

Electric Vehicle Review: BEV, PHEV, HEV, or FCEV?

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Abstract

Electric vehicles (EVs) are rapidly advancing as a sustainable transportation solution in the global effort to reduce carbon emissions. There are four main types of EVs: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs). This article reviews each EV type's advantages, limitations, and prospects based on energy efficiency, carbon emissions, technological development, and infrastructure readiness. The findings indicate that BEVs hold the most significant potential for personal vehicles and urban transportation, while FCEVs are more suited for heavy-duty and long-distance applications. PHEVs and HEVs are considered transition solutions, but their relevance is expected to decrease as technology and global policies evolve. BEVs provide zero emissions. PHEVs provide high flexibility, while HEVs do not require charging infrastructure, and FCEVs offer zero emissions and long-range and fast charging times. FCEV can travel up to more than 800 KM, which is very promising for the distance travelled problem, which is a challenge for electric vehicles.

Keywords: electric vehicle; renewable energy; batteries; hydrogen; fuel-cell.

1. Introduction

In recent decades, the world has faced major climate change challenges that primarily caused by human activities and especially in the transportation sector [1], [2]. Transportation is one of the main contributors to global carbon emissions, contributing around 25% of total greenhouse gas emissions, even in Asia contributing up to 39% [2]–[6]. To address this issue, many countries have turned their attention to electric vehicles (EVs) as a sustainable solution [7]–[10]. EVs are considered a cleaner alternative to fossil fuel vehicles, as they can significantly reduce carbon emissions, especially when powered by renewable energy sources [10].

Electric vehicles include several types of technology: battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), hybrid electric vehicles (HEV), and fuel cell electric vehicle (FCEV) [11]–[13]. Each type has unique characteristics, advantages, and disadvantages, making it suitable for certain applications. BEVs, for example, are known for their high energy efficiency and zero emissions during operation, while FCEVs offer a solution for heavy and long-distance transportation due to their long-range and fast hydrogen refueling [12], [14]. However, infrastructure and energy efficiency limitations are challenges for each technology.

The development of EV technology continues to accelerate along with the increasing global demand for environmentally friendly vehicles [15], [16]. On the other hand, government policies, such as EV purchase incentives, gradual bans on fossil fuel vehicles, and net-zero emissions targets, have also encouraged EV adoption in various countries [15], [17]–[19]. Major automotive companies are also competing to develop electric vehicles that are more efficient, affordable, and in line with consumer needs [20]. However, an important question remains: of the four types of EVs available, which technology has the best prospects for the future [21]?

This study aims to review in depth the potential, advantages, and challenges of each type of EV. This study includes an analysis of energy efficiency, carbon emissions, infrastructure readiness, and the most suitable applications for each type of vehicle. Thus, this study is expected to provide comprehensive insight into the role of EVs in transforming global transportation.

The contribution made in this paper will let researchers select proper technology for developing electric vehicle technology. Through this discussion, it is hoped that readers can understand the development and prospects of EVs and the important role of this technology in global efforts to reduce the carbon footprint. In

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A red circular graphic with a gradient, appearing as a semi-circle or a partial circle, located to the right of the author's name.

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Electric Vehicles - Design, Modelling and Simulation Nicolae Tudoroiu, 2023-12-13 Clean and efficient transportation in countries around the world is only possible if governments and scientists focus on stimulating and supporting the electric vehicle industry by developing and deploying the most advanced Li ion battery technologies Recently several improvements have been made in the direction of operational safety the elimination of explosion hazards and the mitigation of chemical toxicity The state of charge of an electric vehicle battery is an essential internal parameter that plays a vital role in utilizing the battery's energy efficiency operating safely in various realistic conditions and environments and extending the battery's life Also automated systems are integrated into the architecture of electrical vehicles allowing for technology machinery or systems to perform tasks or processes with minimal human intervention Automation in electric vehicles involves the integration of advanced technologies to enhance the driving experience improve safety optimize energy efficiency and facilitate the transition to sustainable transportation The key aspects of automation in electric vehicles are advanced driver assistance self driving capabilities battery and energy management and safety and collision avoidance This book provides a comprehensive overview of electric and hybrid electric vehicles exploring their design the modeling of Li ion battery management systems state of charge estimation algorithms and the most used electric motors It also discusses new trends in electric vehicle automation as well as different control strategies

Vehicle Electrification in Modern Power Grids Vitor Monteiro, João L. Afonso, Sheldon Williamson, 2024-07-13 Vehicle Electrification in Modern Power Grids Disruptive Perspectives on Power Electronics Technology and Control Challenges collects the newest advances in technology for electric vehicle integration into one practical volume for professionals and advanced researchers The book not only summarizes and clarifies legislation and grid codes for the area but also outlines the modeling and analytical techniques needed including predicting power converter reliability and its remaining useful life Specializing in microgrid clusters the book provides advanced power electronics device technology from wide band gap WBG to DSP based digital control platforms and new materials for passive filters Blending cutting edge research and practical technology this book provides a centralized resource for advanced researchers and engineers looking to accelerate vehicle electrification in the power grid Reveals new disruptive power electronics and modeling technologies to enable EV integration into the grid Collects guidance on mechanisms for digital control for EV charging and modes of operation from V2G to G2H Provides legislation and grid codes needed by engineers working on vehicle electrification in power grids

Hybrid Electric Vehicles Teresa Donateo, 2017-06-21 This book on hybrid electric vehicles brings out six chapters on some of the research activities through the wide range of current issues on hybrid electric vehicles The first section deals with two interesting applications of HEVs namely urban buses and heavy duty working machines The second one groups papers related to the optimization of the electricity flows in a hybrid electric vehicle starting from the optimization of recharge in PHEVs through advance storage

systems new motor technologies and integrated starter alternator technologies A comprehensive analysis of the technologies used in HEVs is beyond the aim of the book However the content of this volume can be useful to scientists and students to broaden their knowledge of technologies and application of hybrid electric vehicles

Fuel Cells and Hydrogen Viktor Hacker, Shigenori Mitsushima, 2018-07-20 Fuel Cells and Hydrogen From Fundamentals to Applied Research provides an overview of the basic principles of fuel cell and hydrogen technology which subsequently allows the reader to delve more deeply into applied research In addition to covering the basic principles of fuel cells and hydrogen technologies the book examines the principles and methods to develop and test fuel cells the evaluation of the performance and lifetime of fuel cells and the concepts of hydrogen production Fuel Cells and Hydrogen From Fundamentals to Applied Research acts as an invaluable reference book for fuel cell developers and students researchers in industry entering the area of fuel cells and lecturers teaching fuel cells and hydrogen technology Includes laboratory methods for fuel cell characterization and manufacture Outlines approaches in modelling components cells and stacks Covers practical and theoretical methods for hydrogen production and storage

Hybrid & Electric Vehicle Progress, 2003 *Power Converters for Electric Vehicles* L. Ashok Kumar, S. Albert Alexander, 2020-12-10 Power Converters for Electric Vehicles gives an overview topology design and simulation of different types of converters used in electric vehicles EV It covers a wide range of topics ranging from the fundamentals of EV Hybrid EV and its stepwise approach simulation of the proposed converters for real time applications and corresponding experimental results performance improvement paradigms and overall analysis Drawing upon the need for novel converter topologies this book provides the complete solution for the power converters for EV applications along with simulation exercises and experimental results It explains the need for power electronics in the improvement of performance in EV This book Presents exclusive information on the power electronics of EV including traction drives Provides step by step procedure for converter design Discusses various topologies having different isolated and non isolated converters Describes control circuit design including renewable energy systems and electrical drives Includes practical case studies incorporated with simulation and experimental results Power Converters for Electric Vehicles will provide researchers and graduate students in Power Electronics Electric Drives Vehicle Engineering a useful resource for stimulating their efforts in this important field of the search for renewable technologies

Consumer Response to Plug-in Hybrid Electric Vehicles Kenneth S. Kurani, 2012 Environmental Reviews, 2004 Asia's Energy Revolution Joseph Jacobelli, 2021-06-21 Asia is home to 60 per cent of the world's population including the world's two most populous nations China and India The region's economic gains and rising middle class are accelerating demand for more consumer goods and a better quality of life For further economic growth to be realised the region will need a massive supply of additional energy three to five fold 2020's amount by 2050 These changes create new business and investment opportunities for domestic companies and overseas participants Asia's energy market already the world's biggest will soon be the most advanced There will be mass adoption of

digital technologies like artificial intelligence to make the distribution of solar wind and other clean resources smarter and more efficient Led by China billions of dollars in capital investment will drive the region s shift to green sustainable energy replacing polluting and expensive fossil fuels which will help to rein in climate change In Asia s Energy Revolution leading energy markets analyst and practitioner Joseph Jacobelli explains why Asia is the world s most important territory for energy transition how developments in the region will drive change in the rest of the world as well as how it will all be financed The book discussion includes Analysis of past events and forward looking analysis of the industry in the region encompassing commercial economic and financial aspects Appraisal of new energy technologies such as electric vehicles and digital solutions such as blockchain for energy Review of the capital flows and sustainable financing channels needed to fund energy infrastructure and tech growth

Electric Vehicle Progress ,1999 *Light-duty Vehicle Attribute Projections (years 2015-2030)* Eleftheria Kontou (Ph.D.),Marc W. Melaina,Aaron Brooker,National Renewable Energy Laboratory (U.S.),2018

Advanced Control Technologies for Distribution Grid Voltage and Stability with Electric Vehicles and Distributed Generation John Mead,Vaibhav Donde,John Garnett,Pacific Gas and Electric Company,2015 **Michigan Law Review** ,2018 Willing's Press Guide ,2000 A guide to the press of the United Kingdom and to the principal publications of Europe Australia the Far East Gulf States and the U S A *Canadian Periodical Index* ,2000 **Index to Philippine Periodicals** ,2009 **Vertical File Index** ,2003 **Automotive Engineering International** ,1998-07 *The Electric Vehicle* Gijs Mom,2013-02-15 Winner of the Engineer Historian Award from the International History and Heritage Committee of the American Society of Mechanical Engineers and the Nicholas Joseph Cugnot Award given by the Society of Automotive Historians Recent attention to hybrid cars that run on both gasoline and electric batteries has made the electric car an apparent alternative to the internal combustion engine and its attendant environmental costs and geopolitical implications Few people realize that the electric car neither a recent invention nor a historical curiosity has a story as old as that of the gasoline powered automobile and that at one time many in the nascent automobile industry believed battery powered engines would become the dominant technology In both Europe and America electric cars and trucks succeeded in meeting the needs of a wide range of consumers Before World War II as many as 30 000 electric cars and more than 10 000 electric trucks plied American roads European cities were busy with electrically propelled fire engines taxis delivery vans buses heavy trucks and private cars Even so throughout the century long history of electric propulsion the widespread conviction it was an inferior technology remained stubbornly in place an assumption mirrored in popular and scholarly memory In *The Electric Vehicle* Gijs Mom challenges this view arguing that at the beginning of the automobile age neither the internal combustion engine nor the battery powered vehicle enjoyed a clear advantage He explores the technology and marketing consumer ratio faction relationship over four generations of electric vehicle design with separate chapters on privately owned passenger cars and commercial vehicles Mom makes comparisons among European countries and between Europe

and America He finds that the electric vehicle offered many advantages among them greater reliability and control less noise and pollution He also argues that a nexus of factors cultural underpowered and less rugged electric cars seemed feminine at a time when most car buyers were men structural the shortcomings of battery technology at the time and systemic the infrastructural problems of changing large numbers of batteries ultimately gave an edge to the internal combustion engine One hopes as a new generation of electric vehicles becomes a reality The Electric Vehicle offers a long overdue reassessment of the place of this technology in the history of street transportation

Air Quality Implications of an Energy Scenario for California Using High Levels of Electrification Marcus Alexander, Electric Power Research Institute, Rambøll

(Firm), 2019

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