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Environmental and Ecological Impacts of Hybrid Electric Vehicles: A Comprehensive Literature Review

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Abstract

The ideal balance between fuel efficiency and environmental friendliness is what electric hybrid vehicles are designed to offer. However, they might not be as advantageous for the environment and ecology as they first appear to be. In this quest for efficiency and advancement, one of the many unresolved issues is the impact of mining on both ordinary mine workers and locals. A large number of workers risking their lives for the benefit of electric battery manufacturing businesses; communities in pre-mining areas lacking access to clean water; and job uncertainty are examples of ecological difficulties. One final event that takes place when an electric motor and battery reach the end of their lives. Sales of electric vehicles will lead to an increase in the amount of waste generated by electric motors and batteries.

Introduction

Nicolaus August Otto's discovery of the internal combustion engine revolutionised the automobile industry. Later, gasoline and diesel became the primary fuel sources. Later in the twentieth century, the world was on the lookout for technology that was both cost-effective and environmentally benign. The reason for this is that the rate of carbon monoxide and carbon dioxide has climbed to a dangerous level as a result of the use of gasoline and diesel, which has a bad influence on the environment, such as global warming. Road transportation accounts for more than half of all greenhouse gas emissions among modes of transportation. The major reasons for this increase are an increase in private car ownership and fast expanding mobility.

This compelled scientists, researchers, and policymakers to think about green technology, with a main focus on the automobile sector. With the invention of hybrid technology, such as hybrid electric cars, hybrid solar vehicles, and hybrid fuel cells, the technologies entered new phases, with hybrid electric vehicles being the most effective of all. Efficiency wise It is more efficient than a car running on petrol, diesel, or natural gas.

Hybrid solar vehicles have low efficiency compared to vehicles running on petrol, diesel, and gas. Electric vehicles with low carbon footprints provide a green alternative to fossil fuels. This will reduce direct carbon dioxide emissions and reduce the shortage in supply compared to demand for oil. Electric vehicle technology was initially for drivers who cover short distances. Later, it developed plug-in hybrid electric vehicles to overcome its limitations.

While reducing fuel use has a direct influence on vehicle economy, there are additional aspects that may have a long-term detrimental impact. The battery components in the best hybrid vehicles normally have an 8-year guarantee, and consumers will be responsible for repair and disposal. This topic hasn't come up as an issue yet because the business is still young, but as hybrids become more prevalent and age, these issues will become more prominent. This article will look at electric hybrid cars from an ecological and environmental standpoint, noting not only the benefits, but also the issues that develop when batteries and electric motors reach the end of their useful lives, as well as the existing remedies.

Electric vehicles are divided into categories based on their reliance on electricity as a power source. EVs are currently classified into three categories.

Battery electric vehicles (BEVs) are fully electric vehicles with rechargeable batteries. BEVs, sometimes known as "plug-in" EVs, get their electricity from an external electrical charging outlet. They are powered by electricity and lack a gasoline engine, fuel tank, or exhaust pipe.

Plug-in hybrid electric vehicles (PHEVs), also known as extended-range electric vehicles, run on a combination of gasoline and electricity. They have externally charged batteries as well as regenerative braking capabilities. A gas engine is also used in PHEVs to increase the vehicle's range and recharge the battery.

Hybrid electric vehicles (HEVs) use both fuel and electricity to power them. They vary from PHEVs in that they charge their batteries solely through regenerative braking. When driving, these EVs use their electric motor, which is supplemented with the gasoline engine as needed by changes in load or speed.

The "Toyota Prius Series" is a hybrid electric car, whereas the "Astrolab" is a hybrid solar vehicle and the "Chevrolet Volt" is a plug-in hybrid electric vehicle.

1.1 Regenerative braking is an energy recovery technology that slows a vehicle by converting its kinetic energy into another form, usually electrical energy, that can be utilised right away or stored in high-voltage batteries until it is needed. During braking or coasting, the electric motor acts as a generator by spinning backwards. As current is induced in the motor coils, opposite torque is applied to the rotors of electric traction motors when they are coupled with wheels. Kinetic energy is transferred from the wheels to the generator via the drivetrain. Simultaneously, the vehicle is slowed by generator resistance caused by the electricity produced. Friction brakes are used when additional braking torque is required beyond what the generator can produce.

2.Side effects of raw materials

The lithium-ion cells that power most electric vehicles, like many other batteries, rely on raw minerals such as cobalt, lithium, and rare earth elements, which have been linked to serious environmental and human rights concerns. Cobalt has been particularly troublesome.

Cobalt mining produces dangerous tailings and slags that can leach into the environment, and studies have identified significant levels of cobalt and other metal exposure in local populations, particularly among youngsters. Smelting, which emits sulphur dioxide and other damaging air pollutants, is also required to extract metals from their ores.

Human rights groups warn that the Democratic Republic of Congo mines up to 70% of the world's cobalt supply, with a significant portion of that mined in unregulated "artisanal" mines where workers, including many children, dig the metal from the earth using only hand tools, putting their health and safety at risk.

The world's lithium is either mined in Australia or extracted from salt flats in Argentina, Bolivia, and Chile, activities that consume a lot of groundwater to extract the brines, depleting the water supply for Indigenous farmers and herders. Electric vehicles use around 50% more water than typical internal combustion engines due to the amount of water necessary to manufacture batteries. Rare earth deposits, which are primarily found in China, frequently contain radioactive chemicals that can produce radioactive water and dust.

Focusing first on cobalt, automakers and other manufacturers have committed to eliminating "artisanal" cobalt from their supply chains and have also said they will develop batteries that decrease, or do away with, cobalt altogether. But that technology is still in development.

Initially focusing on cobalt, automakers and other businesses have pledged to remove "artisanal" cobalt from their supply chains, as well as develop batteries that reduce or eliminate cobalt entirely. However, that technology is still in the works.

Lithium-ion batteries, which can store more energy in the same space as lead-acid batteries, are utilised in the majority of today's electric vehicles. Lead-acid batteries are recycled at a rate of 99 percent in the United States, while lithium-ion battery recycling rates are estimated to be around 5%.

According to experts, exhausted batteries contain valuable metals and other components that can be salvaged and reused. Battery recycling can waste a lot of water or spew toxins into the air, depending on the method.

Finding a second life for used electric vehicle batteries in storage and other uses is a distinct and potential strategy for dealing with them. Several automakers, notably Nissan and BMW, have experimented with grid storage using leftover electric vehicle batteries. General Motors claims that its battery packs were developed with long-term use in mind. However, there are obstacles. To ensure that lithium-ion batteries may be reused, they must be thoroughly tested and upgraded.

2.1 Mining's Ecological Challenges Using the Kolar Gold Mine as a Case Study

People in India dug gold by hand during the Chola Empire. Hand digging was no longer an option as demand increased. India was under British rule at the time, and they began using technology to extract more gold. Torches and lanterns were initially used to light the mines. Later, when the light became insufficient, Asia's second and India's first power plant, Koolar, were born. In order to accomplish this, British engineers presented Mysore Maharaj with a proposal for a new hydroelectric plant on the Cauvery River in 1900, and they installed electricity for the first time in India. The mine employed nearly 30,000 people. The KGF was powered by an uninterruptible power supply. Kolar was also known as Little England, and because it was a British mining colony, life in the Kolar gold mines was heavily influenced by British culture. The miners were mostly Tamil imigrants who lived in coolie lines. Life was difficult because each small shed housed more

than one family. This area was also known for rat invasions, with around 50,000 rats killed by workers. The workplace was also challenging for them because dehumidified air is constantly supplied to underground tunnels; the temperature in the tunnel was 55 degrees Celsius; and accidents were common.

As a result of high demand and overmining, the gold reserve was depleted, and expatriates began to flee Kolar. Most of the key mining locations were under British ownership, and after 1956, the central government decided to take over all mines, even though most of the mines were already under state government ownership at the time. To avoid shutting down the mines that produce nearly 95% of India's gold output, they were nationalised. Despite massive protests, the Kolar gold field was closed down in 2001. They left without closing the underground tunnels, which caused flooding from groundwater. Despite the fact that KGF has a gold reserve, mining it has become difficult due to the cost. Kolar Gold Fields, or KGF, has lost its golden lustre. Only during election seasons are people duped into believing that they will restore the old golden glory. Poverty, unemployment, and disease have become common among common mine workers as a result of the loss of this glory.

Once a prosperous village and the home of the Kolar Gold Fields, which later became Bharat Gold Mines Limited (BGML), the town now has a run-down appearance. As a result of the mine closures, thousands of people became unemployed and began to migrate to Bangalore in search of work. On average, over 25000 people per day migrate from KGF to Karnataka. Many mine workers and their children are still suffering from the health consequences of previous mining. Silicosis, a lung ailment, is one of the most common diseases. Another major issue is the cyanide hill. Without prior notice, the mine was closed and environmental waste was left behind. Over the years, mines have produced approximately 35 million tonnes of ore processing residue. The effluents are deposited in mounds containing cyanide and silica. Cyanide hills are toxic residue hillocks. Untreated toxic waste contaminates land, air, and water, posing a health risk to local residents.

After the Kolar Gold Field closed in 2001, the town lost power and water. They even lack proper sanitary facilities. In addition, open drain systems for wastewater in the colonies result in a slew of communicable diseases. The Kolar Gold Fields still have a population of about 260,000 people. The British government had also constructed a lake to meet the area's water needs. When the mine was operational, there were no power outages or water shortages in the surrounding area. However, now that the gold has been depleted, the area has lost its lustre due to a lack of adequate electricity and drinking water. The former mineworkers are impoverished, with no financial or medical assistance from the government.

3.Hybrid electric vehicles

3.1 Electric automobiles

Currently, electric automobiles are built on the same chassis as gasoline automobiles, making it impossible to discern between the two from the exterior. The noise level produced by the vehicle is the only thing that could suggest that it is an electric vehicle. A simple definition of an electric car is a vehicle with an electric motor in place of the gasoline engine. One of the most promising approaches to boosting energy efficiency and minimising greenhouse gas emissions is to employ electric automobiles.

3.2 Hybrid automobiles

A hybrid car is defined as a vehicle that has two power sources. Hybrid vehicles are powered by both a gasoline engine and an electric motor. Hybrid cars are built in such a way that both power sources are used concurrently in some circumstances and alternately in others. When a hybrid automobile travels below 5 to 10 kilometres per hour, such as when approaching or leaving a traffic signal, it relies solely on the electric motor, reducing fuel usage. The electric motors of hybrid cars are powered by either batteries or an external power source (which can be replenished while the car is breaking (regenerative braking) or while idling). Another method of recharging is when Another method of recharging is to link the internal combustion engine to a generator that recharges the batteries directly. For hybrid autos, having access to numerous design strategies for connecting the internal combustion engine and electric motors is crucial. The first game in the series is linked to the series, with the combustion engine utilised to replenish the batteries and the electric motor handling traction. Another connection strategy is a parallel connection, in which both engines are used to power the car and the communication between them is controlled by a controller. Mild hybrids and complete hybrids are two types of hybrid vehicles. The way the electric motors operate the car differs between the two. If the motor can drive the car without the gasoline engine, it is referred to as a "full hybrid," but if it cannot, it is referred to as a "mild hybrid."

3.3 A hybrid and electric vehicle comparison

Both electric and hybrid automobiles are supposed to be environmentally friendly, but there are some key differences.

Carbon dioxide and other hazardous emissions are reduced to near zero in hybrid automobiles and almost zero in electric cars. A hybrid vehicle is quieter than a conventional vehicle, and electric vehicles are even quieter. In electric cars, the battery that powers the electric motors must be recharged. Hybrid automobiles, on the other hand, do not require recharging because, in most cases, the battery recharges itself while the car is in use. In electric and hybrid vehicles, electric motors and batteries are used.

The motor and batteries are the major components in electric and hybrid cars that have been upgraded, in contrast to those with an internal combustion engine. Following that, we'll concentrate on those two elements and their qualities.

3.4 Electrically powered motors

Electric motors are components of a car's electrical system that transform electrical energy into mechanical energy. Direct-current motors and alternate-current motors are the two types currently used in automobiles.

Electric motors provide a number of advantages over internal combustion engines. Electric motors produce little to no noise, lowering carbon dioxide and other dangerous gas emissions over their lifetime. Electric motors are smaller and easier to control, and the maintenance is done quicker and easier, resulting in a lower cost.

Demand charges are a significant disadvantage for electric motors. When large horsepower motors are used in applications, the cost per hour of operation can be significant. Researchers are currently working on ways to

recycle electric motors, with a particular focus on permanent magnets, which contain several rare earth elements. Approximately 30% of the range of rare metals is required to build a compact and lightweight electric motor. The production of electric and hybrid cars will increase in the future, necessitating the development of new permanent magnet technologies for these models in order to limit the consumption of raw rare earth metals.

Hundreds of earth metals are not always included in electric motors for electric and hybrid automobiles. Several types of electric motors are in use that do not need permanent magnets. Electric motors without magnets are often less expensive and are usually AC motors. The Tesla Roadster, for example, has an electric motor that does not use dry earth metals. Removal of magnets from waste motors, repair, and subsequent reuse of the electric motors or their components are some of the alternatives presented by researchers in the field of electric motor recycling.

When an electric motor reaches the end of its life cycle, after removing and studying it, it can be determined if it can be fixed, restarted, or recycled by its components.

3.5 Batteries

The battery is a device for strong chemical energy and converts it into electricity.

4.Emissions

Because the gasoline engine is not running all of the time in hybrid cars, they should produce fewer emissions when driving. The concept of a second power source, on the other hand, adds weight to an automobile without removing any. Electric engines use a lot of copper cables, which adds weight to the vehicle. Hybrids are typically the same weight, if not heavier, than comparable-sized automobiles, implying that more power is required to attain comparable performance.

The need to generate additional power increases emissions, bringing hybrids closer to parity with conventional vehicles. Hybrids are fantastic for the environment in cities or stop-and-go traffic since they release nearly no pollutants. However, when hybrid cars drive on highways, the electric motor is not functioning at all, so they are essentially normal cars. Taking into account all of these factors, hybrid automobiles only reduce CO2 emissions by roughly 20% on average.

4.1 Production Emissions

Different types of materials will be required for cars with various propulsion systems. Tires, windows, and paint are all pretty much the same in all cars, and there isn't much variance in the amount needed to finish a car. Lead and nickel, on the other hand, have a significant variance amongst cars. Lead-based batteries are used in traditional ICE automobiles. Emissions levels, specifically CO2 levels, for the processing of the elements that make up cars can be examined and compared to see if hybrids are more environmentally friendly. In the case of batteries, for example, lead-based batteries produce 9 kgC from raw materials, whereas nickel-based batteries yield 2430 kgC, and as high as 215 kgC in the case of a strictly electric car. The difference in CO2 emissions levels would be much greater if businesses used only recycled materials. However, carbon dioxide is not the only pollutant that harms the ecosystem. There are numerous more by-products that are released. Painting, fibre glassing, cleaning parts, and moulding can all produce pollutants.

6.Production: Energy Consumption

The resources used to make cars must originate from someplace, and no matter what procedure is used, it requires energy. Certain procedures consume more energy than others, which increases the car's cost as well as its environmental impact. These processes require electricity from a power plant. Coal-fired power plants, nuclear power plants, hydroelectric power plants, wind power plants, and other small-scale power plants are all possible. Energy has harmful environmental consequences regardless of where it originates from.

7.Electric Vehicle with Fuel Cells

Fuel cell electric vehicles in which the electric part is the same as that of an electric hybrid vehicle, with the difference being that hydrogen power is used instead of an internal combustion engine. Hydrogen used as fuel is produced by the electrolysis of water. Electrolysis is the process by which water is split into hydrogen and oxygen by passing electricity through it. In the fuel cell, hydrogen and oxygen fusion reactions take place. Since the hydrogen fusion reaction is exothermic, a large amount of heat is produced, which makes it more advantageous than electric hybrid vehicles. This excess heat can be used for battery heating as well as cabin heating (Source: core.ac.uk).

7.1 Ecological Aspects

The problem with such vehicles is that if the electricity used for splitting hydrogen and oxygen from water molecules produced is not from a renewable source, the same pollution problem that is seen with gasoline will arise. Byproduct wise, it doesn't create any problems because the byproduct produced by fuel cell electric vehicles is water. The next issue is that hydrogen is stored under high pressure inside the fuel cells. Heavy fuel tanks are needed since hydrogen is compressed and stored. Since the density of hydrogen is lower, a larger storage area is also needed. Storage cells need higher energy for compression and liquefaction of hydrogen. It also has all the ecological side effects of an electric vehicle, which are already discussed in the environmental aspects of electric hybrid vehicles. (from nasp. edu)

Considering the shortage of pure water for drinking purposes, the electrolysis process nowadays uses sea water. The seawater is desalinated and used inside the electrolyzer. Since the wide range of uses of this technology is still developing, it has too many hurdles to pass through. (source: cardrivers.com)

7.2 Economic Considerations

Since hydrogen storage is a little bit difficult, the cost of the storage cells is very high when compared to the internal combustion engine. Since hydrogen is highly flammable, storage and transportation are at great risk, and a high cost is needed. Current infrastructure for gasoline and natural gas, like pipelines, needs to be changed to hydrogen, which is a more costly process. (source: nasp.edu)

8. Strong Hybrid Electric Vehicle with Flex Fuel

A flex-fuel strong hybrid vehicle is one in which the vehicle has a flex-fuel engine and an electric motor. In this type of vehicle, flex fuel engines have a mixture of ethanol or methanol and gasoline that is used. Usually, the composition is 85% anhydrous ethanol or anhydrous methanol and 15% gasoline. Ethanol is a biofuel that is obtained from grains such as corn and soya by a fermentation process. A flex-fuel is one in which more than one type of fuel is present. An internal combustion engine is designed to run on both fuels. Most parts of

the flex fuel engine are the same as those of a normal gasoline vehicle, but there are some exceptions, such as the fuel line with nickel coating, the higher volume fuel pump, and the aluminium rotor. Sensors that are attached to the fuel system detect the blend, and the computer will work on the rest. (source: carbibles) Compared to gasoline, the long-term release of very low fumes So it is a much cleaner fuel than gasoline. The demerits of this are that the mileage of flex-fuel vehicles is less compared to gasoline and the low number of fuel stations for biofuels. Ethanol absorbs dirt very fast, which causes corrosion of the engine very quickly. (source: caranddriver.com)

8.1 Ecological Impact

Biofuel produced now is mainly from food crops such as corn and soya, which contributes to food insecurity. A portion of the land area that needed to be used for food crop cultivation is instead being used for biofuel source crop production. Corn and soya beans, which are used for biofuel production, are used as animal feed too. Since the demand for such crops increases, the price of corn and soya even booms. As a result, farmers are forced to grow those crops at a greater income than other food vegetation (source: ncbi.nlm.nih.gov). The electric source of this hybrid has the same environmental issues as that of an electric hybrid car.

By switching bioethanol production sources from food crops to algae such as seaweed and food waste, food crop dependency can be reduced. It is being researched in order to make it more efficient and commercially viable. (source: cordis.europa.eu)

9. Case Study: What is the ecological impact of the Toyota Prius plug-in hybrid car?

The Prius Plug-in Hybrid (Prius PHV in Japan, Prius Prime in the US) is a plug-in hybrid liftback from Toyota. The first-generation model was created between 2012 and 2016. The model's second generation has been produced since 2016. Let's start with a look at how the Toyota Prius works. As you may know, the Toyota Prius is a plug-in hybrid, meaning it has a modest 1.5-liter engine, a small electric motor, and, of course, batteries. As you may have seen, the amount of pollution produced by this small automobile is so tremendous that even Toyota admits that the Prius is a polluter during its manufacturing process. If we are thinking that the little fuel-efficient Prius will make it on the road, we are mistaken. The second difficulty is that, while the Toyota consumes less fuel than the usual family car, we need to know where the Toyota's energy comes from. Because the Prius' battery is the only reason it gets high gas mileage. Unfortunately, the battery obtains its energy from largely non-eco-friendly sources, because whether you plug it in or just use the engine to charge it, you're still using fossil fuels to generate electricity. This issue, however, does not apply to all hybrid/electric vehicles because many EV chargers, such as Tesla superchargers, rely heavily on solar electricity to lessen their vehicles' carbon impact. The third and final point is more subjective, because while the Toyota Prius fares well on petrol, it only does so when it isn't being pushed. Simply put, if you pit a car like the BMW M3 against a car like the Toyota Prius on a racetrack, the Toyota Prius will consume more fuel. This is because the M3 needs to utilise less power, but the Toyota has to use all of its meagre power while staying on the redline for longer. As a result, you have a car that is universally regarded as drab, slow, and uninteresting, with a starting price that is $8,000 higher than the Toyota Yaris.

10.Conclusion

Going green and reducing greenhouse gas emissions is important for a sustainable environment. However, we must consider whether the steps taken by the government and major markets toward going green are truly green or are having a negative impact on the environment. Through the burning of gasoline, natural gas, and other petroleum sources, we are producing carbon dioxide and greenhouse gases as byproducts. That's true, but while we are considering an alternative, it should be eco-friendly in all senses of the word. If it is creating many more problems than an internal combustion engine or gasoline, then how can it become a solution to increasing greenhouse gas emissions and climate change? Environmental and energy-efficient concerns, as well as rising fossil fuel prices, are putting pressure on automakers to design and build cleaner, more energy-efficient vehicles. As far as now, even though electric hybrid vehicles are considered the most eco-friendly option ,in their production phase they are creating lots of ecological and environmental problems. In usage, hybrid electric vehicles emit carbon dioxide, which means they're not completely zero emission. The main disadvantages from an ecological standpoint are how it affects common people during the production phase and how using biofuel as a fuel source affects food insecurity. The main environmental disadvantage is the source of energy: batteries. Researchers are working on ways to recover as much as possible from destroyed batteries because rare earth elements are in short supply and expensive. Regrettably, none of the proposed solutions have been widely adopted. Based on their potential, they won't be around for long.

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