Edited Book

Green Frontiers

Emerging Technologies for a Sustainable Future

Editors

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Preface

In an age marked by rapid scientific progress and increasing global challenges, the integration of knowledge across disciplines has become essential for meaningful innovation and sustainable development. *Green Frontiers: Emerging Technologies for a Sustainable Future* is conceived as a comprehensive academic work that brings together diverse fields of study to present a unified perspective on contemporary scientific and technological advancements. The book seeks to highlight how evolving knowledge systems can address pressing environmental concerns, enhance technological capabilities, and contribute to the betterment of society.

The primary purpose of this volume is to provide a balanced understanding of both foundational concepts and emerging trends across multiple domains. It explores critical issues such as environmental degradation, renewable energy development, advanced materials, and intelligent systems, emphasizing their interconnected nature.

The scope of the book is intentionally broad, encompassing insights from environmental science, physics, engineering, biotechnology, and applied sciences. It reflects the growing need to move beyond isolated disciplinary frameworks and adopt integrated perspectives that foster innovation.

This volume is designed to serve as a valuable resource for students, researchers, and professionals alike. Students will find it particularly useful in building conceptual clarity and gaining exposure to emerging areas of study.

The relevance of *Green Frontiers: Emerging Technologies for a Sustainable Future* lies in its focus on the dynamic relationship between scientific advancement and societal needs. As the world faces challenges such as climate change, resource scarcity, and technological disruption, there is an increasing demand for knowledge that is both comprehensive and applicable. It is hoped that this work will encourage critical thinking, inspire innovation, and enable readers to contribute effectively to a sustainable and technologically advanced future.

— Editorial Board

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“Innovation and sustainability are not opposites—they are partners in shaping the future.”

— Paul Polman

Former CEO, Unilever; Sustainability Leader

CHAPTER 10

HYBRID ENGINES: A STEP TOWARDS THE FUTURE OF CARS

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Abstract:

Over the years, car parts have changed and improved to meet our needs and be more effective in every area/feature of the vehicle. These advancements with car engines have also introduced us to hybrid engine cars; many of the large car manufacturers have introduced hybrids for some time now. Hybrid engine cars are typically considered better than traditional gas or diesel powered vehicles because they are more efficient and also produce less pollution compared to traditional fossil fuel based vehicles, while still providing the same amount of power and the same rate of speed as the others. The continued shift towards hybrids will ultimately provide benefits to everyone on Earth.

Keywords: Hybrid car, regenerative braking, automotive technology, charging infrastructure

Introduction:

Hybrids are a type of automobile that use two types of engines: the traditional gas-powered engine and an electric engine that can run on the battery. The battery in a hybrid is charged by a variety of methods, including regenerative braking, using the gas engine, and charging from a standard outlet (plug). The electric engine can provide additional power to the rest of the vehicle, such as headlights and other accessories, and it can also provide added horsepower to the gas engine when starting and stopping. The advancements made in hybrid technology have changed the way automotive manufacturers design and manufacture cars. For example, because of hybrid cars, consumers are now able to experience a smoother driving experience with minimal engine noise and vibration than previous models. Additionally, hybrid vehicles

produce less carbon than other fuel-powered vehicles; therefore, hybrid cars offer consumers greater savings through improved fuel economy. The popularity of these types of vehicles has prompted continued investment in research and development of more efficient engines and body designs. Regenerative braking is the ability to recharge a vehicle's batteries while braking. In addition to reducing speed, braking generates kinetic energy that would otherwise be lost as heat, but instead is converted to electricity, recharged into the battery, and used to power the vehicle's electric engine. Three types of hybrids are commonly defined: mild hybrids, plug-in hybrids, and full hybrids. Mild hybrids utilize large batteries and use a belt-driven motor to assist with engine power output. Direct sources of electricity supply charge hybrid vehicles through plug-ins. The charge time is dependent on several factors, including the full battery charge, the type of battery, the capacity of the battery, and temperature conditions. Self-charging or full hybrids don’t require direct plug-in charging; the electric engine on a full hybrid functions by using greater means than a mild hybrid engine.

Review of Literature:

The onset of hybrid cars: The beginning of gasoline-electric hybrid rail-car propulsion systems goes back to 1889 when William H. Patton filed for a patent application for this type of propulsion system. The Armstrong Phaeton developed and built by Harry E. Dey by the Armstrong Company in Bridgeport, Connecticut and produced by the Roger Mechanical Carriage Company was a revolutionary vehicle with several types of firsts. The Armstrong Phaeton was powered by a six-and-one-half (6.5) liter-(gas) powered two-cylinder engine that also contained a dynamo flywheel and battery in the onboard vehicle.

Ferdinand Porsche, an Austrian-German automotive engineer and founder of the Porsche company, was involved with the use of his company's experience to utilize hybrid drivetrain design to power armored vehicles for the Nazis. One of the heaviest armored vehicles/fighting vehicles that Ferdinand Porsche developed and built was the Panzerkamfwagen Maus that weighed 190 tons and would have been used by the Wehrmacht as a "weapons system"; however, the production of the Maus was hampered

due to the then-substandard-quality electrical grade copper needed to manufacture the electric final drive in Porsche's armored vehicle powertrain design for the war effort.

Figure 1: The Amitron as shown in 1967 [1]

The roots of modern technology: The regenerative braking system that is now a standard feature for the majority of hybrid vehicles was first conceived in 1967 with the development of the American Motors Amitron as a fully electric urban car, referred to as an Energy Regeneration Brake. The Amitron recharges via its regenerative braking feature, increasing the distance the driver can travel. As such, this was the first time regenerative braking had been used on a vehicle in the United States.

A prototype HEV was developed by Victor Wouk, one of the inventors of the Henney Kilowatt, the world's first transistor-based electric car, and Dr. Charles L. Rosen, prior to Wouk's appointment as the "Godfather of the Hybrid." In 1972, Wouk and Rosen retrofitted a 1972 Buick Skylark with an experimental hybrid drivetrain utilizing a 16 kW (21 hp) AC electric motor. This vehicle was the prototype for a federal program designed to evaluate the use of clean vehicles. However, the program was terminated in 1976 by the Environmental Protection Agency (EPA).

Audi introduced the Audi Duo in 1989 as an experimental vehicle. The Duo was able to run using both power sources; a 12 horsepower electric motor and a 139 horsepower liquid-cooled 2.3L 5-cylinder gasoline internal combustion engine. In 1991, Audi introduced the next generation of its Duo - the Audi 100 Duo. This new vehicle was based on the Audi 100 Avant Quattro and contained a 21 kilowatt (29 PS, 28.6 bhp)

electric motor. In addition, the Audi 100 Duo used a Torsen Center Differential, in which the rear wheels were powered by a center differential from the (2.0L) 4-cylinder engine.

Figure2: First-generation Toyota Prius [2]

Hybrid automotive technology has been in use since approximately 1997, when, for instance, Toyota introduced the world's first mass-produced hybrid car: the Prius. Honda soon followed suit after that, first launching its hybrid vehicle, the Insight, in Japan in 1999 and then later bringing it to America later the same year. The first generation of each of these hybrids were rated at 52 miles per gallon of gasoline in city driving and 45 mpg in highway driving (Prius) and 61 mpg in city driving and 68 mpg in highway driving (Insight).

Hybrid Drivetrains: Hybrid drivetrains are of two types:

i) **Parallel Hybrid:** Parallel hybrids consist of both an electric motor and an internal combustion engine (ICE) and can function separately from one another to provide power to the vehicle. When both sources are coupled together, they create power for the vehicle by working on a common drive shaft with both units being driven at the same speed (adding their torque values). Whereas, when necessary for torque management, the electric motor can add or subtract from the total torque by its action on the total torque on the common drive shaft. When compared to series hybrids, parallel hybrids primarily utilize regenerative braking. Additionally, the ICE can serve as an additional source of power to recharge the batteries; therefore, overall, parallel hybrid powertrains are

typically found more on passenger vehicles than series hybrids.

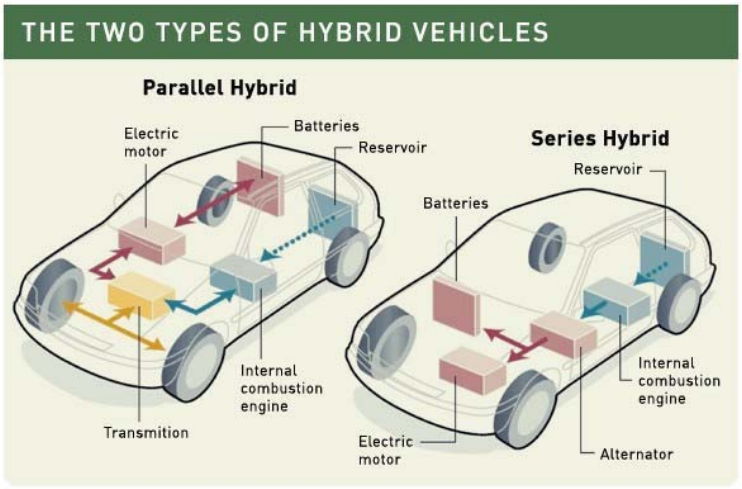

Figure3: Hybrid Drivetrain types [3]

ii) **Series Hybrid:** Series hybrids are commonly referred to as extended-range electric vehicles (EREV). All series hybrids are considered EREV; however, not all EREV is series hybrids. With series hybrids, the gasoline engine does not directly provide power to the wheels; rather, the gasoline engine produces electricity used by the electric motor to drive the wheels. No mechanical connection exists between the engine and the electric motor, with the engine's only purpose being to produce electricity for the generator. Based on algorithms built into the vehicle's computer, the computer determines how much power is produced by the battery or the generator.

Types of Hybrid Cars: Hybrid cars are generally classified into the following three types:

I. **Mild Hybrid (MHEV)**: The electric motor supports and works with the conventional internal combustion engine but does not have the ability to drive the vehicle on its own. Two key advantages of this type of engine are enhanced acceleration through assistance from an electric motor and using regenerative braking to recharge the battery. The electric motor assists the internal combustion engine but cannot function alone to provide movement; thus, it is one of the simplest types of hybrids available that produces a small amount of fuel economy improvement, e.g., Volvo XC 90.

Figure 4: Volvo XC 90 [4]

II. **Full Hybrid (FHEV):** While the vehicles equipped with this type of engine are capable of running on only using an IC engine, only using electric motors, or in hybrid mode (both together), the main drawback to using only electric motors is that you can only travel short distances before needing to switch over to IC mode or don't have enough energy left to keep running in electric mode. The most popular selling hybrid vehicle is the Toyota Prius.

Figure 5: Toyota Prius [5]

III. **Plug-in Hybrid (PHEV):** PHEV is a variation of HEV. PHEV vehicles feature larger batteries than HEVs, and these batteries can be charged by connecting them to (plugging them into) an outside power source. This enables PHEV cars to frequently travel long distances using only electric power. If/when the battery depletes, the car will transition from using electric power to using the internal

combustion engine (IC). One of the fastest hybrids in the world would be the Koenigsegg Regera.

Figure 6: Koenigsegg Regera [6]

Advantages of Hybrid Engine: Hybrid engines provide benefits such as better fuel economy, reduced emissions, and regenerative braking technology. They use electric power for city driving and rely on traditional gasoline engines for highway driving or when longer distances must be travelled, thus lowering overall gas usage along with increasing the efficiency of fuel usage through its use of both electricity and gasoline as a form of motoring fuel. Since not all energy from hybrid vehicles is derived from fossil fuels, hybrids help mitigate carbon footprint and create a cleaner environment than vehicles that rely solely on fossil fuels. Another major benefit provided by hybrid engine technology is the ability to reclaim kinetic energy lost when a vehicle brakes and convert that energy into usable electrical energy to maintain battery charge; this process of converting kinetic energy into usable electrical energy is much more energy efficient than operating without the regenerative braking system.

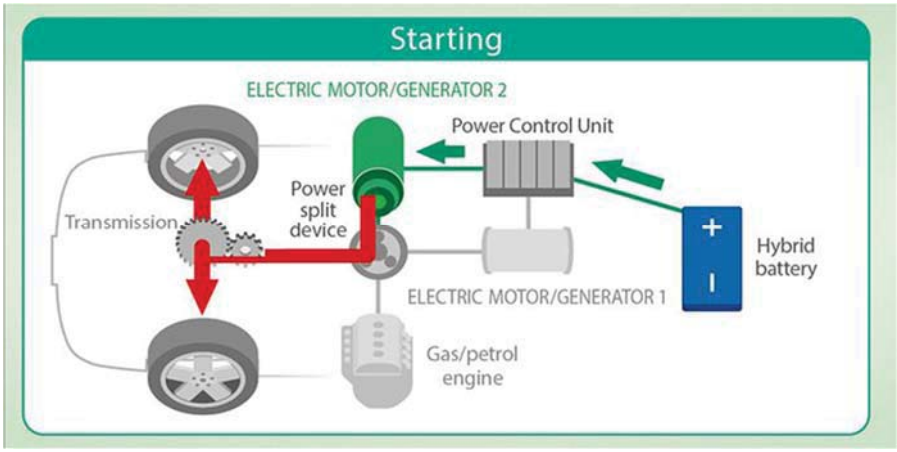

Figure 7: Regenerative Braking Mechanism [7]

Global scenario of HEV: In many developing countries such as Brazil, India, and Mexico, there is an increased demand for HEVs due to the greater need for low or zero emissions vehicles and also because of the stricter government regulations on controlling carbon emissions associated with vehicles. The government of Brazil has already begun to reduce taxes on HEVs. The global hybrid vehicle market size was valued at 271.80 billion USD as of 2023, which estimates a growth of hybrid vehicles from USD 291.42 billion in 2024 to $504.18 billion by 2032, representing a 7.1% CAGR during that timeframe.

In India, hybrid vehicle market size estimates were 0.42 billion USD in 2024 and will grow to approximately 1.47 billion USD by 2030, reflecting a CAGR of approximately 23.30% over that time period.

Figure 8: Innova Hycross [8]

There has been significant development with regards to hybrid transportation in the Middle East and North Africa, especially in Saudi Arabia, the UAE, Israel, Jordan, and Oman. According to a recent announcement by the Dubai Taxi Corporation's Strategic Plan 2022-2024, the RTA will add to Dubai's taxi fleet with 2219 new hybrid taxis, of which 72% of the total will have environmentally friendly technology by the end of the RTA's current fiscal year.

Figure 9: Toyota Camry [9]

Conclusion:

The introduction of hybrid engines into the global marketplace allows automotive manufacturers to create power-producing engines while simultaneously promoting a cleaner, sustainable form of transportation. Hybrid cars benefit from superior fuel-efficiency, lower greenhouse gas emissions, and smoother acceleration by combining conventional gas and emerging technologies. In response to stricter environmental regulations imposed by governments around the globe to help offset carbon footprints, as well as government subsidies for environmentally-friendly automobiles, retail hybrids have seen positive growth rates during recent years. Hybrid vehicles represent a major advancement toward achieving an environmentally sustainable future, and greater consumer acceptance of this technology will help define the future direction of the automotive industry.

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