The impact of hybrid vehicles on the environment

for students

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The aim of the lesson:
To gain knowledge about the impact of hybrid vehicles on the environment.

ANNEX 1

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ANNEX 2

Introduction

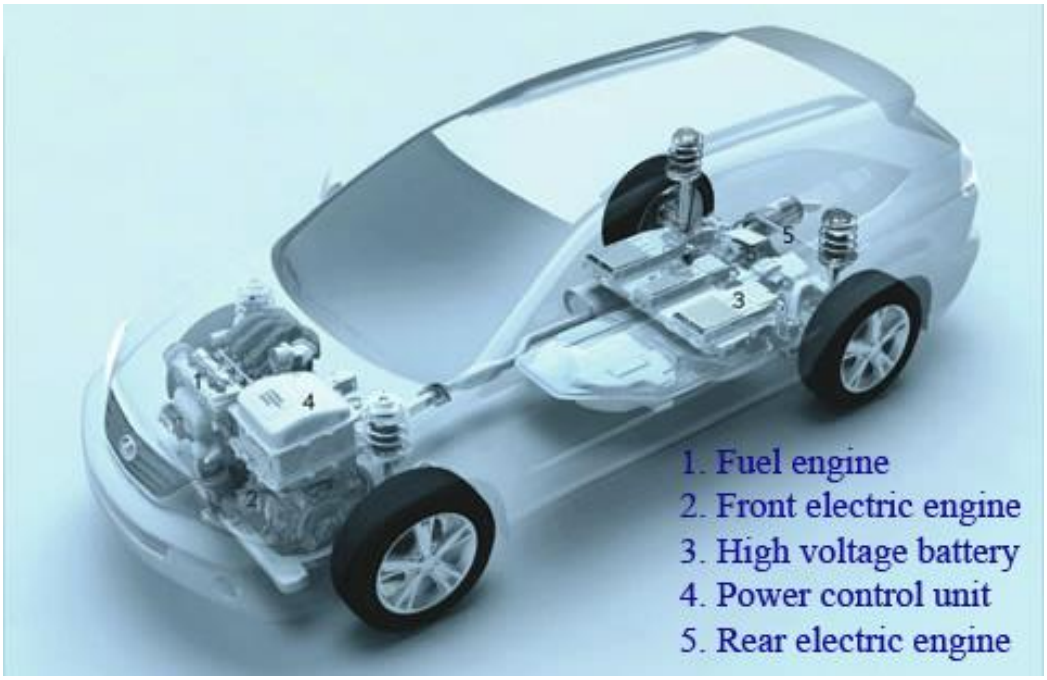
At the end of the 20th Century, first hybrid vehicles were developed. At that time, the main motivation to develop them was to offer an alternative for mobility for those who were interested in using accessible energies for mobility. Crude oil was scarce at the time, not because there was no more of it, but because of the limited infrastructural development of the techniques used for its extraction and further processing.

In the mid 70s, the lifetime of oil reserves was calculated for the first time. They had into consideration the hypothesis that oil consumption will remain at the same level that it was at that time. They concluded that we would have enough reserves for only about 50 years. Car manufacturers reacted to this statement and they started to get interested in looking for a replacement of internal combustion engines, and consumption of mineral oils, by using alternative engines fed by bio fuels, alcohol, hydrogen....

At the beginning of the 90s, a new worry shows up: the ecological impact of using crude oil, as the number one source of energy. It is currently causing on planet Earth a negative impact and there will also be possible negative consequences in the future related to crude oil use.

Over the year's, automotive industries have been concerned about developing cars which were as efficient as possible and they have been ahead of governmental administrations imposing themselves restrictions on emissions of on-road vehicles and on the engine fuel consumption.

In this context, the development of hybrid cars has arisen as a self-made need, in most cases, or determined by law regulations to manufacture more environmentally friendly cars. This has prompted the development of innovative solutions, more efficient to reduce the use of non-renewable energy sources as fuels, and often, more polluting. One of these solutions was hybrid cars, and the market, also influenced by this situation, has welcomed this extra effort of different brands, and has supported this type of vehicles with their decision to purchase the product.



Picture by DRMA20 Project. Spain

Environmental Impact and Fuel Consumption Decrease

Motor vehicles constitute one of the main sources of environmental pollution and gas emissions responsible for the greenhouse effect. The two most important types of greenhouse emissions are CO2 and methane.

On the other hand, the main polluting emissions caused by vehicles are the nitrogen oxides (NOx), hydrocarbons (HC) and the carbon monoxide (CO). These gas emissions coming from cars respectively account for 58%, 50% and 75% of total atmospheric emissions.

Moreover, cars contribute to other toxic pollutants such as lead, benzene, butadiene and some other carcinogens associated to the small solid particles emitted by car exhausts.

Gasoline produces a different type of pollutants through evaporation of fuel at specific parts of the car drive system; This evaporation represents about 30% of global emissions of hydrocarbons coming from mobile sources.

Suspended particles do not only proceed from the combustion process, since some of them are detached from the pavement itself due to the transit of vehicles. It is estimated that between 40% and 60% of suspended particles in urban areas come from road traffic; the rest of it proceeds from other type of activities (industry, farming, public and private works...)

Diesel vehicles cause five times more solid particles than petrol power units: meanwhile the former beams between 20 and 30 micrograms of particles per kilometre, cars powered by petrol only beam 5 micrograms covering the same distance.

As far as hybrid cars use an internal combustion engine, they can not be considered zero emission vehicles and they are still a source of atmospheric, as well as noise, pollution, exactly the same as conventional cars are.

On the other hand, the improved environmental performances of hybrid cars tend to decline over time, increasing polluting emissions as the car gets older.

On the following chart you can observe the average reduction of emissions of a hybrid car comparing it to a conventional car fulfilling current standards as far as EURO IV emissions, and depending on the fact they are petrol or diesel cars.

Average reduction of emissions. Comparison between hybrid vehicles and conventional vehicles.

		Gasoline		Diesel	
Emissions	Hybrid	Euro IV	% Reduction	Euro IV	% Reduction
NOx	0,01	0,08	87,5	0,25	96
CO	0,18	1,0	82	0,50	64
HC	0,02	0,10	80	0,05	60
PM	--	--	--	25	100
CO2	104	165	37	146	29

Reduction of emissions percentage, hybrid vehicle (Toyota Prius), with respect to one that complies with Euro IV regulations
Data CO2: Average values in new vehicles 2004. Data in g/Km except for PM that are indicated in mg/km

Worrying about CO2 emissions is pretty common for customers and governments, due to, among other factors, the commitments undertaken through the signature of Kioto Protocol.

Because of specific mechanical features, like the regenerative braking, some hybrid cars can reach low average fuel consumption or even match those of smaller cars, not only in urban, but also in interurban trips.

As in the case of polluting emissions, hybrid cars offer a greater consumption decrease when driving in the city and the heavier the traffic. The possibility of turning off the combustion engine and keep moving by using the electrical engine together with the regenerative brake brings energy savings in vehicle fuel consumption.

Savings resulting from the use of the regenerative breaking equal a litre of fuel for each 100 kilometres when driving in urban areas. A generative braking, KERS (Kinetic Energy Recovery System) is a device which allows reducing car speed by transforming part of its kinetic energy into electrical energy. This energy is stored for future use.

The engine stop sequence of a combustion engine may represent on its own a saving in terms of energy consumption of about 10% in the 'urban cycle', reaching 17% if there is very heavy traffic, and a 6% savings in the 'mixed cycle'

Waste generation

The use of cars generates a number of waste products:

- In the manufacturing process
- Throughout the vehicle's life
- At the end of the vehicle life (VFU)

Cars as waste generators:

Solid waste: Car bodywork parts (sheet metal panel, plastic, glass,….) tyres, batteries, mechanical components, electrical components, heavy metals….

Image https://pxhere.com/es/photo/775488

Liquid Waste: engine and transmission oils, liquid from the braking system, steering system, coolant, grease, lacquer and paint, solvent, paraffin's...

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Gaseous waste: Emissions produced by thermal engines (CO2, CO, HC, NOx, SO2...), air - conditioning systems, shock absorbers, airbags….

Image https://pxhere.com/es/photo/774074

Gaseous Waste (Exhaust emissions):

- Carbon Dioxide (CO2): Generated during combustion and responsible for the greenhouse effect.
- Sulphurous Anhydride (SO2): Generated during combustion, especially by diesel engines, as they use high-sulphur fuels, causing acid rain (SO4H2).

- Nitroxides (Nox): They appear during combustion causing acid rain (NO3H).
- Particles (PM): Generated during engine combustion, especially by diesel engines. They cause mist and respiratory ailments.
- Hydrocarbons (HC): Volatile compounds. Gasoline. They cause mist.
- Carbon Monoxide (CO): Very toxic. Almost non-existent.

Low performance of thermal engines

Combustion engines performance may vary a lot depending on the intended usage at any stage. The optimum use of energy produced by gasoline engines of this type are the following: 30% is obtained when the engine is running in conditions akin to full load. According to Bosch estimates, the thermal performance of an engine during an urban cycle for type- approval barely exceeds 10%.

Every modification in the charge of operation closer to partial or lower loads, as for example city slow traffic, involves accepting an inefficient use of gasoline, due to the consumption and emissions involved.

According to this, the best way to run a gasoline engine would be using it as close as possible to a full load. This cannot be done with a conventional vehicle, as the power generated by the engine is directly sent to the wheels and it would imply a constant acceleration.

Nevertheless, in some hybrid cars combustion engines are forced to run on a high level load, over 80%, only sending to the floor the power the driver demands by using the electronic throttle. The rest of the power would be stored as electric energy to a later use. The performance of both engines adapts automatically to the driving conditions and to the charge status of the batteries.

During the car first start-up, the gasoline engine remains inactive, and it is the electric engine the one in charge of moving the vehicle. This situation is maintained provided that the power required by the driver is moderate and the battery charge is enough. This allows a smooth, silent, and completely clean driving.

When a higher power is required or when the battery charge is lower, the gasoline engine starts running, as we mentioned before, on a load range over 80%. As soon as the battery charge is enough, the combustion is deactivated and the car is again driven by electrical means only. With this, we avoid getting the gasoline engine working with partial and lower loads, where it is particularly inefficient.

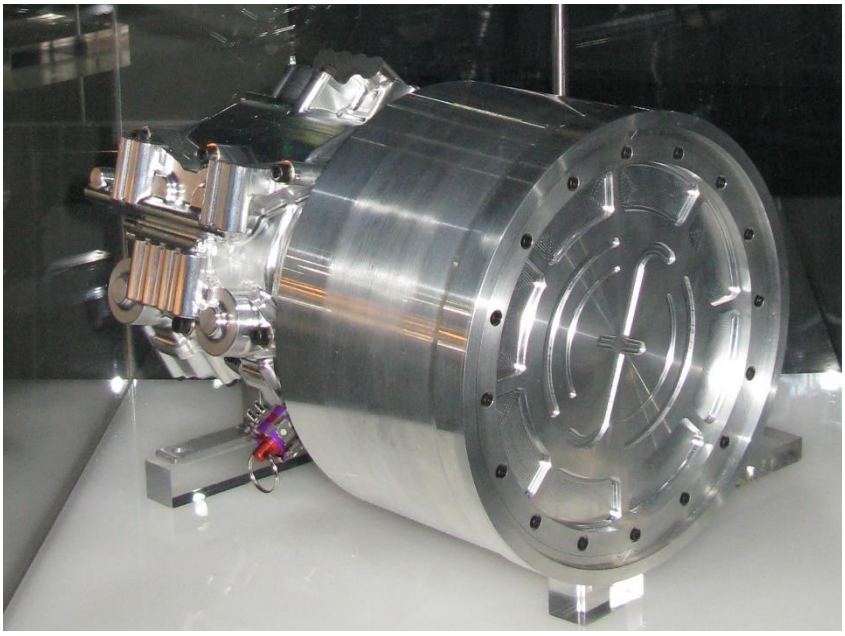
Power recovery

As it's said, one of the new features provided by hybrid cars is the possibility of recovering part of the power by using the regenerative braking.

This brake system is able to restore during braking part of the kinetic energy of the vehicle, just because the car is moving at a certain speed.

In a conventional braking system, the kinetic energy is converted (it fades) to heat or thermal energy as a result of friction between the brake lining or brake blocks, on one side, and brake discs or brake drums on the other.

During deceleration and braking, the electric engine behaves as an electricity generator and makes the most of the kinetic energy of the car to get electricity to be stored in the batteries.



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This allows to get some power back, which otherwise would be lost as heat with a conventional braking system. The regenerative braking system works as long as the brakes are used and when the car stops speeding. This way, the system offers its greatest performance in those situations in which we find continuous speeding and non - speeding, as for example in an urban context.

When driving on a highway the regenerative braking system works from time to time, for example, when driving down a slope for a long time or when speed is reduced after overtaking another car.

It is calculated that it is possible to get back 30% of kinetic energy, which means saving about a litre of gasoline in 100 km when driving in an urban context, where you can find constant braking. Moreover, regenerative braking allows the reduction of weight of the conventional braking system in about 22%, lengthening its lifetime.

Silent advantages

There is another type of pollution which is not so easily recognised, but equally harmful: that is acoustic contamination caused by engine cars. The main sources of acoustic pollution in nowadays society are caused by engine vehicles. They are considered to be responsible for almost an 80% of that type of pollution.

Industry is thought to be responsible for at least 10% of noise emissions; railway services cause another 6% and public places, such as bars, the other 4%.

In Spain, the second noisiest country in the world after Japan, the vehicle fleet – consisting of 22 million vehicles nowadays – generates some areas of intense urban noise close to 85 dB(A).

From 65 dB(A) upwards, which is the limit accepted by the World Health Organization, human beings suffer some symptoms caused by that constant noise. In urban areas with heavy traffic, part of it comes from engines, another part from the high friction of tyres and the road itself which causes a considerable degree of noise levels.

During the last decades car manufacturers have made a great effort to reduce the noise caused by vehicles. Thus, the exhaust systems have been improved; the engine compartment has been isolated and encapsulated, and some other noise sources have been acoustically optimized like the air inlets or the external aerodynamic shape.

To a certain extent, hybrid cars are still conventional cars, as long as they have a combustion engine which is more or less used. That is why, when the combustion engine is running to medium or high speed, almost 100% of the noise sources match those of a conventional vehicle.

Nevertheless, when the hybrid car is stopped or is moving at a low speed, some of them stop their gasoline engine and drive only using the electrical system to move. In that way, the noise emissions can be reduced in more than 95%. In an urban context, this circumstance is quite usual, as most of the time cars move with heavy traffic, and very slowly (below 45km/h) or, simply, they are stopped.

Thus, the great advantage of hybrid cars is the silent use which it allows in urban areas, where the negative impact of acoustic pollution is bigger.

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