

BEng Motorsport Engineering

Sustainability Challenges in Industry

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Introduction

In this assignment, I will discuss the idea of alternative fuels and powertrains in the automotive sector. This includes the use of battery electric vehicles, fuel cell electric vehicles, as well as synthetic fuel internal combustion engines and hydrogen powered ICE vehicles, among others. The environmental impact of current automotive fuel technology will be investigated, as well as the sustainable practices currently being put into place in order to mitigate this impact. The challenges facing the widespread uptake of alternatively fuelled vehicles will also be explored, and a PEST analysis will be carried out to this end. Finally, a prediction will be made looking to the future of alternative fuels, including the impact of this on consumers, manufacturers and suppliers, and governments.

1: Environmental Impact

The automotive industry demands the manufacture and use of a significant amount of petrol and diesel from crude oil. 2021 saw the production of 77.07 million barrels of crude oil per day (Davis & Boundy, 2022). This produces a large amount of pollution in itself, in both the acquisition of crude oil and its processing into petrol and diesel. The drilling for crude oil disturbs land and marine ecosystems, at oil wells and oil rigs, due to the clearing of land and the probing for oil (EIA, 2022), and the processing and transport of oil can see oil spills that deal long lasting damage to the environment, where recovery can take up to 10 years (Barron, Vivian, Heintz, & Yim, 2020).

There is also a concern about the depletion of world crude oil reserves. The expected decline in production in ex-USSR countries and in Africa, which together comprises more than 50% of EU supply, coupled with the expected increase in demand from Asia and Africa both jeopardise overall crude oil availability (The Shift Project, 2020). Due to the depletion of commonly used oil reserves, other methods of finding oil are employed. One of these methods is fracking, which consists of pumping water, sand, and other chemicals deep underground in order to force oil and natural gas to the surface. This fracking can also damage water quality, and cause adverse effects for the health of people in nearby communities (National Institute of Environmental Health Sciences, 2022)

Air quality can also be badly affected, with combustion processes releasing toxic chemicals derived from the natural gas. This includes the flaring of natural gas, the use of heavy equipment at the site itself, and the array of chemicals used in the process itself (National Institute of Environmental Health Sciences, 2022).

Fuels in the automotive sector also produce emissions when in use. The combustion of these hydrocarbon fuels produces many pollutants, chief among them being CO₂, CO, carbon dust, and NO_x emissions.

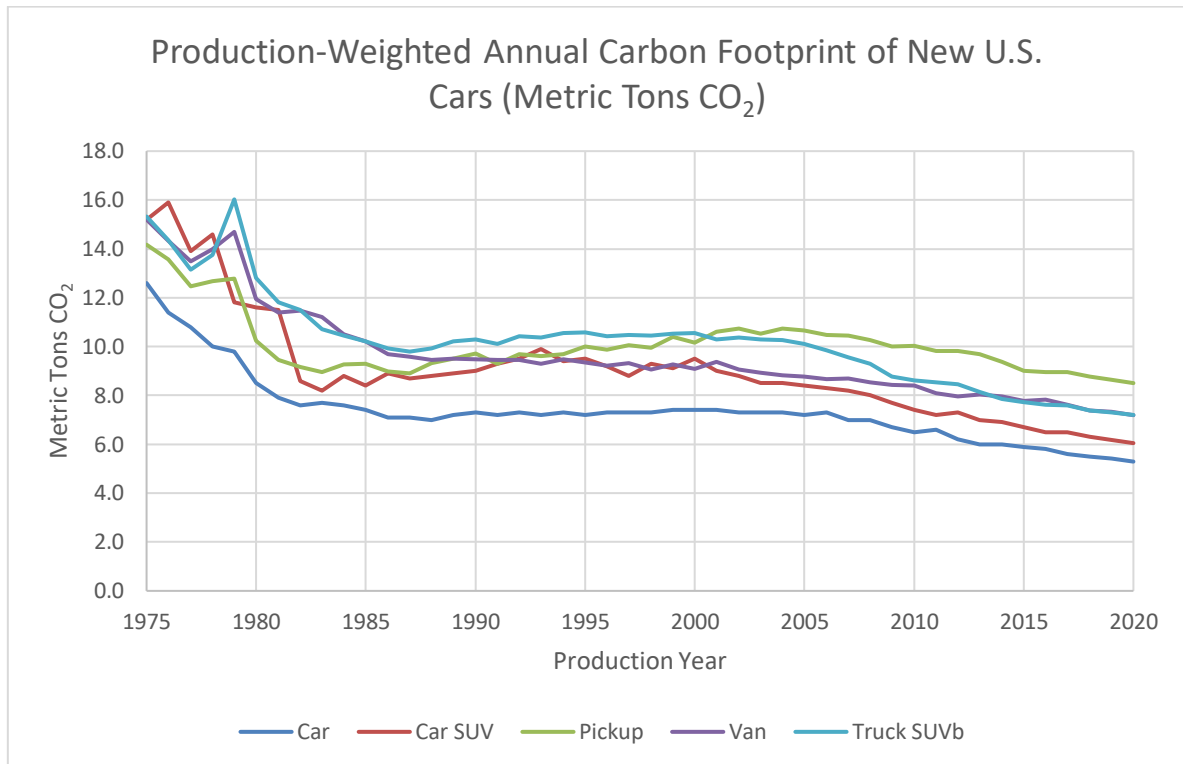


Figure 1 - Annual Carbon Footprint of New U.S. Cars (Davis & Boundy, 2022)

The figure above shows the carbon footprint of new U.S. cars over time, and one can see that the overall carbon output is decreasing, however still amounts to roughly 4.6 metric tons of CO₂ for cars. CO₂ is a greenhouse gas that contributes to global warming and the acidification of the oceans (Lindsey, 2023), and thus has a large adverse impact on the environment.

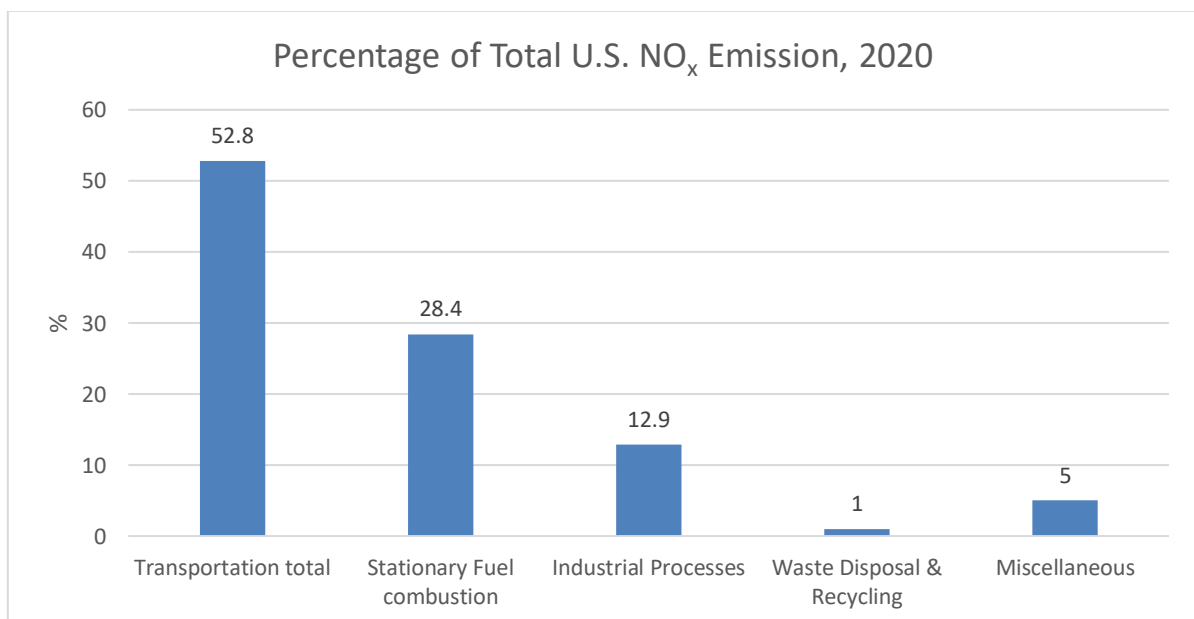


Figure 2 – Percentage of Total U.S. NO_x Emission, 2020 (Davis & Boundy, 2022)

NO_x emissions are also significant pollutants, and NO_x emissions from transport makes up nearly half of all NO_x produced (Boningari & Smirniotis, 2016), and over half of USA NO_x production (Davis & Boundy, 2022). NO_x emissions are created by the burning of air, and are thus generated in ICE engines of all fuel types. NO_x emissions consist of a variety of nitrogen oxides, chiefly including nitrogen monoxide (NO), nitrogen dioxide (NO₂), and nitrous oxide (N₂O). NO_x emissions can cause respiratory problems, including lung inflammation, bronchitis, and so on (Boningari & Smirniotis, 2016), and N₂O is a greenhouse gas whose greenhouse impact per molecule is 300 times higher than that of CO₂ (Boningari & Smirniotis, 2016). NO_x emissions also react with sulphur dioxide in that atmosphere to form acid rains, and also react with other common organic chemicals in the air to form a variety of toxic products.

2: Sustainable Practices and Legislation

In a drive to make the automotive industry more sustainable, alternative fuels and powertrains are seeing increasing use and technological development. In the UK, the current cutoff date for the sale of ICE-powered vehicles is 2035, which was pushed back from 2030 in late 2023 (Roberts, Industry reacts to 2030 new car and van fossil fuel ban delay, 2023). In Europe, the EU reached an agreement with Germany on the 25th of March to permit sale of new ICE cars past the original 2035 deadline provided those cars operate only on carbon-neutral fuels (Visnic, 2023), such as synthetic fuels or hydrogen. European cars must also follow the Euro 6 emissions regulations, with buses and trucks having stricter exhaust emissions limits come Euro 7, as well as electric vehicles having minimum performance requirements for battery durability in electric and hybrid cars (European Parliament, 2024).

Electric Vehicles

Electric vehicles use lithium-ion batteries to run cars on pure electricity. This of course produces no emissions at the tailpipe, and so the environmental impact of running the car is based on the source of the electricity used, which varies based on location (ElectricityMaps, 2024). EVs have taken a larger and larger place in the automotive industry in recent years, with EVs becoming commonplace on the road, and in February 2024, 17.7% of all new car registrations in the UK were electric cars (Edwards, 2024). Carmakers have also pledged to go all electric with new cars, with Jaguar targeting 2025, Bentley, Cadillac, Volvo, and Fiat targeting 2030, Lexus 2035, and so on (Duffy, 2023), not to mention Tesla itself. Virtually all major carmakers are making or are planning on making new electric vehicles, with the battery technology improving significantly from the early EV models to give greater ranges and performance (Citroen, 2021).

One drawback of electric vehicles is the carbon footprint of their manufacture in comparison to conventionally powered vehicles. Due to the environmental impact of the manufacture and disposal of lithium-ion batteries, manufacturing these cars produced roughly 60% more carbon emissions than conventional cars (Jolly, 2023). This trend can also be seen in the figure below, using data from 2015, albeit to a lesser extent:

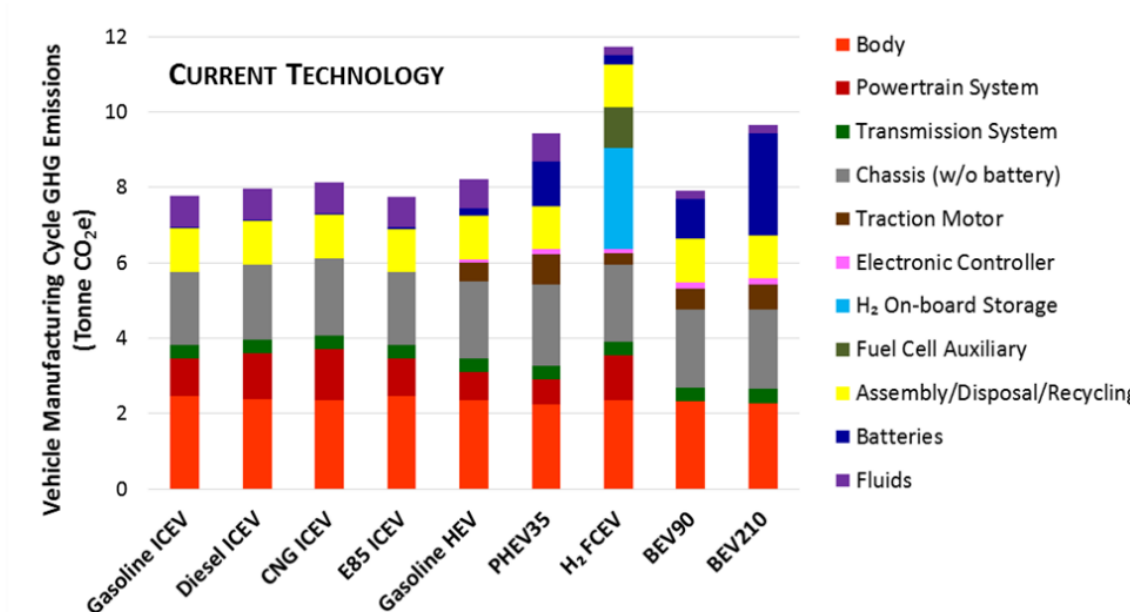


Figure 3 - 2015 vehicle cycle GHG emissions by vehicle component (Elgowainy, et al., 2015)

However, due to the reduced emissions from using electric vehicles, there comes a break-even point where the overall carbon footprint of the EV is less than the overall footprint of a conventionally powered car, and this point varies based on the cleanness of the available electricity. However, even if the car is manufactured and powered with mostly coal-derived electricity, the EV's overall footprint is lesser after 70,000km, or roughly 6 years, and in 2 years based on the UK electricity data (Jolly, 2023).

Synthetic Fuels

Synthetic fuels are a drop-in replacement for conventional hydrocarbon fuels, that are created synthetically rather than by using crude oil. This process harvests CO₂ from the atmosphere in order to create petrol cleanly, and this CO₂ is then released back into the atmosphere when the fuel is burned. Car manufacturers like Porsche (Porsche Newsroom, 2023) and Mazda (Mazda, 2017) are backing the adoption of synthetic fuels. Porsche aims to run their current cars on synthetic fuels in the future, and run some new cars on these fuels as well. This is another benefit of the adoption of synthetic fuels: ICE cars running on conventional petrol today can run on synthetic fuel, bringing them into the decarbonisation effort (Porsche Newsroom, 2023). On the other hand, due to the creation of synthetic fuel being energy intensive, and the manufacturing process not being totally lossless, it can be seen as inefficient to create synthetic fuel (Liboreiro, 2023), and given that there is now way to ensure that end users use e-fuels rather than conventional fuels, there is created a risk of greenwashing. The eFuel Alliance admits that the concern over energy efficiency is a valid one, however suggests setting up production centres in countries with ideal conditions for solar and wind power generation, such as in Africa, the Middle East, and South America (Liboreiro, 2023). This has been met with resistance from

groups arguing that, in the midst of the Ukraine war and the climate crisis, another dependency on imported fuel and energy would be detrimental for Europe in a wider political sense.

In the motorsport industry, Porsche are also working to bring synthetic fuels to their hybrid powertrains in IMSA, working the Exxon to do so. IMSA currently runs an 80% synthetic fuel blend, but state that ‘in the future, a 100% renewable fuel could be in our playbook’ (Payne, 2023). The Formula 1 technical regulations also mandates the development and use of race synthetic fuels from 2026 (FIA, 2023), which will direct significant resources into the development and use of these fuels with OEM and tier 1 supplier support.

Hydrogen

Hydrogen powered cars can be split into hydrogen FCEVs and hydrogen ICE vehicles. Hydrogen FCEVs can be found on the roads today, notably the Toyota Mirai and Hyundai NEXO. These cars use stored hydrogen and the air to generate clean electricity, with zero tailpipe emissions (USDOE, 2024), only producing water from the tailpipe. The production of hydrogen can be carried out with a variety of methods, from water electrolysis, via biomass, and by using fossil fuels, where carbon capture can be utilised to reduce the carbon footprint of the process (USDOE, 2016). Another difficulty of hydrogen is it’s transportation and storage, as it is a very light gas. Generally, hydrogen is either stored at high pressure or cryogenically, in order to give meet expectations for range, refuelling time, performance, and space (HFTO, 2020). One concern of hydrogen ICE cars is that, while they do not produce carbon emissions at the tailpipe, due to the burning of air NO_x is still produced as a pollutant (Berg, 2023), and in high quantities due to the lean fuel mix that hydrogen engines typically run. To mitigate this, EGR systems are often employed (Yao, Sun, Tian, Luo, & Tang, 2014).

In motorsport, Toyota is pushing for hydrogen-powered ICE vehicles to stay. They have developed a GR Yaris rally car, run a GR Corolla in the Japanese Super Taikyu endurance racing series, and have teased a potential Le Mans entry with the GR H2 Racing Concept (Berg, 2023).

3: Sustainability and Technological Challenges

It is widely accepted that there needs to be a large uptake and increase in infrastructure and availability for alternative fuels to become economically viable. Even electric vehicles, which has been widely adopted by the industry, still face infrastructure challenges in many parts of the world, with limitations in charging stations and in the availability of green electricity.

For the manufacture and sale of synthetic fuel-powered cars, this is less of an issue, due to the general compatibility of the cars with conventional crude-oil derived fuels. However, for hydrogen powered cars for example, the issue of refuelling infrastructure becomes a larger one, where there simply isn't enough infrastructure present to justify the widespread commercialisation of hydrogen powered cars (Berg, 2023). The development of this infrastructure needs to be worked on with co-operation between researchers, developers, and governments to ensure that all areas of the industry are working in unison.

It is also important to keep costs of alternatively powered vehicles manageable if the goal is for widespread adoption. At present, electric vehicles have a greater upfront cost than their conventional counterparts, with, for example, a brand new petrol Vauxhall Corsa costing £19,625, and the electric version costing £32,445 (Vauxhall, 2024). While the average cost of running an electric car tends to be lower, this upfront cost difference is nevertheless a deterrent to the widespread uptake of electric vehicles, especially in developing countries.

These factors are connected, as the economic viability of alternatively fuelled vehicles is directly tied to the demand. This is influenced by the available infrastructure, the advancement of the fuel technology itself, as well as the government regulations themselves. When governments make provisions for alternative fuelled cars in legislation for the future, manufacturers invest in furthering the technology, and can be sure that the technology will not quickly become obsolete. This results in better cars, increasing demand, and thus makes investing in increased infrastructure economically viable, further increasing the desirability of the cars themselves. Therefore, each aspect of the industry is codependent. For example, emissions regulations that specify zero tailpipe emissions jeopardise the future of synthetic fuel development (StarCarSifu, 2022).

As a result of this, it is best that world governing bodies can come together based on research into the current and projected future state of the industry, and are able to give manufacturers the confidence to commit to long-term technology and infrastructure development.

4: Future Outlook

Looking to the future, it appears that EVs will likely continue to play a large part in sustainability in the automotive industry in the short and medium term. However, at present EVs are synonymous with the sustainability drive in the industry, although it appears that with the pace of other technologies advancing this will no longer be the case, and more research will be made into synthetic fuel and hydrogen, which will play a larger part in the industry in the future. Car manufacturers want to continue to use ICE technology they have engineered to be so efficient, and consumers, especially in Germany, wish to continue to buy and drive ICE-powered cars. Furthermore, especially in developing countries, the upfront cost and electricity requirements of EVs are a deterrent to their widespread adoption. Therefore, it appears that the impending ban on ICE engines, bar the use of carbon neutral fuels, such as synthetic fuels and hydrogen, will go ahead in the EU as now planned. This allows a suitable transition period for manufacturers. It is also important to stick to this timescale, as otherwise the automotive industry cannot effectively plan for the future, such as in the fallout of the UK's decision to postpone their ban (Roberts, 2023). It is likely that the rest of the world will somewhat follow suit with the EU's decision, considering the impact that Europe has on the car industry and the desire for congruence between regional regulations, in order to optimise technology costs. It also appears that EVs will continue to have a large place in the future, with the current plans for the future of the UK, USA, and China heavily including EV investment.

The impact this would have on different stakeholders should also be considered. A move away from pure EVs, more towards maintaining the ICE using synthetic fuel, would benefit car manufacturers and oil companies, due to the decreased cost of maintaining this technology into the future (Zaremba, 2023). The impact on consumers will also vary based on the consumer. This is due to differing priorities that car buyers are looking for, including cost, range, running costs, maintenance costs, environmental concerns, performance, and even emotional connection (Gauer, Axsen, Dutschke, Long, & Kelber, 2023). Buyers tend to have a greater emotional connection to ICE cars, however also often see buying EVs as being environmentally conscious.

Conclusion

To conclude, the environmental impact of conventional and alternative fuels and powertrains were explored. The impact made by the manufacture and use of conventional fuels were explored, as well as the use of some alternative fuels and powertrains, with their effectiveness and limitations discussed. The main challenges facing the widespread implementation of alternative fuels were also analysed, regarding the political, social, economic, and technological obstacles that need to be solved. Finally, the future of the industry was examined, in regards to sustainability, future technology development, and the impacts made on consumers, manufacturers, suppliers, and governments.

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