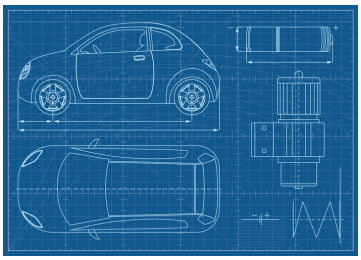
Hybrid Vehicles – a simple guide



hybrid [pronounced **hahy**-brid]

noun *A thing made by combining two different elements.*

Hybrid cars are becoming more and more prevalent and here at AA Thornton we handle patent applications directed to the wide range of technology involved.

This brief article explains exactly what is meant by a "hybrid", the different types of hybrid vehicle available and some of the technologies involved.

What is a hybrid?

Commonly called hybrid electric vehicles (HEV), as the definition above suggests, a hybrid car is simply one that relies on two different power sources for motion. The two different power sources are typically petrol and electricity (most common in the US) and diesel and electricity (which can be found in Europe).

There are three main types of hybrid vehicle; **full hybrids**, **mild hybrids** and **plug-in hybrids**.

- A **full hybrid** (FHEV) can run on just the combustion engine (i.e. diesel/petrol), the electric engine (i.e. power from batteries), or a combination. The Toyota Prius is the most commonly known example of this. A full hybrid is not plugged in to recharge; the battery is recharged by running the combustion engine.
- A **mild hybrid** has an electric motor and combustion engine which always work together. An example of this is the Honda Accord Hybrid. Mild hybrids cannot run in just electric or just combustion engine mode; the engines/motors always work in parallel.
- A **plug-in hybrid** (PHEV), as the name suggests, requires plugging into the mains in order to fully recharge its battery. PHEVs can be run in just electric mode.

The technology involved

The three types of hybrid all share features in order to work. The goal of a hybrid is to use the electric portion of the drivetrain as much as possible without compromising performance. Harmful emissions are reduced and the fuel efficiency of the car increases. This is because the electric motor is more efficient than a combustion engine and produces no emissions.

An exception to such a goal may be the La Ferrari, McLaren P1 and Porsche 918. These high performance cars use their electric motors to maximise performance, rather than maximise their efficiency and eco-friendliness.

> *"We wanted to use the hybrid technology to boost performances, like in F1, rather than use it just to reduce fuel consumption and emissions"*
>
> *Roberto Fedeli, Ferrari's technical director*

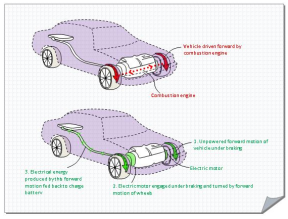
As mentioned above, to power the electric portion of a hybrid engine, a hybrid vehicle must carry a battery. The size of the battery varies depending on how much the vehicle is designed to depend on it, and the way in which the battery is recharged depends on the size of the battery.

For example, a plug-in hybrid can partially recharge whilst a car is being driven but usually needs to be plugged into the mains in order to fully recharge its large battery. It is not efficient for the combustion engine to fully recharge the battery on the go.

The smaller batteries in full and mild hybrids can be recharged in a number of different ways:

Regenerative Braking

Without such a system this kinetic energy would be lost – mainly in the form of heat as the brake pads of the car heat up due to friction of the brake pad on the brake disc.



Stop-start

There are numerous different types of stop-start system, which we will not go into in this article, but essentially a stop-start system automatically shuts the engine off every time the vehicle stops (for example, at the traffic lights) and restarts it instantly when the accelerator pedal is pressed.

Miles per gallon (MPG) figures can be noticeably improved by removing engine idling from a journey.

Engine Management

Hybrid vehicles also often include engine management systems which allow the engine to drive the electric motor/generator in certain portions of the drive cycle where it can most efficiently do so – thus charging the battery.

The fuel efficiency of a hybrid vehicle can also be improved by optimised tuning of the engine and transmission, for example:

Atkinson Cycle

Full hybrids most often use the "Atkinson Cycle". This is a four-cylinder engine operating cycle designed to increase efficiency at the expense of power by shortening the intake and compression strokes.

With the addition of an electric motor to fill in the gaps, the driver does not feel that the vehicle is underpowered.

Continuously Variable Transmission (CVT)

CVT is an efficient type of automatic transmission in which drive ratios are varied more steadily.

This enables an engine to run in its most fuel-efficient rpm range, thus increasing MPG.

The **Full hybrid** (FHEV)

e.g. Ford Fusion Hybrid, Toyota Prius, Honda Accord Hybrid

FHEVs use all the technologies described above and are the most fuel efficient type of hybrid vehicle. They are also able to operate in **series mode**, **parallel mode** or **all-electric mode**.

All-electric mode is self-explanatory and is typically used by FHEVs at low speed (for example up to around 30mph). Series mode also uses the electric motor to drive the wheels but the combustion engine is used at the same time as an on-board generator. Parallel mode uses the combustion engine and the electric motor together to drive the wheels.

The Mild Hybrid

e.g. Peugeot 308 e-HDi, Ferrari LaFerrari, Chevrolet Malibu

A mild hybrid is limited to parallel mode so can really be looked upon as having a battery and a helper motor. The electric motor is not powerful enough to drive the wheels at any real speed without the assistance of the combustion engine.

Mild hybrids typically have stop-start and regenerative braking, but are not capable of the MPG figures of a FHEV.

Plug-in Hybrid

e.g. Audi A2 E-Tron, BMW i8, Ford C-Max Energi, Kia Optima, Porsche Cayenne S, McLaren P1

Typically, plug-in hybrids use all the technology of a FHEV but have a larger capacity battery which can be plugged into the mains to charge (for example, overnight). The range they can drive in all-electric mode is higher than the average FHEV.

High Performance Hybrids

e.g. McLaren P1, Ferrari LaFerrari and Porsche 918 Spyder

Finally, and as touched on above, hybrid cars need not all be about maximising fuel efficiency. Another branch of hybrids use the technology to boost performance.

The LaFerrari, (defined as a mild hybrid from the list above) charges its batteries during braking or every time the combustion engine produces more torque than required, for example during cornering.

The excess energy (stored by the batteries) can then be used to provide a boost the next time the driver accelerates.

The LaFerrari can travel around 14 miles in pure electric mode, but Ferrari limited the top speed in full battery mode to just 3 mph. As Roberto Fedeli (Ferrari's technical director) said:

*"You can exit the garage in pure battery mode, but that's it. **This car is designed for extreme performance**"*

If you would like further detail on any of the above, or would like to discuss developments in the automotive world, then please do not hesitate to contact one of our experienced attorneys in the Engineering, Physics and Mechanical Devices sector.

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