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Use of Energy Carriers:

Legislation & Practicality Approach

Automotive Materials and Sustainability (ACHA6012)

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1 Introduction

Motorsports, particularly Formula One (F1), have always been at the forefront of technological innovation. The advancements made in F1 have often been translated to the automotive industry, making it an ideal platform for research and development. In recent years, the need for sustainable energy sources and the negative impact of fossil fuels on the environment has led to a shift in focus towards renewable energy sources. This paper will critically analyse a range of energy carriers in terms of operation and effectiveness and consider the implementation of said carriers to reduce environmental impact.

Climate change, pollution, and depletion of natural resources are all pressing issues that require urgent attention. This is especially true for industries that have a significant impact on the environment, such as the automotive and motorsports industries. In recent years, there has been a growing recognition of the importance of sustainability in motorsports, with stakeholders working to develop and implement solutions that promote sustainable practices while maintaining the excitement and competitiveness of the sport.

Motorsports are a popular form of entertainment and competition that attract millions of fans and generate billions of dollars in revenue worldwide. However, they are also known for their high carbon emissions and environmental impact. The use of Internal Combustion Engines (ICE) in motorsports has been a major contributor to this impact, with the emissions of greenhouse gases such as carbon dioxide and nitrogen oxides. The industry has recognized the need to promote sustainable practices, and there have been significant efforts in recent years to develop and implement solutions that reduce the environmental impact of motorsports whilst maintaining their excitement.

The growing concern over the impact of carbon emissions on the environment has driven various industries to seek sustainable alternatives to their current energy sources. The motorsports industry has been under intense scrutiny due to its significant contribution to carbon emissions. As such, stakeholders within the industry have been under pressure to seek ways to mitigate the impact of their operations on the environment.

This report presents a proposal to the Fédération Internationale de l'Automobile (FIA) for Formula 1 to adopt e-fuels as a more sustainable energy carrier for both their racing cars and logistics operations. The proposal will critically analyse the advantages of e-fuels compared to other alternative energy sources such as battery-electric and hydrogen fuel cell. The feasibility and cost-effectiveness of such

a transition will also be evaluated. Moreover, the potential impact of this transition on the environment and how it aligns with current and future legislation will be discussed in detail.

2 Literature Review

According to the 2023 Formula 1 Technical Regulations teams are allowed to use a maximum of 105 kg of fuel per race. The regulations do not specify how much fuel is allowed to be used in qualifying and sprint races and it is mentioned that during practice sessions, teams may use as much fuel as they deem necessary to complete their testing and preparation for the race weekend, the only rule they must still comply with is the fuel flow rate limit of 100kg/hr. ('2023 FORMULA 1 TECHNICAL REGULATIONS', 2022)

Considering only the fuel used on race days in a single F1 season, with 20 cars competing in each race across 23 events, a total of 48,300 kg of fuel is estimated to be used on race days. Although no specific limitations are specified for fuel utilisation during qualifying and sprint race sessions, the considerable fuel consumption on race day highlights a growing concern over the environmental impact of F1 racing. Making certain assumptions regarding the fuel consumption of F1 cars during the practice sessions, qualifying and sprint races, it could be assumed that the total amount of fuel utilised in a single season may be double the figure estimated earlier. This assumption is based on the fact that 17 out of the 23 race weekends feature three free practice sessions, each with a duration of one hour, and the remaining 6 race weekends replace one of the free practice sessions with a sprint race thereby significantly increasing fuel consumption used over a race weekend.

Despite the estimated fuel usage of approximately 48,300 kg during race days, it is important to note that this figure only accounts for the fuel consumption of F1 cars and does not factor in the significant amount of fuel required for logistical operations.

Logistics operations, including transportation of equipment and personnel, have also been identified as a significant source of carbon emissions in motorsports. The extreme logistics behind Formula 1's 'global circus', as described in (*The extreme logistics behind Formula One's global circus - FreightWaves*, no date), highlights the challenges and emissions associated with transporting equipment and personnel to various locations worldwide. (*Formula 1 logistics – How do teams move equipment between races?*, no date; *The Logistics Of Formula 1 - F1Destinations.com*, no date)

With the carbon footprint of motorsports being significant, stakeholders in the industry are under pressure to reduce their emissions and explore alternative energy sources. One such alternative is e-fuels, which have been gaining attention in recent years. E-fuels are synthetic fuels made from renewable sources such as biomass, carbon dioxide, or water, and they have been shown to have the

potential to significantly reduce carbon emissions compared to conventional fossil fuels. (*eFuels - eFuel Alliance*, no date)

According to the FIA Environmental Strategy 2020-2030 (Formula 1, 2022) the organization has set a target for motorsports to achieve net-zero carbon emissions by 2030, and E-fuels are seen as a promising solution towards this goal.

However, a focus only on e-fuels alone may not be a comprehensive approach towards addressing the environmental challenges faced by the automotive and motorsport industry. Therefore, this report aims to examine a range of alternative energy carriers, comparing their respective advantages and drawbacks to enable an informed decision-making process for their potential use in Formula 1.

The FIA environmental strategy aims to achieve net-zero carbon emissions by 2030, with a focus on three main areas: reducing emissions from the cars themselves, transitioning to cleaner energy sources for the events, and sustainable operations at F1 offices and facilities. The plan includes initiatives such as the use of hybrid engines and biofuels, reducing single-use plastics, and promoting more sustainable transportation methods for fans and staff. Overall, the sustainability plan demonstrates a commitment to reducing the environmental impact of the sport and promoting a more sustainable future for all. (*Formula 1 publishes Environment, Social & Governance briefing note to detail its sustainability progress & plans | Formula One World Championship Limited*, no date; *Formula 1 continues push to hit Net-Zero Carbon by 2030 target | Formula One World Championship Limited*, no date)

2.1 Automotive Legislation

In response to the urgent need to address climate change and reduce carbon emissions, the UK government has taken a step towards a net-zero future by announcing the end of the sale of new petrol and diesel cars and vans by 2030. This new legislation, which is part of the UK's overall strategy to reach net-zero emissions by 2050, is a significant move towards the widespread adoption of electric vehicles. The transition to electric vehicles will require significant investment in charging infrastructure and new technology development to improve their range and efficiency. In this context, the UK government's new policy is expected to accelerate the transition to electric vehicles and drive the development of cleaner, more sustainable transport systems. (*Government takes historic step towards net-zero with end of sale of new petrol and diesel cars by 2030 - GOV.UK*, no date)

However, the transition to a carbon-neutral future is complex and would require coordinated action at local, national, and international levels. Recent developments in Germany and Italy have highlighted the ongoing debates around the role of e-fuels in the transition away from internal combustion

engines (ICEs). According to a recent report, the European Union has allowed an exemption for e-fuels as part of its wider ban on the sale of new petrol and diesel vehicles by 2035. This exemption has been seen by some as a potential lifeline for ICE vehicles in Germany and Italy, where the auto industry plays a crucial role in the economy. However, the long-term viability of e-fuels remain a topic of debate, particularly in the context of the rapid advancements being made in electric vehicle technology. (German government approves sale of 100% synthetic fuels | Biofuels International Magazine, 2023; EU Alters 2035 Combustion Engine Ban, Gives Ok For Synthetic Fuels, 2023)

3 Synthetic Fuels

E-fuels, also known as synthetic fuels, are synthetic hydrocarbons that are produced from carbon dioxide and hydrogen through a chemical process. The production process uses renewable energy sources such as wind, solar, and hydroelectric power to generate the necessary electricity needed for the chemical reactions. The resulting fuels can be used in existing combustion engines with little or no modification, making them a potential solution for the transition from fossil fuels to renewable energy sources. (e-Fuel explained: what are synthetic fuels? | AutoTrader, 2022; Ausfelder and Wagemann, 2020)

One of the advantages of e-fuels is their potential to reduce greenhouse gas emissions. According to a study by the (Ausfelder and Wagemann, 2020; Machhammer, 2021), e-fuels can reduce greenhouse gas emissions by up to 90% compared to conventional gasoline or diesel fuels. This is due to the fact that the carbon dioxide emissions produced during the combustion of e-fuels are offset by the carbon dioxide that was initially captured during the production process. This means that the e-fuels are effectively carbon-neutral, which is a significant advantage in the effort to combat climate change. (Hombach *et al.*, 2019; Ausfelder and Wagemann, 2020)

Another advantage of e-fuels is their compatibility with existing infrastructure. Because e-fuels can be used in existing combustion engines, there is no need for costly modifications to vehicles or for the development of new infrastructure. This makes e-fuels a potentially attractive option for the transition to renewable energy sources, as it could be accomplished without significant disruption to the existing transportation system. (*eFuels – missing link, or costly distraction?* - Regen, no date; *Can biofuels and e-fuels be clean alternatives to petrol?* - Innovation Origins, no date)

However, there are also some potential drawbacks to e-fuels. One concern is their energy efficiency. E-fuels require a significant amount of energy to produce, and some studies have suggested that the energy required to produce e-fuels may exceed the energy contained in the fuels themselves. This means that e-fuels may not be as efficient as other renewable energy sources, such as battery-electric vehicles. (*eFuels - eFuel Alliance*, no date; *eFuels – missing link, or costly distraction?* - Regen, no date)

Another concern is the cost of producing e-fuels. Currently, the production is relatively expensive compared to traditional fossil fuels. However, as renewable energy sources become more widespread and economies of scale are achieved, the cost of producing e-fuels is expected to decrease. (*eFuels – missing link, or costly distraction?* - Regen, no date; Hombach *et al.*, 2019)

4 Electric

Electric vehicles (EVs) are gaining increasing popularity as a sustainable alternative to conventional petrol and diesel vehicles. EVs are powered by an electric motor and rechargeable batteries, and they do not emit any tailpipe emissions. As a result, they offer significant environmental benefits and help to reduce greenhouse gas emissions. (Blomgren, 2017; König *et al.*, 2021)

One of the main advantages of EVs is that they have zero tailpipe emissions, which helps to reduce air pollution and improve air quality in urban areas. In addition, EVs are very efficient, with over 80% of the energy stored in their batteries being converted to power the wheels. This is significantly higher than the typical efficiency of an internal combustion engine, which is around 20%-30%. (Schmuch *et al.*, 2018; Ajanovic and Haas, 2019)

EVs also have lower running costs than conventional vehicles, as electricity is generally cheaper than petrol or diesel, and EVs require less maintenance than internal combustion engines, which have many moving parts that require servicing. However due to the rise of cost-of-living, this is not as low as initially thought it would be.

Despite these advantages, there are also some challenges associated with the widespread implementation of EVs. One of the main challenges is the limited range of current EVs, which can be a barrier for long-distance travel. However, this is gradually being addressed through the development of faster charging infrastructure and longer-lasting batteries. Another challenge is the cost of EVs, which can be higher than equivalent petrol or diesel vehicles. However, this is also gradually reducing as battery costs fall and production volumes increase. (Blomgren, 2017; Bekel and Pauliuk, 2019; König *et al.*, 2021)

There are also concerns about the environmental impact of the production of batteries for EVs, particularly regarding the mining of minerals such as lithium, cobalt, and nickel. However, research is ongoing to develop more sustainable and ethical sources of these minerals, and to improve the recycling and reuse of batteries at the end of their life. The environmental impact of lithium mining can be significant. The process of mining lithium can lead to deforestation, habitat destruction, soil erosion, and contamination of water sources. (Gajardo and Redón, 2019; Liu, Agusdinata and Myint, 2019; Vera *et al.*, 2023) In addition, the chemicals used in the processing of lithium, such as sulfuric

acid, can pollute the air and water and have detrimental effects on local ecosystems. The large amount of water required for brine extraction can also put pressure on local water sources, leading to water scarcity in some areas. (Li *et al.*, 2018; Costa *et al.*, 2021)Also, lithium mining can cause social and economic disruption for indigenous communities and other local populations. As the demand for lithium continues to increase with the rise of electric vehicles and other clean energy technologies, it is crucial to develop sustainable and responsible mining practices to minimize the negative impact on the environment and local communities. (Agusdinata *et al.*, 2018; Alam and Sepúlveda, 2022; Vera *et al.*, 2023)

5 Fuel Cell

Fuel cell vehicles are an emerging technology in the automotive industry that offer an alternative to traditional internal combustion engines (ICEs) by using hydrogen as a fuel source to produce electricity to power the vehicle. FCVs have the potential to be a sustainable and efficient alternative to petrol or diesel vehicles, but there are still several challenges that must be addressed before they can become a viable option for mainstream adoption.(Bethoux, 2020; Greene, Ogden and Lin, 2020)

One of the main advantages of fuel cell vehicles is their high energy efficiency. Unlike ICEs, which rely on combustion to produce energy, FCVs use an electrochemical reaction to generate electricity. This means that FCVs can convert up to 60% of the energy stored in hydrogen into usable electricity, compared to just 20-30% for ICEs. Furthermore, FCVs emit only water vapor and heat, making them a zero-emission alternative to traditional vehicles. (Pollet, Staffell and Shang, 2012; Olabi, Wilberforce and Abdelkareem, 2021)

Another advantage of FCVs is their quick refuelling time, which can be as little as 5 minutes for a full tank of hydrogen. This is a significant advantage over electric vehicles, which can take hours to recharge their batteries. Additionally, FCVs have a longer range than most battery electric vehicles (BEVs), with some models capable of traveling over 300 miles on a single tank of hydrogen. (Emadi and Williamson, 2004; Ajanovic and Haas, 2019)

However, there are still several challenges that must be addressed before FCVs can become a mainstream alternative to petrol or diesel vehicles. One major challenge is the lack of infrastructure for hydrogen refuelling. Currently, there are only a few hundred hydrogen refuelling stations worldwide. This limited infrastructure makes it difficult for FCV drivers to travel long distances, and it also makes it less attractive for automakers to invest in the technology. (Emadi and Williamson, 2004; Pollet, Kocha and Staffell, 2019; Staffell *et al.*, 2019; Samsun *et al.*, 2022)

Another challenge is the cost of producing and distributing hydrogen fuel. Currently, hydrogen production is primarily done through steam reforming of natural gas, which is a fossil fuel-based process. (Samsun *et al.*, 2022)This means that the production of hydrogen is not entirely emissions-free, although it still produces significantly fewer emissions than petrol or diesel. Additionally, the cost of producing and distributing hydrogen is currently higher than that of petrol or diesel, making it less economically attractive for consumers and businesses. (Thompson *et al.*, 2018; Bethoux, 2020)

Furthermore, there are challenges related to the durability and reliability of fuel cells. While significant progress has been made in the development of fuel cell technology, the high cost and low durability of fuel cells remain significant barriers to adoption. The performance of fuel cells can be affected by factors such as temperature and humidity, which can make them less reliable in extreme weather conditions. (Kluschke *et al.*, 2019; Cunanan *et al.*, 2021)

6 Evaluation

After examining the three possible options for implementation in Formula 1 engines and logistics operations, it has been concluded that the best course of action is to shift towards e-fuels. If F1 allocates resources towards creating an e-fuel that can replace petrol or diesel with little or no modification to internal combustion engines (ICE), it could benefit not only its global emissions created by racing and logistics operations but also the entire automotive industry.

The use of resources to develop e-fuels could result in a lesser environmental impact than fuel cell or electric cars. Although challenges such as crop displacement may arise, this is still a lesser harm to the environment than lithium mining. (CBeidl and Berndt Straße, no date; Schwarz *et al.*, 2019; Costa *et al.*, 2021) Lithium mining has been demonstrated to cause substantial environmental damage, and the recycling of lithium-ion batteries still poses challenges that need addressing. (Agusdinata *et al.*, 2018; Vera *et al.*, 2023)

Moreover, there is a significant need for investment in infrastructure to support a transition to all-electric transportation, and the UK currently struggles to meet demand with only 1.8 million EVs on the road. (*General facts and figures about roads and road use*, no date) Therefore, replacing approximately 33.2 million registered cars in the UK with EVs would require a massive infrastructure investment. (*General facts and figures about roads and road use*, no date; *UK Electric Vehicle public charging infrastructure 2021*, no date)

This same infrastructure issue applies to fuel cell-powered vehicles as well. Without sufficient infrastructure, it is not feasible to transition entirely to fuel cell or electric-powered vehicles. In conclusion, a shift towards e-fuels in F1 would be a sensible decision, and investing in their development could have positive implications for the entire automotive industry and possibly the whole transportation and shipping industry where electrification would not work.

7 Conclusion

In conclusion, it is evident that the automotive industry is rapidly moving towards more sustainable and eco-friendly energy carriers to reduce the environmental impact. The motorsports industry, including Formula 1, needs to follow suit and implement new energy carriers and recovery systems to stay relevant, sustainable and as eco-friendly as possible.

Based on the research conducted, it is clear that there are several options available to replace petrol or diesel in motorsports, including electric, hydrogen and synthetic fuels. Each option has its benefits and drawbacks, but it is crucial for the FIA and the motorsport bodies to evaluate and invest in the most promising and sustainable technologies, which in this study has been deemed to be e-fuels.

The FIA should encourage the circuits they visit to invest in supporting infrastructure and prioritise health and safety considerations to ensure that the transition to new energy carriers is smooth and effective. They should also keep a close eye on the legislative changes and ensure that they comply with the regulations and guidelines.

In summary, it is crucial for the motorsport industry to keep up and move towards sustainable and eco-friendly energy carriers to reduce the environmental impact. The FIA should take an active role in promoting and investing in the most promising technologies while also prioritising safety and infrastructure considerations.

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