperatures of the internal combustion engine.(3)

In order to motivate customers to buy electric vehicles, they need to be as reliable as conventional vehicles. Good reliability and high availability are also required in the introduction phase. Besides the problem of slow-charging times, the number of consumers that are willing to accept inferior reliability is relatively large. However, advanced technology cars are supposed to be as reliable, if not more, than the gasoline cars they replace. It does not help that reliability targets may be discussed and that electric vehicles are supposed to be choosy about their owners. The reliability life cycle of an electric drive vehicle is becoming an important factor in purchasing decisions. The maximum acceptable product downtime and the maximum acceptable number of failures can vary with the production model and the application.(4)

8. Examples

In this comprehensive study, we will thoroughly analyze and compare the various power systems utilized in the automotive industry. The focus will primarily be on conventional vehicles, specifically those equipped with internal combustion engines (both gasoline and diesel vehicles). Additionally, we will closely examine and compare three different engine setups: the internal combustion engine (IC engine) option, the electric motor option, and the hybrid setup that combines both IC engine and electric motor found in micro hybrid vehicles. It is important to note that electric vehicles will also be included in our analysis, encompassing both pure

(1)Santos, N. D. S. A., Roso, V. R., Malaquias, A. C. T., & Baeta, J. G. C. (2021). Internal combustion engines and biofuels: Examining why this robust combination should not be ignored for future sustainable transportation. Renewable and Sustainable Energy Reviews, 148, 111292.

(2)Yang, Z., Wang, B., & Jiao, K. (2020). Life cycle assessment of fuel cell, electric and internal combustion engine vehicles under different fuel scenarios and driving mileages in China. Energy.p98

(3)Santos, N. D. S. A., Roso, V. R., Malaquias, A. C. T., & Baeta, J. G. C. (2021). Internal combustion engines and biofuels: Examining why this robust combination should not be ignored for future sustainable transportation. Renewable and Sustainable Energy Reviews, 148, 111292.

(4) Andrych-Zalewska, M., Chłopek, Z., Merkisz, J., &Pielecha, J. (2022). Analysis of the operation states of internal combustion engine in the Real Driving Emissions test. Archives of Transport, 61(1), p79.

electric vehicles and extended-range electric vehicles. These vehicles are powered by electric motors or traction engines, which provide an innovative and sustainable alternative to conventional power systems. Within the realm of hybrid vehicles, we will further define and explore various types, such as micro hybrid vehicles and hybrid vehicles. Micro hybrid vehicles will feature either an IC engine or an electric power system, while hybrid vehicles will incorporate both IC engine and electric power systems. To ensure a representative sample, our study will focus on a micro hybrid vehicle equipped with an advanced start-stop system, allowing for enhanced efficiency and reduced emissions. Moreover, for the hybrid vehicles, a parallel hybrid vehicle with an engine start-stop system and a sail system will be examined to assess its benefits and performance. By conducting this detailed analysis and comparison, we aim to gain valuable insights into the advantages, disadvantages, and overall performance of each power system. This study will contribute to the ongoing development and advancement of automotive technology, leading to more sustainable and efficient vehicles in the future.

This section will first consider a number of examples of electric vehicles that are based upon a bi-directional energy converter and discuss how these vehicles are related to the proposed vehicle designs. We will then consider actual designs of power stages for electric vehicles, both those that are realized by the hybrid and EV designer in order to convert the high voltage from the transmission media to the low voltage and high current required by the motor and the medium voltage DC link right at the traction inverter. Once again, the relationship of these vehicle designs and the elements of the proposed vehicle design are examined in order to illustrate the operation of the proposed vehicle paradigm.(1)

The first example we consider is the Toyota RAV4 EV. The inherent premise of Toyota's design is that the plug-style vehicle will often spend most of its time in the no-travel standby mode. When the desired travel occurs, Toyota will meet the average required power of 25 kW through a relatively low fixed efficiency bi-directional converter from the distribution media. The energy source will be the high energy of the power system that has provided status information and checked connection during the standby mode. The obvious load is a single rear-axle motor that consumes this energy as required by the traction. More of the insightful design examples in the study of these powerful technologies are demonstrated by examining the systems that are seen by this power stage. Therefore, for the control of the SSC and for the control of the rear axle, we expand the Toyota RAV4 EV.(2)

(1)Dong, H., Zhuang, W., Chen, B., Wang, Y., Lu, Y., Liu, Y., ... & Yin, G. (2022). A comparative study of energy-efficient driving strategy for connected internal combustion engine and electric vehicles at signalized intersections. Applied Energy, 310, 118524.

(2)Zhao, F., Chen, K., Hao, H., & Liu, Z. (2020). Challenges, potential and opportunities for internal combustion engines in China. Sustainability.p 21

Conclusion

Electric, hybrid, and conventional vehicles have many differences, characteristics, and advantages. The most important results that should be considered in the conclusion are: the vehicle life cycle contributes significantly to environmental impacts; electricity production with renewable sources reduces these impacts; and mileage greatly influences energy consumption, emissions, and environmental impacts. Therefore, electric and hybrid vehicles should be used mainly for kilometers that will utilize zero gas technology. These results are very selective and specific to the basis used to develop the environmental classifications. Conventional vehicles are much less expensive than electric or hybrid vehicles, but maintaining and spending money on the use of vehicles in kilometers is more costly. However, the environment and our limited and non-renewable resources should also be crucial in evaluating the use of vehicles. All vehicle categories have some advantages in particular situations. This work is a very useful tool for evaluating the different environmental implications or impacts of conventional, electric, and hybrid vehicles and our decisions in one of these vehicle categories. These results can help to support the choice of vehicles, clarifying the decisions of stakeholders such as national authorities.

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