

A STUDY REGARDING HYBRID ELECTRICAL VEHICLES

¹Eliza Chircan*, ¹Bogdan Benea

¹Transilvania University of Brasov, Romania

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ABSTRACT - The earth is almost at its peaks. It's hard to be indifferent to the big changes that occur every day, such as climate change. People in this world have forgotten that we are able to live due to our planet's kindness. It's time to give back to the one that is taking care of us for such a long time providing food and different materials such as fossil fuels.

One of the main causes of the climate change is pollution due to transportation. It's hard to live nowadays without the help of home appliances and cars. The last category, the vehicles, is the main contributor when it comes to CO₂ and NO_x emissions. Another bad thing about vehicles is the amount of fossil fuels that they burn. These fuels that help our car function are starting to disappear, shortly transportation being made impossible. Therefore it appears the need of renewable energy sources and vehicles that can work without using a big amount of fuel.

The next to be introduced are the cars of the near future: the hybrid electrical vehicles. They are eco-friendly vehicles that have low fuel consumption. One important feature of this kind of vehicles is the second battery, which stores energy. This kind of vehicle provides itself with energy from regenerative braking.

Hybrid electrical vehicles are quite simple to understand. In the content of the paper we will describe its way of working, its components, and discuss emission efficiency problems, that make the hybrid technology stand out.

A major change will occur if people will start to embrace the new technology, which will reduce not only the fuel consumption but also the amount of CO₂ and NO_x emission, which will help not only our planet but our lives as well.

THE IMPACT OF FOSIL FUELS

One of the most important technical, social, and public policy issues that face mankind today is represented by the use of energy and its impact on the environment. A big challenge of our time is to provide enough energy to satisfy the increasing demand. Nowadays it's very hard to live without its help. Therefore consuming large amounts of the natural resources makes us hurt our planet. Getting used to the commodities that energy has provided us with is not only bad for the environment, but to ourselves as well. Because of the human greed to have more and more, we overlooked some important issues such as soil, water, and air pollution. We gradually consume all that earth can provide us with, without thinking of the consequences or of the future generations.

The global climate change, especially global warming, has underlined our large appetite for fossil fuels. According to a considerable amount of debates, the principal cause to the big concentration of CO₂ in the atmosphere is represented by the use of fossil fuels, therefore explaining the greenhouse gases. As a result of these conclusions it appears the need to find a more sustainable energy supply, which will not endanger our health or the future of the planet.

In the heavily polluted areas of the big cities, we can talk about localized air pollution, that results from direct chemical reaction with the products of combustion and from the formation of ground-level ozone. Some of the combusting products are carbon monoxide (which results from the incomplete burn of carbon in fuels), sulfur dioxide (one of the causes of acid rain), nitrogen oxides, unburned hydrocarbons and carbon dioxide, which presents most concern.

Carbon monoxide is a poisonous gas if found in large quantities. It usually appears in small concentrations due to well-adjusted burners or internal combustion engines, the amount increasing if there is insufficient air present for complete combustion. Sulfur dioxide is the result of fossil fuel combustion process (mostly coal). It is a colorless, nonflammable, non-explosive gas that is a chemical component of the acid rain, having a huge impact on the human lung tissue, as well to nature, the environment in general. Nitrogen oxides emissions come from high temperature combustion processes, such as those of the automobiles. During this process the nitrogen oxide NO obtained during combustion it interacts with the excess oxygen, when discarded in the atmosphere, and becomes nitrogen dioxide NO₂, which, because of sunlight, it dissociates, releasing free oxygen atoms. They interact with O₂ molecules, creating high levels of ground-level ozone.

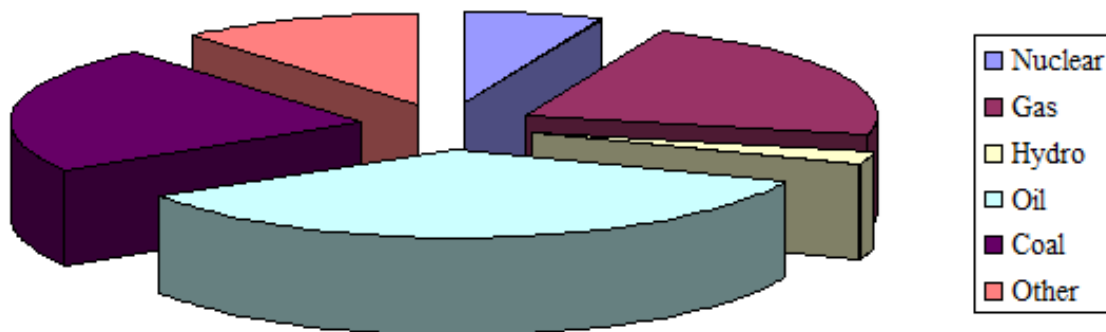


Fig. 1 World energy consumption 2010

Fossil fuels are the predominant primary sources of energy, being used more than 75% in the last couple of years, as presented in the picture above. But fossil fuels such as crude oil, coal or natural gas, are non-renewable by natural means, therefore a solution is needed.

A NEED OF CHANGE; ECO-FRIENDLY TRANSPORTATION FUELS

Transportation is the principal contributor to the climate change. Therefore this area should be the one to change the most. The greatest concern is how to reduce the consumption of oil and the emission of greenhouse gasses. As a result of these measures it appears a new need of transportation fuels and new fuel technologies.

Fuels can have three modifiers: alternate, renewable and biomass. Alternative fuels are those that are not based on petroleum-based liquid, such as natural gas. Those fuels that can be

produced with the existing resources and can replace the consumed fuel within a definite time span are considered renewable fuels. Biomass fuels or biofuels are produced from plants and animals. Biodiesel, ethanol and natural gas, all offer advantages in comparison to gasoline.

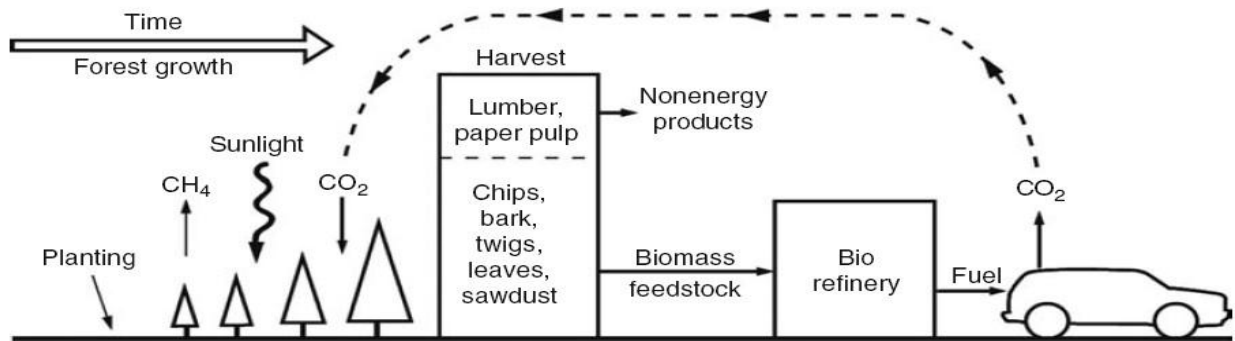


Fig. 2 ¹The CO₂ cycle applied for a fuel from biomass.

FUTURE VEHICLES

HYBRID ELECTRICAL VEHICLES

Changing direction from the fuels to the vehicles that burn them, one can observe the growth of hybrid electrical vehicles in the automotive industry in the past couple of years. This new appearance will certainly influence the fuel economy, as people will be informed about its advantages. A hybrid combines two methods of propulsion for the vehicle such as diesel/electric, gasoline/flywheel and fuel cell/battery (one being the storage and one converting the fuel to energy).

Regarding performance, when it comes to hybrid vehicles it's all about how much distance they can cover using only the electrical mode. Another important factor is the reduced emissions and the small amount of fuel they use.

As the figure above illustrates, a hybrid vehicle may be composed from a gasoline engine and a motor/generator, merging the components of both type of engines. The motor/generator of the electric engine allows regenerative braking; therefore, installed in a hybrid electric vehicle, it enables that feature. In this case, the motor/generator is placed right behind the engine, but in some cases it may be connected directly to the engine. The next issue that we have to look upon is transmission, which has two torque producers: the motor/generator mode and the gasoline engine, the motor/generator and the battery being connected electrically.

The newest component that has been added is the control system. Its major functions are to maximize the mileage/gallon and to minimize the exhaust emissions, and its minor functions are those to monitor and protect the components (ex. battery state of charge, battery temperature).

¹ "Hybrid Vehicles and the future of personal transportation", Allen E. Fuhs, pg. 437

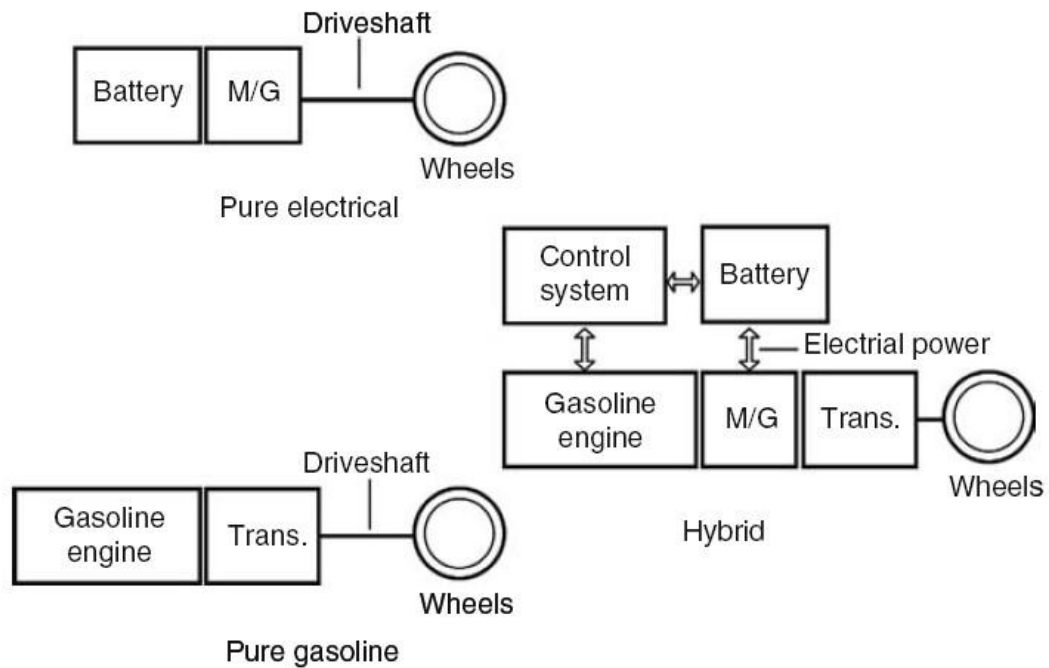


Fig. 3 ¹Components of a hybrid car.

Usually the control system provides a fail-safe mode in the case of failure. Another important control function is onboard diagnostics. These features are very important for the hybrid vehicle. While changing between hybrid modes the driver should not notice a ting. Therefore integration and control software should work smoothly without any foul.

When it comes to hybrid electrical vehicles, one important feature is the interplay that exists between the engine and the motor, which depends on the driving conditions and demands of the driver. When climbing a hill, a huge power demand is made and the motor will supplement the engine. This procedure is known as motor assist. All this obstacles that the hybrid has to overcome are saved in the driving cycle. This data is very important for the driving process.

Regarding regenerative braking a dual-purpose motor/generator is needed. The whole purpose of this kind of braking is to recover as much vehicle kinetic energy as possible, using special sensors and other equipment. This equipment can be used, when modified, for the antilock braking system, stability control, traction control and brake force distribution. Regarding the dimensions of the brakes of hybrid electrical vehicles, they are larger then the ones a normal vehicle has. The only thing to point out is that in case of a panic stop, usual friction brakes cover 90% of the stopping, but during normal braking, the regenerative brakes are most used, usual friction brakes, in case of hybrids, lasting longer.

Another important issue to discuss is brake cooling. When designing a vehicle, one must consider not only the performance but also the aspect. Using chrome wheels with shiny spokes provides good cooling for friction brakes, but adding to the overall drag of the vehicle.

¹ "Hybrid Vehicles and the future of personal transportation", Allen E. Fuhs, pg. 74

When building a hybrid that's the last thing you wish for. Therefore the best way to obtain lower drag with increased miles/gallon is using flat plane hub caps. However, there is still the matter of cooling. In case of friction brakes, flat plane hub caps don't provide enough cooling for friction brakes. But in case of the hybrid electrical vehicle, most of the braking is regenerative braking, so the amount of heat produced will be reduced, resulting a lower drag, increased miles/gallon and cool brakes.

Hybrids can be categorized by their design options, such as series, parallel and mixed. The series hybrid electrical vehicle has two draft shafts that are not connected; therefore the engine can work at its best, with minimum fuel consumption. In this case the engine and the generator form a unit that is not connected to the drive shaft.

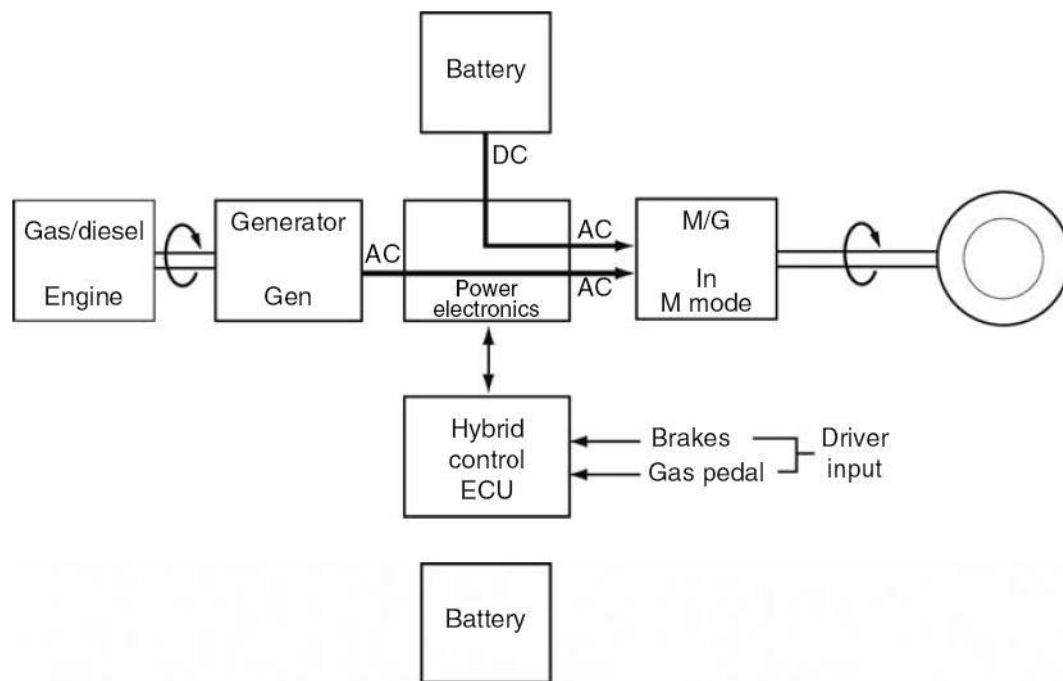


Fig. 4¹ Components of a series hybrid electrical vehicle (acceleration, going uphill)

The only disadvantage of the series configuration is the extra weight from the generator (alternator/rectifier) that is needed. The sum of the capacity of the generator and the battery maximum power must equal the total power of the hybrid electrical vehicle. In addition, the motor/generator (M/G in M mode) must have the same power as the total vehicle power for propulsion, as illustrated in the image above. Therefore, the series hybrid electrical vehicle has double conversion of energy, from mechanical energy, to electrical energy and then back to mechanical. In this kind of design option, the high power traction motor/generator has its advantages, increasing the regenerative braking power.

The parallel hybrid electrical vehicle has a direct mechanical connection, which can be traced from the motor/generator to the drive wheels. In addition, a direct mechanical connection can be achieved from the engine to the drive wheels. Therefore, transmission is needed. This transmission will equal the engine speed with the drive shaft speed. In this case, a continuously variable transmission is superior. As an advantage of the parallel hybrid

¹ "Hybrid Vehicles and the future of personal transportation", Allen E. Fuhs, pg. 76

electrical hybrid, is the single energy conversion (electrical and mechanical). Compared to the series design option, there is no need for the alternator/rectifier, which is a heavy element.

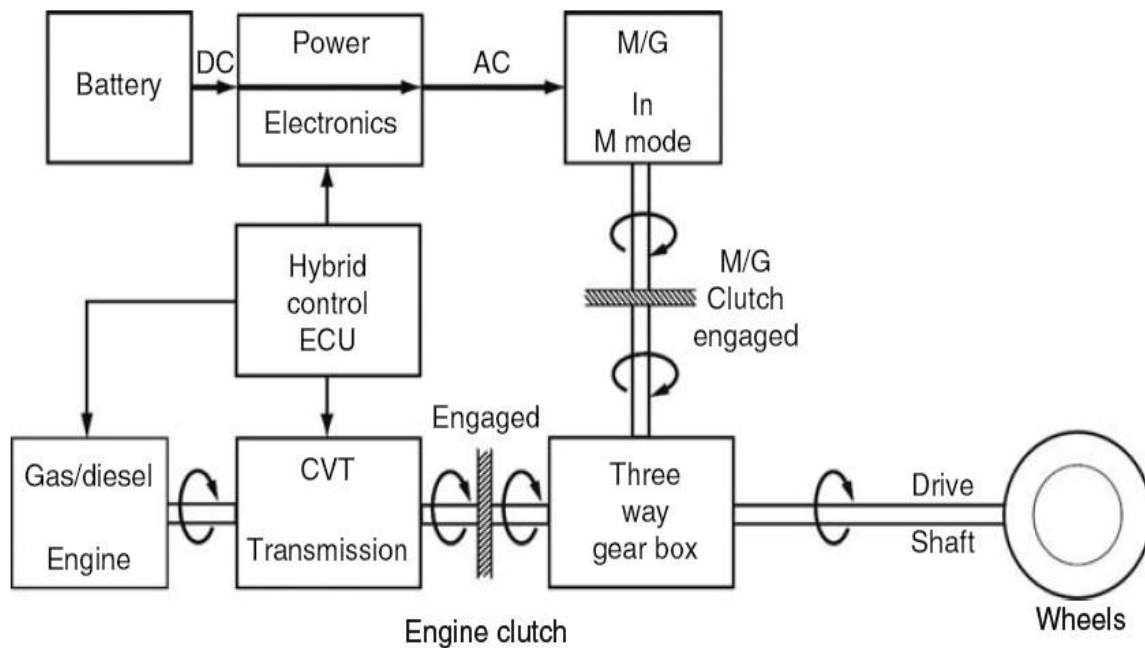


Fig. 5 ¹Components of a parallel hybrid electrical vehicle (acceleration, going uphill) [2]

The figure above represents the energy flow for acceleration, going uphill or driving in deep snow, this being the operating mode that gives most power. Regarding the electrical part, the battery is leaking power into the motor/generator (in M mode), where the clutch is engaged and the torque is feed into the gearbox. Looking up to the engine, its torque is routed through and adjusted with the help of transmission, its clutch being engaged with the torque and merged in the gearbox.

An important issue regarding all type of vehicles is engine efficiency. Regarding the hybrid electrical vehicles, two important aspects are the Atkinson cycle and the amount of heat recovered from the engine. In the case of a normal gas engine, its efficiency is around 25%, the other 75% going out the exhaust pipe or the radiator. Therefore, several new engine technologies have appeared, such as the stoichiometric, the spark and the direct injection engine. There are several big companies that have adapted to the new request of engine efficiency, creating vehicles such as Lexus GS450h. This model is a hybrid electrical vehicle that uses dual injection. This combination helps with improving the power, reducing the emissions and fuel consumption. Dual injection has injection in the manifold (port injection) and directly into the cylinder and it allows higher compression ratios. The advantage of this type of injection is a gain of 7% in peak engine power.

The hybrid electrical vehicle not only has the advantage of low fuel consumption but it also has a huge impact on the environment. A small amount of exhaust emissions means a smaller amount of CO₂ emissions. Due to the decrease of CO₂ emission, there will be registered a regulation of the greenhouse gas. Therefore the next image will show the expected emissions of a hybrid electrical vehicle in comparison to a conventional vehicle.

¹ "Hybrid Vehicles and the future of personal transportation", Allen E. Fuhs, pg. 78

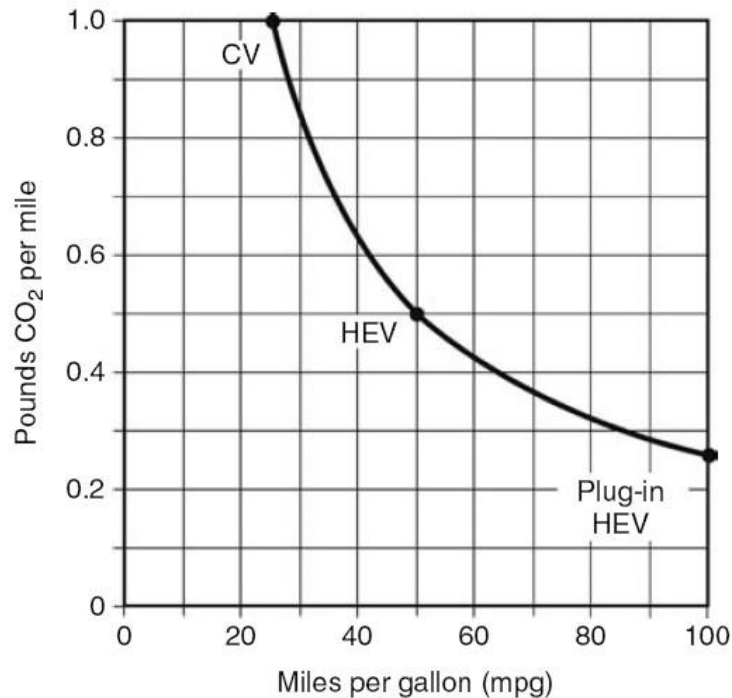


Fig. 6 ¹Level of CO₂ emissions to be expected from conventional, hybrid electrical and plug-in hybrid electrical vehicles

When it comes to hybrid electrical vehicles, there are three electrochemical devices that are very important: battery, fuel cell and capacitor. The battery provides energy storage, which is needed for regenerative braking, and is essential for electric-only propulsion. Capacitors are similar to batteries, providing storage, but are suited for applications that involve a big amount of power for a short amount of time.

For hybrid vehicles, batteries are of two types: primary and secondary. The primary battery is not rechargeable, while the secondary one can be charged or discharged. The main components of a battery are the collections of cells. Each cell has a different voltage that mostly depends on the electrochemical potential of the chemical that has been used. For example the nickel metal hydride battery has a metal hydride anode and a nickel hydroxide cathode. This kind of battery provides a good amount of power when it comes to hybrid applications. Its power density is around 200W/kg. Another example is the lithium-ion battery, which can provide high power and energy for hybrid applications. But there are different concerns regarding the use of this kind of battery, such as safety, costs and calendar life.

Hybrid vehicles are the new idea for an eco-friendly way of life. They represent a small step in becoming aware of the damage that the current transportation ways has brought upon us. The impact of such a little gesture, such as supporting this new technology, can help reduce the amount of CO₂ and NO_x emissions. The best way to ensure a bright future for the upcoming generations is to take the matters in our own hands. Even though the oil supply is decreasing it shouldn't affect our liberty of movement that is provided by vehicles. Using the new hybrid technology we can slow down the consumption of non-renewable resource and

¹ "Hybrid Vehicles and the future of personal transportation", Allen E. Fuhs, pg. 398

make path for alternative fuels. This way not only the planet will be saved, the environment protected, but our lives too, our health as well, leading the human kind to a safer future.

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