The Hybrid-Electric Vehicles (HEV) – History, Possible Future, Pros and Cons

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The Vehicles We Drive

The road vehicles at the moment can be generally classified in three groups depending on their power trains:

1. Internal Combustion Engine (ICE) Vehicles
2. Electric Vehicles (EV) – having an electric drive train
3. Hybrid-Electric Vehicles (HEV) – having both
Internal Combustion Engine (ICE) Vehicles

Most common:
Gasoline and Diesel

Also popular in many countries:
Converted versions running on
• Liquefied Petroleum Gas (LPG)
• Liquefied Natural Gas (LNG)
• Compressed Natural Gas (CNG)
Internal Combustion Engine (ICE) Vehicles

Fashionable:
Bio-hydrogen, bio-fuel

Internal Combustion Engine (ICE) Vehicles

Hydrogen
Though not yet commercially available, hydrogen has been in the center of renewed public attention
Ironically, the very first operational Internal Combustion Engine in history was running on hydrogen.

Built by François Isaac de Rivaz between 1805 and 1807.
Now, two centuries later, hydrogen (still) has great chances to become the fuel of the future.

Its main advantages as ICE fuel are:

- relatively easy to adapt present ICE technology
- the almost zero direct emissions and
- its renewability
A technical review of the modern development of the Hydrogen-fuelled Internal Combustion Engine (H₂ICE) recently concluded that “Undoubtedly aided by the technological advancements of the ICE, simple H₂ICE options are convenient and economically viable in the near-term” (White et al).

Unfortunately, in the next 30 years there will not be enough renewable energy to produce hydrogen sustainably in any country, except for Iceland, with its abundance of geothermal and hydroelectrical power (Vergragt).
Other production methods are out of the question: if we would decide to replace transportation fuel with hydrogen by taking it from fossil fuels, then that would require more fossil fuel than currently used for the same purpose …(Shinnar)

If the hydrogen were to be released by electrolysis using solar- or nuclear-derived electricity, the cost would be higher. The direct use of the electricity would cost half as much as via the hydrogen route!
What about bio-fuel?

The most widely used transportation bio-fuel at the moment is bio-ethanol.
Using ethanol as a fuel additive to unleaded gasoline causes an improvement in engine performance and exhaust emissions (Agarwal).

But in all considered regions of the world ethanol is currently more expensive to produce than gasoline. Only ethanol produced in Brazil comes close to competing with gasoline.
Ethanol produced from corn in the US is considerably more expensive than from sugar cane in Brazil, and ethanol from grain and sugar beet in Europe is even more expensive (Demirbas).

Other disadvantages include significantly lower energy density than gasoline, **corrosiveness**, lower vapor pressure (making **cold starts difficult**), miscibility with water, toxicity to ecosystems, increase in exhaust emissions of acetaldehyde…
The EU biofuel policy has its outspoken critics too: “Knowing the current situation of the prices for raw materials, forcing European countries to produce and consume biofuel is not profitable either for the European countries or for individual users (Sobrino-Monroy).

It is worth mentioning that bio-ethanol is another example of a revived initiative.
The first commercially available vehicle already built to run on biofuel was offered in 1908.

Its engine was capable of running on gasoline or ethanol, or a mix of both.
Nevertheless, it was gasoline that grew to be the fuel of choice on the market, and the automotive industry became addicted to petroleum.

From 1895 to 1910, electric automobiles were more common in most areas of the United States and Europe than gasoline internal combustion vehicles (Sovacool).
Among the reasons blamed for the decline of the EVs we shall mention their much shorter range compared to ICE, the lack of infrastructure, the poor management and faint marketing on behalf of the electric car manufacturers, as well as the successful lobbying of the petroleum companies.
Environmental and economic worries of modern time have revived the interest towards the EVs. Despite their need for time-consuming recharging and high battery costs, the Battery Electric Vehicles (BEV) have stayed with us in more or less inconspicuous forms.
Electric Vehicles (EV)

They are noiseless, have no direct emissions, but at the same time their disadvantages have remained generally the same.

Electric Vehicles (EV)

Apart from BEV, another type of EVs has emerged – the high-tech FCEV, using hydrogen or ethanol to produce its own electricity. But their commercial application is still under development.
The HEV represents a combination of ICE and an electric motor in an attempt to bring together their benefits.

The hybrids use the worldwide infrastructure created for ICE over the last one and a half century, and at the same time partly enjoy the advantages of the BEV - as a result we achieve improved fuel economy and reduced emissions.
The idea of the hybrid is not new – the luxury sports car producer Porsche proudly states that the first HEV was built in 1900 by their founder Ferdinand Porsche at the age of 25.

Lohner Porsche - the first hybrid vehicle
Hybrid-Electric Vehicles (HEV)

After many attempts over the decades by different inventors and carmakers, the HEV equipped with a modern gasoline engine and an electric motor finally came back on a commercial scale in 1997.

It was then that Toyota successfully launched its Prius model in Japan.
Hybrid-Electric Vehicles (HEV)

Honda followed in 1999 with the Insight

Then in 2004 Ford launched the first American HEV.

Let us have a guess…
Yes, it was an SUV…

The birth of this Hybrid-Electric Off-Road Vehicle insulted some of the environmentalists:
if someone would like to reduce its fuel consumption, why doesn’t he reduce the size of the driven vehicle?
Hybrid-Electric Vehicles (HEV)

The truth is, that when consumers choose their vehicle, they start with a wrong formula: they are looking for efficient ways how to spend less without changing their way of life.

In other words, if I drive like I do now, how much fuel can I save if I choose the more expensive, but less fuel consuming engine for the same size of the vehicle I am now used to?
Instead of changing their attitude, most customers are trying to keep their habits as constants.

They start calculating based on a wrong model, and as soon as the extra purchase cost seems to be too high in comparison to the future returns on this investment, most of the customers abandon the idea of purchasing expensive efficient technology.
Hybrid-Electric Vehicles (HEV)

Or they start driving more in order to justify the more expensive purchase, which brings us to a classical form of the rebound effect.

Hybrid-Electric Vehicles (HEV)

A recent analysis of the driving habits of about 360,000 vehicle owners by an American insurance services company has shown that many owners of hybrid vehicles drive as much as 25% more miles than owners of non-hybrids.
Hybrid-Electric Vehicles (HEV)

So is it a good thing to sell / buy hybrids?

A study in Switzerland investigated two different possible direct rebound effects of Toyota Prius: above trend increase in size of the purchased car and the increase in average household car ownership.
No rebound effect was revealed in either case. On the contrary: vehicle size slightly decreased, and the low numbers of first-time buyers and non-replacement vehicles would even lead to a decrease in average vehicle ownership.

Furthermore, according to the study, the introduction by some of the Swiss cantons of tax rebates for hybrid vehicles appears to be effective in achieving reduced CO₂ emissions.
But this is only Prius and only in Switzerland.

An American study in 2002 found that the Prius was not cost-effective in improving fuel economy or lowering emissions.

Following the line of thought drawn by the Swiss study, in the future it would be interesting to investigate the change in size of the purchased car in the case of Hybrid Electric SUV like Ford Escape Hybrid, Toyota Highlander Hybrid or Lexus RX 400h.
Hybrid-Electric Vehicles (HEV)

We may then consider the following possible Hybrid Electric SUV cases:

A. If the customer would have bought a smaller and more efficient car, but buys an SUV only because it is available as a hybrid, then we have a negative effect.

B. If the customer would have bought a regular SUV anyway, and chooses a similar size Hybrid Electric SUV instead, then we have a clear reduction in the direct emissions per km as well as in the noise level.

In both cases incentives for the buyers are questionable, because

In case ‘A’ they will provoke a negative effect.

In case ‘B’ the state will be financially supporting those buyers, who have higher than average income and are spending it on the more expensive SUVs.
Consequently, instead of tax rebates on hybrid versions it may be beneficial and fair to add a punitive tax to vehicles with worse environmental performance.

Whatever the average European opinion is on the American taste for SUVs with big gasoline engines, if we agree that the hybridization process shall start with the most popular models on the market, then the presence of Hybrid Electric SUVs there shall be fully justified.
Hybrid-Electric Vehicles (HEV)

Obviously, it shall be a totally different issue in other countries, where SUVs are considered luxury goods and are taxed accordingly.

Hybrid-Electric Vehicles (HEV)

That is why from the environmental point of view it is utterly strange to see the following Hungarian example.
According to the current legislation a new Toyota iQ (998 cm\(^3\) gasoline engine, combined fuel economy 4.3 L/100km, CO\(_2\) combined mass emission 99 g/km) has a registration tax of 250,000 HUF (circa 919 EUR).

while any newly registered HEV has a tax of 190,000 HUF (circa 699 EUR), even if it is a vehicle like Lexus RX 450h (Hybrid Electric with 3,456 cm\(^3\) gasoline engine, combined fuel economy 6.3 L/100km, CO\(_2\) combined mass emission 148 g/km).
Hybrid-Electric Vehicles (HEV)

Still yet, in terms of the average new vehicle’s CO₂ emissions significant progress is expected from the large vehicle segments through their hybridization. There is a paradox of seeing hybrid SUVs or hybrid luxury cars as part of the solution…
Hybrid-Electric Vehicles (HEV)

But the strongest point in favour of HEV is the role it plays in bridging the gap between different technologies.

Hybrid-Electric Vehicles (HEV)

Their commercial success will certainly contribute to the development of better batteries, paving the way for the Battery Electric Vehicles of the future or for the Plug-in HEV running on biofuel.
Hybrid-Electric Vehicles (HEV)

The greater part of the consumers is distrustful of the new technology and sceptical of BEVs due to its limited range and heavy expensive batteries.

Hybrid-Electric Vehicles (HEV)

HEV can operate with smaller batteries than BEV due to its ICE and the existing convenient fuelling opportunities.
Hybrid-Electric Vehicles (HEV)

Compared to BEV and FCEV the moderate price premium of the HEVs makes them look affordable, while the constantly rising fuel prices make the purchase look more and more practical.

Hybrid-Electric Vehicles (HEV)

HEV seems a totally acceptable solution to many, providing crucial selling volumes for the carmakers and a great testing ground for improving batteries.
Hybrid-Electric Vehicles (HEV)

If the HEV trend shall continue, then the progress in improving the batteries will subsequently influence the development of the Plug-in Hybrid Electric Vehicles (PHEV), which will naturally create a demand for charging facilities.

Hybrid-Electric Vehicles (HEV)

A new network of charging points will gradually appear to meet the new requirements, encouraging more and more customers to join the electric club.
A commercial application of the promising FCEV is still at least two decades away. The sustainable production of biofuel and hydrogen is still to be achieved, regardless of the fact where these fuels will be used – in ICE vehicles or in FCEV.
Conclusions

While creating an ethanol fuel network appears to be feasible, the infrastructure for hydrogen filling stations is still in the distant future, waiting for many solutions of technical and safety nature.

Conclusions

Compared to the above the HEV technology has matured and has earned a popular progressive image.
Conclusions

With proper support HEV can become an essential tool for accustoming the consumers to personal electric transportation, paving the way to PHEV, provoking the spread of electric charging (or “battery swap”) points, and finally arriving to a point where the engine would be replaced by fuel cell technology.

Conclusions

Until then the HEVs can help reduce CO$_2$ emissions, pollution and noise.
Thank you!