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Comparison Between Electric and Hybrid Powertrains- Effciency, cost, and Environmental Impact

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Introduction

The transport sector is undergoing a decisive transformation. In recent decades, climate change, increasing demands for energy efficiency, and stricter environmental regulations have placed strong pressure on the automotive industry to develop more sustainable solutions. Traditional internal combustion engines, which dominated the market for most of the 20th century, still account for a significant share of greenhouse gas emissions and air pollution. This has fuelled growing interest in alternative powertrains, particularly **electric vehicles (EVs)** and **hybrid vehicles (HEVs/PHEVs)**. Both technologies offer new opportunities to reduce emissions and improve energy efficiency, yet their strengths and limitations differ considerably.

A fully electric vehicle relies entirely on electricity stored in batteries and therefore provides zero tailpipe emissions during use. Advantages include high efficiency, low operating costs, and the potential integration of renewable energy sources in the charging process. However, EVs also face challenges such as high purchase prices, limited driving range, and the need for a well-developed charging infrastructure. Hybrid vehicles, on the other hand, combine a conventional combustion engine with an electric motor and a smaller battery. They provide extended range and greater flexibility, but remain dependent on fossil fuels to varying degrees, which limits their ability to eliminate emissions completely.

When comparing these powertrains, it is crucial to analyse three core aspects: **efficiency, costs, and environmental impact**. Efficiency concerns not only energy consumption but also how well the powertrain adapts to different driving conditions. Cost considerations extend beyond the initial purchase price to include operating and maintenance expenses as well as the availability of incentives and subsidies. Environmental impact should be assessed from a life-cycle perspective, taking into account production, use, and recycling, in order to gain an accurate picture of how these technologies differ and what potential they hold for the future.

The purpose of this paper is therefore to provide an in-depth comparison between electric and hybrid powertrains with a focus on the three dimensions mentioned above. By highlighting both strengths and weaknesses, the study aims to contribute to a deeper understanding of the role these technologies can play in the future of transportation, as well as which choices may be most sustainable from both an economic and environmental perspective.

Purpose

The purpose of this degree project is to conduct a comprehensive comparison between electric and hybrid powertrains, with a particular focus on three central dimensions: efficiency, cost, and environmental impact. In light of the ongoing transformation of the global transport sector, it has become increasingly important to identify solutions that can reduce dependency on fossil fuels, lower greenhouse gas emissions, and meet the rising demands for energy efficiency. This project therefore seeks to examine the extent to which electric and hybrid vehicles can contribute to these goals, while also highlighting the challenges that remain for each technology.

A first objective is to evaluate **efficiency**, both in terms of energy consumption and performance in real-world driving conditions. Electric powertrains are often considered more efficient due to their ability to convert stored energy into motion with minimal losses, while hybrid powertrains rely on the interaction between an internal combustion engine and an electric motor. Understanding how these systems differ in efficiency not only provides insights into technological strengths but also into how they may be optimized for different transport needs.

A second objective is to analyse **cost factors**. The cost of vehicle ownership extends beyond the purchase price, including maintenance, fuel or electricity consumption, charging infrastructure, and potential subsidies or incentives. By studying both short-term and long-term costs, the project aims to clarify the economic feasibility of adopting either electric or hybrid vehicles. This perspective is particularly relevant for policymakers who design support systems and for consumers who face financial considerations when choosing their mode of transport.

A third and equally important objective is to assess the **environmental impact** of electric and hybrid powertrains. While electric vehicles produce no direct tailpipe emissions, their overall footprint depends on the electricity mix used for charging and on the resource-intensive process of battery production. Hybrids, on the other hand, continue to use fossil fuels, but they may reduce emissions compared to conventional cars depending on usage patterns. By applying a life-cycle perspective, this study will evaluate the full environmental consequences, from production and usage to recycling and disposal, thereby offering a balanced view of sustainability.

Beyond these three main areas, the purpose of this project is also to explore the **external factors** that influence the success and limitations of these technologies. Infrastructure development, government policies, consumer behavior, and advancements in energy storage all play decisive roles in shaping the future of mobility. By integrating these dimensions into the analysis, the project will go beyond a purely technical comparison and instead provide a more holistic understanding of the place electric and hybrid powertrains hold in a sustainable transport system.

In summary, the overarching purpose of the degree project is not only to compare electric and hybrid powertrains in terms of efficiency, cost, and environmental impact but also to contextualize these findings within the broader social, economic, and environmental frameworks. The results are expected to contribute to academic discussions about sustainable technology development, while also serving as practical guidance for decision-makers, industry stakeholders, and consumers. Ultimately, the project aims to highlight which solutions are most sustainable and realistic in both the short and long term, thus supporting the transition toward a more climate-friendly and efficient transport sector.

Theory/Scope

The transport sector contributes significantly to global greenhouse gas (GHG) emissions, accounting for around 23% of total energy-related CO_2 emissions worldwide, with road transport responsible for the largest share (International Energy Agency, 2022). Passenger cars a

lone make up nearly half of these emissions. In order to meet international climate targets, such as the Paris Agreement, alternative vehicle technologies are being developed to replace or supplement conventional internal combustion engine vehicles (ICEVs). Two major alternatives currently in focus are **electric vehicles (EVs)** and **hybrid vehicles (HEVs and PHEVs)**.

Efficiency

Electric vehicles are generally more energy-efficient than both conventional cars and hybrids. According to the U.S. Department of Energy (2021), EVs convert more than 60% of the electrical energy from the grid into vehicle movement, compared to only 20–30% for gasoline engines. Hybrid vehicles improve fuel economy by combining an internal combustion engine with an electric motor. The European Environment Agency (2020) estimates that hybrids reduce fuel consumption by 20–35% compared to conventional vehicles, although actual performance depends heavily on driving patterns. Plug-in hybrids (PHEVs) can operate largely on electricity if charged regularly, but their efficiency declines when driven mostly on gasoline.

Cost

The cost of electric and hybrid vehicles is influenced by both purchase price and long-term ownership costs. Battery production remains the largest cost factor for EVs, accounting for 30–40% of the total vehicle price (BloombergNEF, 2021). Although EVs are generally more expensive to purchase, they have lower operating costs because electricity is cheaper than gasoline in most regions and because EVs require less maintenance due to fewer moving parts (International Council on Clean Transportation, 2020). Hybrids, while cheaper to purchase than EVs, involve more complex systems, which can result in higher maintenance costs compared to fully electric cars. Government incentives, subsidies, and charging infrastructure availability also play important roles in shaping the total cost of ownership for both EVs and hybrids.

Environmental Impact

Electric vehicles produce no direct tailpipe emissions during use, which improves urban air quality. However, their total environmental impact depends on the electricity mix used for charging. In countries with high shares of renewable energy, EVs significantly reduce lifecycle emissions, while in coal-dependent regions the benefits are smaller (IEA, 2021). Battery production for EVs is resource-intensive, relying on materials such as lithium, cobalt, and nickel, which raises concerns about mining practices and supply chain sustainability (World Bank, 2020).

Hybrid vehicles emit less CO_2 than conventional vehicles but remain dependent on fossil fuels. According to the International Council on Clean Transportation (2021), hybrids can reduce lifecycle emissions by 20–30% compared to gasoline cars, whereas EVs can achieve reductions of up to 70% in regions with clean electricity grids. Lifecycle analyses also show that although EVs have higher emissions during production due to battery manufacturing, they compensate for this with lower emissions during the usage phase.

Scope of Study

The scope of this project is limited to the comparison of electric and hybrid powertrains in terms of efficiency, cost, and environmental impact. Other alternatives, such as hydrogen fuel cell vehicles or biofuel-powered cars, are excluded due to their limited market share and infrastructure. The presented theory provides the foundation for analysing the advantages and disadvantages of EVs and hybrids in the context of sustainability and future mobility

Methods

The purpose of this degree project is to compare electric and hybrid powertrains in terms of three main criteria: efficiency, cost, and environmental impact. To answer the research question, a structured methodology combining a comprehensive literature review with systematic data collection and analysis was employed. No experiments or personal interviews were conducted, and therefore ethical approval was not required. The methodology ensures that the comparison between electric and hybrid vehicles is based on reliable and verifiable information.

Literature Review

An extensive literature review was conducted to gather current, scientifically validated information about electric and hybrid vehicles. The search focused on three main areas: energy efficiency, costs, and environmental performance. Databases and sources included:

- **Google Scholar** – for peer-reviewed articles, conference papers, and systematic reviews on vehicle efficiency and powertrain technology.
- **ScienceDirect** – for technical publications on battery technology, hybrid systems, powertrain efficiency, and lifecycle analysis.
- **IEEE Xplore** – for engineering-focused studies on electric and hybrid powertrain performance and energy efficiency.
- **ICCT (International Council on Clean Transportation) and IEA (International Energy Agency)** – for global reports on vehicle emissions, operational costs, and real-world performance of electric and hybrid vehicles.

Search terms included: *electric vehicle efficiency*, *hybrid vehicle cost comparison*, *lifecycle assessment electric vehicles*, *battery production environmental impact*, *plug-in hybrid energy consumption*, and *vehicle ownership cost*. Articles were selected based on relevance to the research question, credibility of the source, and publication date (2015–2025).

Data Collection and Organization

Data were systematically extracted from the selected sources. Quantitative variables included:

- Energy efficiency (kWh/100 km for electric vehicles, L/100 km for hybrids)
- Lifecycle greenhouse gas emissions (g CO_2/km)
- Purchase price
- Operational and maintenance costs
- Environmental impact from production, battery manufacturing, and disposal

Qualitative data included technical advantages and limitations, policy incentives, and market trends.

The data were organized in spreadsheets with separate columns for each vehicle type and variable. This allowed for systematic comparison between electric and hybrid vehicles. When conflicting information was encountered, the most recent and peer-reviewed sources were prioritized.

Inclusion and Exclusion Criteria

- **Inclusion Criteria:**
  - Studies published between 2015 and 2025
  - Focus on passenger vehicles
  - Quantitative comparisons between electric and hybrid vehicles
  - Inclusion of real-world performance, energy consumption, and environmental impact
- **Exclusion Criteria:**
  - Studies focusing solely on hydrogen, biofuel, or other alternative powertrains
  - Non-peer-reviewed blogs or unreliable sources
  - Data without clear methodology or numerical evidence

Data Analysis

The collected data were systematically analyzed to identify differences and similarities between electric and hybrid powertrains. Lifecycle assessments were used to evaluate long-term environmental impacts, including battery production, energy consumption during operation, and recycling processes. Cost analyses covered purchase price, maintenance, and operational expenses over a typical vehicle lifespan. Energy efficiency metrics were analyzed to compare actual energy consumption per 100 km.

The results were presented in tables and graphs to clearly illustrate comparisons. By combining both quantitative and qualitative data, trends were identified, and conclusions could be drawn regarding which powertrain type performs best in terms of efficiency, cost-effectiveness, and environmental sustainability under real-world conditions

Result

This section presents the results from the literature study on electric vehicles (EVs) and hybrid vehicles (HEVs), focusing on three main aspects: energy efficiency, cost, and environmental impact. All information is presented objectively, based on data from peer-reviewed articles, industry reports, and international organizations. No interpretation or comparison is made in this section.

Energy Efficiency

Electric vehicles generally show higher energy efficiency compared to hybrid vehicles. According to the literature, small urban electric vehicles, such as the Renault Twizy Urban

45, consume approximately 6.3 kWh per 100 km, while slightly larger models, like the Hyundai Kona Electric, consume around 13.3 kWh per 100 km. Mid-sized electric cars typically consume between 11 and 14 kWh per 100 km, depending on battery capacity, vehicle weight, and driving conditions. In contrast, hybrid vehicles, which combine an internal combustion engine with an electric motor, have a fuel consumption ranging from 4.0 to 6.5 litters per 100 km. For example, the Toyota Prius consumes approximately 4.4 litters per 100 km, while the Toyota RAV4 Hybrid uses about 5.0 litters per 100 km. Plug-in hybrid vehicles can achieve efficiency comparable to electric vehicles when operating in electric mode, but efficiency decreases significantly when the internal combustion engine is engaged.

Lifecycle Greenhouse Gas Emissions

Data from international sources, including the International Council on Clean Transportation (ICCT) and peer-reviewed studies, show that lifecycle greenhouse gas emissions vary significantly between electric and hybrid vehicles. Battery electric vehicles operating in regions with low-carbon electricity generation can produce between 50 and 120 grams of CO_2 per kilometre over their entire lifecycle, which includes production, operation, and disposal. Hybrid vehicles, relying partially on fossil fuels, typically emit higher amounts of greenhouse gases, ranging from approximately 180 to 200 grams of CO_2 per kilometre. Plug-in hybrids have emissions around 160 grams per kilometre on average, although actual values depend on the proportion of electric versus gasoline operation. The production of lithium-ion batteries contributes substantially to the total lifecycle emissions for electric vehicles, whereas hybrid vehicles, due to smaller battery sizes, are less affected by battery production emissions.

Purchase Price

Electric vehicles generally have higher upfront costs than hybrid vehicles. Small to mid-sized electric cars, such as the Nissan Leaf, have a purchase price of approximately $29,000, while larger electric vehicles, like the Hyundai Kona Electric, may cost around $33,000. Hybrid vehicles, such as the Toyota Prius or Toyota Corolla Hybrid, are typically priced between $25,000 and $27,000. Factors affecting price include battery capacity, vehicle size, included technology, and regional market conditions. Government incentives and subsidies can influence these prices, often reducing the effective purchase cost for electric vehicles.

Operational and Maintenance Costs

Operational costs for electric vehicles are generally lower than for hybrid vehicles. The cost of electricity per kilometre is usually lower than fuel costs, with estimated operational costs for electric vehicles ranging between $0.03 and $0.06 per kilometre, depending on electricity prices and driving patterns. Maintenance costs are also lower, as electric drivetrains contain fewer moving parts than combustion engines, resulting in reduced service requirements. Hybrid vehicles, by contrast, require maintenance of both the electric motor and the internal combustion engine. Average operational costs for hybrid vehicles range from $0.06 to $0.10 per kilometre, with maintenance costs estimated between $0.02 and $0.03 per kilometre.

Battery Production and Environmental Impact

Battery production has a significant effect on the environmental footprint of electric vehicles. Studies indicate that production of lithium-ion batteries accounts for approximately 30 to 40 percent of the total lifecycle greenhouse gas emissions for electric vehicles. The extraction and refining of materials such as lithium, cobalt, and nickel are energy-intensive processes, contributing to environmental impacts. Hybrid vehicles, which use smaller batteries, experience a proportionally smaller environmental impact from battery production. Other stages of the vehicle lifecycle, including manufacturing of the vehicle body, electronics, and end-of-life disposal, contribute additional emissions for both electric and hybrid vehicles.

Vehicle Range

Electric vehicles typically have ranges between 250 and 500 kilometres per full battery charge, depending on battery size, vehicle weight, and driving conditions. Hybrid vehicles, which combine a small battery with a gasoline engine, generally achieve greater overall range, often exceeding 800 kilometres per combined tank and charge. Plug-in hybrid vehicles provide a short all-electric range of approximately 30 to 70 kilometres, after which the internal combustion engine is used for propulsion. Real-world driving conditions, such as temperature, terrain, and driving style, influence actual range for all vehicle types.

Market Availability and Adoption Trends

The literature indicates that electric vehicles are increasingly available across multiple vehicle segments, including compact cars, SUVs, and luxury models. Hybrid vehicles remain widely accessible, particularly in markets with limited charging infrastructure. Global adoption trends show a steady increase in the share of electric vehicles. For example, in China, companies such as BYD have achieved significant market penetration, becoming one of the leading EV manufacturers. In Europe, BYD and other manufacturers have reported electric vehicle market shares exceeding 10 percent of new passenger car sales in 2025. In Australia, electric vehicle market share has increased from approximately 10 percent to over 16 percent in a single year, reflecting rapid adoption.

Summary of Key Findings

The literature presents clear factual data regarding differences between electric and hybrid vehicles. Electric vehicles demonstrate higher energy efficiency, lower operational and maintenance costs, and lower lifecycle greenhouse gas emissions under certain conditions. Hybrid vehicles, while less efficient in purely electric operation, offer extended range and slightly lower upfront costs. Battery production contributes substantially to the environmental footprint of electric vehicles, while hybrid vehicles experience smaller battery-related impacts. Market trends indicate growing adoption of electric vehicles, with hybrids continuing to serve as transitional technology in regions with limited charging infrastructure.

Discussion

Discussion

The purpose of this thesis is to compare electric vehicles (EVs) and hybrid vehicles (HEVs) in terms of energy efficiency, cost, and environmental impact. The central research question is which powertrain type is most advantageous considering these factors. By combining theoretical insights with the empirical results from literature, this discussion critically evaluates both vehicle types, highlighting strengths, limitations, and practical implications for users and policymakers.

Energy Efficiency

Both theoretical frameworks and results consistently indicate that electric vehicles have superior energy efficiency compared to hybrid vehicles. Electric drivetrains convert electricity into mechanical motion more directly than internal combustion engines, resulting in fewer energy losses. In practice, small urban EVs, such as the Renault Twizy, consume around 6–7 kWh per 100 km, while medium-sized vehicles like the Hyundai Kona Electric consume approximately 13 kWh per 100 km. Hybrid vehicles, in contrast, consume roughly 4–6 litter of gasoline per 100 km, which translates into significantly higher energy usage per kilometres when considering the full energy content of gasoline.

This efficiency difference is particularly pronounced in urban driving conditions. Frequent stops and starts allowing EVs to maximize regenerative braking and maintain high energy conversion efficiency, while hybrid vehicles rely more on fuel consumption during acceleration. From a practical perspective, this suggests that EVs are highly suited for city commuting and short daily trips, where their efficiency can be fully leveraged. However, hybrids retain an advantage in scenarios requiring longer continuous travel or in regions with limited charging infrastructure. Their ability to switch seamlessly between electric and gasoline operation ensures consistent energy delivery over extended distances, reducing range anxiety for users who cannot rely on frequent charging opportunities.

Costs

Analysing costs, it is evident that electric vehicles typically have higher purchase prices than hybrids. This is consistent with theoretical understanding, as battery production accounts for a significant portion of an EV's total cost. For example, the Hyundai Kona Electric costs approximately $33,000, whereas a Toyota Prius hybrid costs around $25,000. While this upfront difference may be a barrier for some buyers, operational and maintenance costs for EVs are considerably lower. Electricity per kilometre is cheaper than gasoline, and fewer moving parts result in lower maintenance needs. Over a vehicle's lifetime, this can lead to cost parity or even financial advantages for EVs, depending on mileage, electricity prices, and maintenance frequency.

Hybrids, on the other hand, have lower initial costs but higher operating and maintenance expenses. For instance, maintenance for both the combustion engine and electric components adds complexity and potential costs over time. From a practical standpoint, the choice between EV and hybrid is highly context dependent. Urban users with access to charging infrastructure and predictable driving patterns may benefit financially from EVs, whereas individuals in rural areas or regions with sparse charging networks may find hybrids more economically practical despite slightly lower energy efficiency.

Environmental Impact

Environmental considerations highlight one of the strongest advantages of EVs. Lifecycle analyses show that EVs produce significantly lower greenhouse gas emissions than hybrids in areas with low-carbon electricity. For example, in regions relying on hydro, wind, or solar power, emissions can be as low as 50 grams CO_2 per kilometres. Hybrid vehicles, due to partial reliance on gasoline, consistently generate higher emissions, typically between 180- and 200-grams CO_2 per kilometres.

However, battery production for EVs contributes substantially to their overall lifecycle emissions, accounting for approximately 30–40 percent of total greenhouse gases. This emphasizes that while EVs are cleaner during operation, their environmental impact is front-loaded during manufacturing. Hybrid vehicles, with smaller batteries, generate fewer emissions during production but higher emissions during use. This trade-off illustrates the importance of considering the full lifecycle rather than focusing solely on operational emissions.

From a reflection standpoint, the environmental advantage of EVs depends heavily on the regional electricity mix. In countries with high fossil fuel generation, the benefits are less pronounced. Conversely, as the electricity grid becomes cleaner, EVs become progressively more sustainable, reinforcing the argument for transitioning to electric mobility where infrastructure allows. This highlights a policy implication: promoting renewable energy is intrinsically linked to maximizing the environmental benefits of EVs.

Range and Practicality

Range remains a critical practical consideration. EVs generally offer 250–500 km per full charge, which is sufficient for daily commuting but may be restrictive for longer trips. Plug-in hybrids provide 30–70 km of all-electric range and can switch to gasoline for extended trips, offering a safety net against range anxiety. Hybrids, with combined battery and fuel operation, can travel over 800 km without recharging or refuelling, providing convenience for users who need flexibility or drive in regions with limited charging infrastructure.

From a practical experience perspective, this aligns with observed patterns in urban versus rural vehicle usage. City drivers can rely on EVs due to shorter commutes and access to charging stations, while drivers in remote areas may prefer hybrids to ensure travel continuity. Thus, range considerations are not purely technical but also socio-economic, influenced by infrastructure availability and lifestyle patterns.

Market Adoption and Societal Trends

Market data indicate a rapid increase in EV adoption. In China, companies like BYD lead the EV market, while in Europe, electric vehicles now constitute over 10 percent of new passenger vehicle sales in some regions. Australia has seen a jump from 10 to 16 percent market share within a year. These trends suggest that EVs are becoming mainstream, supported by policy incentives, improved infrastructure, and increased consumer awareness of environmental issues.

Hybrid vehicles remain important in transitional markets or where full electrification is not feasible. They offer an intermediate solution, combining cleaner technology with practical flexibility. This reflects the theory that technological adoption is gradual and context-dependent, and hybrid vehicles can facilitate the transition toward fully electric mobility.

Integrated Reflection

Integrating theory with results, several conclusions emerge. Electric vehicles excel in efficiency, operational costs, and environmental performance in regions with clean electricity, making them ideal for the future of sustainable mobility. Hybrids provide flexibility, lower initial costs, and range advantages, which can be critical in less developed infrastructure contexts. The choice between EV and hybrid is therefore context-specific, requiring consideration of driving habits, regional infrastructure, energy sources, and environmental priorities.

From a personal perspective, it is evident that policy measures, such as promoting renewable electricity and expanding charging networks, are key to maximizing the benefits of EVs. Simultaneously, hybrid vehicles should not be dismissed, as they provide a practical bridge until infrastructure and battery technology mature. Both vehicle types can coexist, complementing each other depending on user needs and regional conditions.

Conclusion of Discussion

In conclusion, electric vehicles are clearly positioned as the more sustainable and energy-efficient option under favourable conditions, but hybrid vehicles remain a viable, practical alternative in the current transition phase. The discussion highlights that vehicle choice is multi-dimensional, requiring careful consideration of technical, economic, environmental, and societal factors. Effective decision-making involves balancing these dimensions, rather than prioritizing a single factor. This comprehensive understanding strengthens the overall conclusion that EVs are the future, while hybrids play an important role in bridging today's mobility needs and tomorrow's sustainable transport systems.

Conclusion

This study aimed to compare electric vehicles (EVs) and hybrid vehicles (HEVs) with respect to energy efficiency, cost, and environmental impact, with the goal of determining which powertrain technology is most advantageous under various conditions. By analysing theoretical frameworks alongside empirical data gathered from a wide range of literature, several important conclusions can be drawn.

In terms of **energy efficiency**, electric vehicles consistently demonstrate superior performance. The analysis shows that EVs convert electricity into mechanical energy more efficiently than hybrid vehicles convert fuel into motion, largely due to the simplicity and high efficiency of electric drivetrains. Small urban electric vehicles consume as little as 6–7 kWh per 100 km, while medium-sized EVs average around 13 kWh per 100 km. Hybrid vehicles, in contrast, rely on internal combustion engines for part of their propulsion, resulting in a higher energy requirement per kilometre—roughly 4–6 litters of gasoline per 100 km. These results confirm theoretical predictions that EVs are particularly efficient in stop-and-go city traffic, where regenerative braking and consistent electric propulsion minimize energy losses. Hybrids, while less efficient overall, offer the advantage of extended range and operational flexibility, especially in contexts where continuous access to charging infrastructure is limited.

Cost analysis indicates a nuanced picture. Electric vehicles tend to have higher upfront purchase prices due to the significant cost of battery production, which can comprise a substantial portion of the total vehicle price. For example, medium-sized EVs like the Hyundai Kona Electric cost approximately $33,000, whereas comparable hybrid models such as the Toyota Prius are priced around $25,000. Despite this initial investment, EVs offer significantly lower operational and maintenance costs, including cheaper energy per kilometre and fewer moving parts that require servicing. Over the lifetime of the vehicle, this can result in cost parity or even financial advantages for EV owners, particularly for users with predictable driving patterns, urban commutes, and access to affordable electricity. Hybrids, by contrast, have lower initial purchase costs but higher operational expenses over time, particularly due to maintenance of both the internal combustion engine and the electric motor. This illustrates that the choice between EV and hybrid is highly context-dependent, with factors such as driving habits, electricity prices, and infrastructure availability playing a critical role.

From an **environmental perspective**, electric vehicles clearly offer substantial benefits, particularly in regions where electricity generation is based on low-carbon or renewable sources. Lifecycle assessments indicate that EVs can produce as little as 50 grams of CO_2 per kilometres over their full lifecycle, while hybrid vehicles generally produce between 180 and 200 grams per kilometres due to ongoing fuel combustion. Battery production, however, contributes significantly to EV emissions—often accounting for 30–40% of total lifecycle emissions—emphasizing the importance of considering the full lifecycle when assessing environmental impact. Hybrids, with smaller batteries, contribute less to production-phase emissions but remain reliant on fossil fuels during operation. These findings highlight a key insight: the environmental advantage of EVs depends on the cleanliness of the energy source. In areas with fossil fuel-heavy electricity generation, the benefits are less pronounced, whereas in regions with renewable electricity, EVs offer substantial reductions in greenhouse gas emissions. This underscores the need for policy measures promoting clean energy alongside the adoption of electric vehicles to maximize environmental benefits.

Range and practicality are critical factors influencing vehicle choice. EVs typically provide 250–500 km of range per full charge, which is sufficient for most daily commuting but may create range anxiety for long-distance travel. Hybrids offer a practical solution by combining battery and gasoline operation, allowing drivers to cover over 800 km without the need for frequent refuelling or charging. Plug-in hybrids provide a limited electric range of 30–70 km before switching to gasoline, giving users partial electric operation while maintaining flexibility. This highlights a key difference: while EVs are highly efficient in controlled environments with accessible charging infrastructure, hybrids offer reliability and flexibility, making them a viable choice for rural areas, long-distance driving, or locations with underdeveloped charging networks.

Market trends and adoption patterns further contextualize these findings. EV adoption has grown rapidly, particularly in countries such as China, where companies like BYD dominate the market, and in Europe and Australia, where EV sales have reached significant shares of new passenger vehicles. Government incentives, tax reductions, and infrastructure investments have accelerated adoption, reflecting both environmental policy priorities and consumer demand for sustainable transport. Hybrid vehicles continue to play an important transitional role, especially in markets where full electrification is not yet feasible. They bridge the gap between conventional internal combustion vehicles and fully electric models, providing an intermediate solution that combines cleaner technology with practical flexibility.

Reflecting on all these aspects, several integrated conclusions emerge. Electric vehicles are the preferred choice for efficiency, environmental performance, and long-term operational cost savings, particularly in urban areas with adequate charging infrastructure and access to renewable electricity. Hybrid vehicles remain relevant for users who prioritize flexibility, lower initial costs, and extended travel range, particularly in contexts where charging infrastructure is limited or long-distance travel is common. The optimal vehicle choice depends on a combination of technical, economic, environmental, and practical considerations, rather than any single factor alone.

From a personal perspective, this analysis highlights that the transition toward sustainable mobility cannot rely solely on electric vehicles. Hybrids serve as a practical bridge during this transition period, while widespread adoption of EVs is likely to become the dominant solution as battery production becomes more sustainable, charging infrastructure expands, and renewable electricity becomes more accessible. Policymakers and consumers must therefore consider both vehicle technology and energy system development together to achieve meaningful reductions in greenhouse gas emissions and energy consumption.

In conclusion, this study demonstrates that **electric vehicles are generally the most advantageous option for long-term sustainability, efficiency, and environmental performance**, whereas **hybrid vehicles remain a practical, flexible alternative for current conditions, particularly in areas with limited infrastructure or for users requiring longer range and reliability**. The findings emphasize that while EVs represent the future of sustainable transport, hybrids have an important role in the present, and the choice between these technologies should be informed by a holistic evaluation of efficiency, cost, environmental impact, and practical considerations. Overall, this research confirms that a shift toward electric vehicles is both desirable and necessary for sustainable mobility, but hybrids are likely to remain an essential transitional solution in the short to medium term.

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