



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Utilisation and development of hybrid technology
in road cars and motorsport

Rhodri Jones 2305734

9/10/2023

Academic skills

ACHA4005

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Introduction

The purpose of this technical report is to research and analyse how hybrid technology is being utilised and developed in road cars and motorsports. Hybrid technology utilises a combination of electric and Internal Combustion Engine (ICE) power in vehicles. The report will mostly focus on the development of hybrid technology in road cars but will also touch on some information about motorsports and the benefits and drawbacks of each.

Aims of the report are to look at:

- Limitations and challenges of current hybrid technology
- Benefits and drawbacks of performance hybrid technology in motorsports
- Energy efficiency and fuel consumption patterns with hybrid technology and compare it to ICE in motorsports.

Background

Motorsports has been a major paving way for developing innovative automotive technology and pushing the boundaries of what's possible. Hybrid technology is a way of promoting more sustainable transportation and greener ways of practicing motorsports. In recent years with a slow shift to more hybrid technology in the automotive industry, the motorsport industry is experimenting with hybrid technology as well.

As stated by the racing team president of Toyota, Yoshiaki Kinoshita (2014), their aim is to develop their hybrid technology through racing, enabling the development of advanced road cars for the future and

swiftly bringing well-proven technology to consumers. The of hybrid technology into motorsports is not only responsible for innovation and development in technology, it is also responsible for growth in environmental concerns. Hybrid technology cuts down on fuel emissions and this could be a significant development for motorsport as the ICE cars use a lot of fuel.



Figure 1 Comparison of Petrol Hybrid Toyota Auris II and Diesel Volkswagen Golf VII. Transport & Environment on Twitter.com (3 Oct 2017) (<https://twitter.com/transenv/status/915230175301955584>).

This comparison shows that the petrol hybrid Toyota Auris II has a fuel consumption of 3.9L/100km and CO₂ emissions of 91 gCO₂/km, while the diesel Volkswagen Golf VII has a fuel consumption of 4.4L/100km and CO₂ emissions of 114 gCO₂/km. This comparison is just one example where hybrid technology is more efficient and cleaner to run than an ICE.

Hybrid cars typically have a higher retail price than combustion engine cars due to the increased price of the hybrid technology and batteries, but this can be better in long term as the electric motors in hybrid vehicles are more reliable than a typical ICE car. ICE cars have more parts that wear down faster than hybrid cars, making maintenance more frequent. Hybrid vehicles also cost less in the terms of fuel as they tend to be more fuel efficient than ICE vehicles. The electric motor also reduces fuel costs when driving at lower speeds such as in a town or city.

Limitations and challenges of current hybrid technology

There are many challenges and limitations to having a hybrid engine as there are more issues to look out and complications of one element disturbing another. These are some of the most common.

Current Challenges

- Weak Batteries
- Catalytic Converter Issues.
- Evaporative Emissions System.
- Lower fuel efficiency on motorways.
- Oxygen Sensors.

Weak batteries

Fuel costs in hybrid vehicles are less than ICE vehicles due to increased fuel efficiency and the combination of a conventional combustion engine and an electric battery. While fuel costs are reduced, the batteries in hybrid vehicles can wear down quicker than one in an ICE car.

Catalytic converter issues

Catalytic converter issues usually occur after long term usage of hybrid vehicles and significant mileage accumulated. It normally shows itself via reduced acceleration issues and diminished performance. Also, if the issue is not addressed quickly it could lead to other problems further down the line.

Evaporative emissions system

Another typical issue with hybrid vehicles is the failure of evaporative emissions systems. This issue typically occurs due to leakages in the valves and if this does happen the complete system needs to be replaced.

Lower fuel efficiency on motorways

Hybrid vehicles recharge the battery while driving by using the heat from the brakes. On motorways, braking happens less frequently resulting in the battery being recharged slower and more fuel being used. To counteract this, drivers of hybrid vehicles can stop to recharge the battery at a charging point.

Oxygen Sensors

Oxygen sensors are installed to regulate the amount of unburned oxygen in the exhaust. Sometimes these can fail, leading to issues of high oxygen levels being left behind. The issues created by the higher oxygen levels means that more fuel will be consumed therefore counteracting the purpose and advantages of a hybrid engine.

Hybrid vehicle technology is still in its infancy and as with most mechanical things when they are brought out first, hybrid vehicles are still experiencing some challenges.

Benefits and drawbacks of performance hybrid technology in motorsports

There have been many claims that because of the compromise between power and fuel efficiency, hybrid cars would be slower than ICE cars. This is not always the case as the electric motor in hybrids provide instant torque resulting in slightly faster acceleration. With more development work being done in the performance car industry there are more and more improvements being made.

An example of this would be the Porsche 919 Hybrid “As the twice winner of the FIA World Endurance Championship, Porsche itself has coined it “the most complex Porsche race car ever.”

Coupling a tiny 2 litre V4 turbocharged petrol engine with a series of lithium-ion batteries, Porsche has managed to create a racer with a combined 900 horsepower and one of the most advanced energy recovery systems. Not only is electrical energy recouped upon braking, but again during acceleration through exhaust gas.” ([source](#))

Performance cars were introduced to hybrid engines in 2014 when the rules for F1 were brought in by the FIA. In this year “F1 cars switched from the traditional 2.4 litre V8 to a 1.6 litre V6 “power unit” ([source](#)).

One of the benefits of this technology is that it utilises the braking recovery system to make the sport greener and cars more fuel efficient. The cars now use about 30% less fuel than when they had the 2.4 litre V8’s.

There are growing benefits of hybrid engines in performance cars, such as:

- Increased fuel efficiency
- better performance due to the electric battery providing instant torque
- faster initial acceleration
- increased power.
- Better performance due to no longer needing to carry the weight of the fuel required when racing

However, there are also still many drawbacks of hybrid engines in performance cars too:

- The hybrid technology systems are typically heavier than conventional ICE systems.
- Increased cost to buy and develop.
- maintenance costs are increased due to more expensive components in the hybrid system.

Energy efficiency and fuel consumption patterns of hybrid technology and compared to ICE in road cars and motorsports.

This section of the report looks at the difference in fuel consumption between hybrid and ICE engines both in day-to-day use and racing.

	Fuel Economy mpg	Running Costs p/mile	CO2 emissions g/km
Petrol only	30	25.5	218
Petrol HEV	45	17.0	145
Petrol PHEV	90*	10.4 – 12.2**	95***
Diesel only	45	18.0	170
Diesel HEV	60	12.8	128
Diesel PHEV	120*	8.2 – 10.0**	86***
Full EV	-	3.7 – 7.3**	45***

Table 1: Fuel Economy, Running Costs and CO₂ Emissions

* does not include electrical energy

** depending on price of electricity

*** at current carbon intensity of grid power.

(Figure 2: table comparing fuel efficiency, running costs and CO₂ emissions. from

<https://catagen.com/2022/08/31/blog-benefits-of-hybrid-cars-for-fuel-consumption-and-cost-of-ownership/>)

Road cars

The average fuel consumption of an ICE car is around 24 – 30 mpg while the average fuel consumption of a petrol hybrid car is around 45 – 60 mpg. The average running cost of a 1400cc ICE car is around 15p/mile compared to a petrol hybrid Toyota Yaris with a 1500cc engine which costs around 8p/mile.

CarsDirect.com suggests that the Toyota RAV4 Hybrid performs at 40mpg average fuel consumption and costs around \$1,050 to run annually compared to the ICE RAV4 which costs around \$1,500 annually.

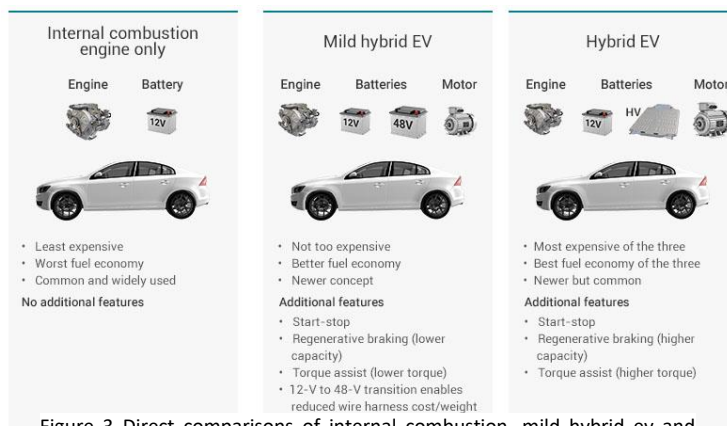


Figure 3 Direct comparisons of internal combustion, mild hybrid ev and hybrid ev. https://e2e.ti.com/blogs_/b/behind_the_wheel/posts/mhevs-optimizing-the-automotive-powertrain-for-efficiency-and-cost

Motorsport

Race car engineering.com says that the development of Toyotas LMP1 hybrid from 2013 to 2019 has made the car much more fuel efficient. The 2019 car performed using 300kg less fuel and travelling 500km further than the 2013 LMP1.

In Le Mans, the hybrid car fuel allocation is 80.2kg per hour, with the non-hybrid cars having a fuel allocation of 110kg per hour with 35.2kg and 52.9kg per stint respectively. (from Autosport.com)

Therefore, it is obvious that hybrid technology has come far in increasing fuel efficiency and is much greener in both aspects of usage, on the roads and in motorsport.

Conclusion

In this report it has been clear to see that on the road hybrid cars appear to better than ICE cars as they are cheaper to run and are significantly more fuel efficient. In the motorsport series discussed in this report, there are many benefits to using hybrid technology. In F1, it can be beneficial as the cars don't need to carry quite as much fuel. In Le Mans, the cars carry less fuel and can travel a much further distance. Therefore, in conclusion the development of hybrid cars continues to take priority in the motor industry and is incorporating all uses, both on and off the main roads. It will be interesting to see what future developments arise from the work currently being carried out.

References

Figure 1: <https://twitter.com/transenv/status/915230175301955584>

Figure 2: <https://catagen.com/2022/08/31/blog-benefits-of-hybrid-cars-for-fuel-consumption-and-cost-of-ownership/>

Figure 3: https://e2e.ti.com/blogs_/b/behind_the_wheel/posts/mhevs-optimizing-the-automotive-powertrain-for-efficiency-and-cost

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