ISSN No:-2456-2165

Formula One and Sustainability

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Abstract:- This research paper examines the sustainability aspect of the industry of Formula One. It includes research about the contribution of different factors namely Tyres, Engines, Fuel as well as Logistics and other Business Operations. The paper includes facts and figures illustrating how these factors contribute to the carbon footprint and how they can be improved to decrease emissions. Working towards this issue contributes to global sustainability as well as climate change and helps make the industry of Formula One more sustainable.

I. INTRODUCTION

Formula 1 is the pinnacle of motorsport. F1 has the most advanced technology and the biggest budget in motorsport. It is one of the most popular industries around the world, being the most-watched motor racing sport globally with 525 million viewers and still growing. However, the sport is in a complicated situation with increasing concerns about sustainability and carbon emissions. For F1 to achieve top speeds for fast-paced racing, the sport needs to use special fuels that produce more carbon emissions and are less environmentally friendly. This compromises sustainability by increasing the carbon footprint of the sport.

FIA, the regulating body of Formula 1 is working towards a solution to make the sport sustainable, but also maintain the standard of racing. FIA aims to make Formula 1 net-zero carbon by 2030 by working with the teams to come up with sustainable options for racing. But only coming up with environmentally friendly fuel is not going to make the sport net-zero carbon. Many more factors come into play, like manufacturing and the special Pirelli P Zero compound tires.

II. OVERVIEW

A very simple solution that many people may think solves this problem is going fully electric like many car manufacturers around the world. Many car brands around the globe are now putting more focus on electric vehicles than Internal Combustion Engine (ICE) vehicles. Renault is already the leading electric vehicle manufacturer in Europe representing about 15% of all EVs in the continent. New car registrations also increased significantly, with 1.33 million units in 2020, which is 11% of all new car registrations in the year. This number increased to 2.21 million units in 2021, showing the increasing rate of shift towards electric vehicles.

Formula E is the electric segment of FIA regulated motorsport. Big names like Antonio Giovinazzi (former F1 driver for Alfa Romeo) and Mercedes F1 test and reserve driver Nyck De Vries are already part of the competition's 8^{th} season. The sport also has big manufacturers like Mercedes and Jaguar participating along with Indian car manufacturer Mahindra. As suggested by its name Formula **E**, it is fully electric, but the cars are much slower than Formula 1 cars. A vague comparison of the speeds of Formula E (Sam Bird's 250kW lap) and F1 (Lewis Hamilton's 2019 pole lap) was done around some part of the extremely famous Monte Carlo Street circuit where Formula E was about 8-9 seconds slower.

III. WORKING OF TYRES AND THEIR SUSTAINABILITY

A very important factor in an F1 race is the tyre. The tyre has the potential to win or mess up your race. Factors like tyre wear and degradation come into play when deciding the race strategy for a race weekend. It also determines how much you can push the car to the limit for a faster lap time. But who manufactures these tyres? FIA has very specific needs that it requires for an F1 tyre. The formula and exact specs of the tyre are kept secret to maintain competition between manufacturers. In 2011, FIA and Pirelli signed a contract till 2024 onwards, Pirelli would be the sole tyre supplier of the sport (Past manufacturers include Michelin, Bridgestone and Goodyear). Pirelli supplies special P Zero compound tyres that we get to see today on all the F1 cars.

A normal Formula tyre only lasts 50 miles. Some could say F1 tyres are engineered to fail. But why is that? To know that we need to understand how a tire works and what makes a tyre stop working. A tyre is the only point of contact between a car and the road so its job is to create grip so you can accelerate, brake and turn. To create grip a tyre's tread needs to be soft enough to squish into and around the tiny peaks and valleys that make up a rough road surface, in this case, a racetrack. This theory is true for all tyres, be it a minivan tyre or a F1 tyre. By looking at an F1 tyre, you may think F1 tyres do not have treads, they're called slicks. Slicks do have treads. A tread is just a layer of rubber that is in contact with the road or track surface. All tyres have treads, slick or groovy. Sometimes the word tread is used to say tread pattern, which we see on regular road tyres as well as F1 rain tyres which maintain grip by channeling water out of the tread. An F1 full wet tyre (best for very wet surfaces) can displace up to 85 litres of water per second at 300kph while the less groovy intermediate tyres (used in slightly wet surfaces as well as drying tracks) can displace up to only 30 litres of water per second at 300 kph. In short, the job of every tyre is to **make a grip**.

A minivan on normal all-season tyres can produce about 0.7 Gs of cornering force or lateral grip and about 0.8 Gs of braking force. An F1 car is capable of roughly 7 times that. It can produce 4.5 Gs of cornering force and 5.0 Gs of braking force. This much force is enough to bring tears out of your eyes as this amount of force is enough to bring tears out of your tear ducts.

A conventional tyre is mainly made of natural rubber and a dozen synthetic polymers, with names like styrene-butadiene and halogenated butyl-rubber, along with fillers, textile and steel. Carbon Black, a pure form of carbon is also mixed in to improve the tyre strength which also gives tyres their black colour because rubber is naturally white. The tyre also includes antioxidants and antiozonants to prevent oxygen and ozone exposure deterioration. The tread also includes silica to decrease rolling resistance, increase fuel economy and reduce wear and tear. So, a conventional tyre can last up to 90000 miles because of the specific chemical makeup of the tread rubber which makes that possible. By fine-tuning that chemical makeup, the manufacturer can determine how long a tyre lasts, how soft it is, and at what temperature it produces maximum grip.

The exact formula of a F1 tyre is kept secret as mentioned earlier but to increase performance the tyre includes more synthetic rubbers and up to 10% lesser of natural stuff. This provides more strength, heat resistance and consistent grip. The F1 tyre also has lesser antioxidants and antiozonants because they don't last long enough for oxygen to be a concern for degradation. They probably would also contain less silica because reduced rolling resistance means less grip. An average person looks for a tyre that is comfortable, economical, durable and safe but F1 teams only require one thing, which is grip. To satisfy F1 requirements and make sure tyres can withstand the extreme limits of a race, Pirelli constantly keeps developing these tyres. The F1 tyres are tested at speeds up to 280 mph, subjected to impact up to 162 mph and exposed to track temperatures up to 300 degrees Fahrenheit. F1 cars generate massive downforce so each tyre is load tested up to 2200 pounds. Every tyre is precisely weighed, X-rayed and inspected to look for flaws. So much testing and development cost billions of dollars. The company is so thorough with their inspection, that if one has a blowout in a race, the company employees will make sure that no pieces of the tyre are left behind just so that other tyre manufacturers cannot get their hands on their secret formula.

If so much money is spent developing these tyres, why do they last only 50 miles? The lifespan of a tyre is determined by degradation, which happens in 2 ways: tread wear and giving up. As mentioned earlier, for a tyre to produce high levels of grip, it has to be really soft so that it can sink into the road surface. This amount of grip creates a lot of abrasions, particularly when a car is turning. At a microscopic level, a rough road surface acts like sandpaper which is constantly removing tiny bits and pieces of rubber from the tyre. F1 tyres also have a lot less tread so it is easy for them to wear out faster. An average consumer tyre can have tread as thick as 30 mm and it takes a lot of time for it to wear all the way down whereas a slick F1 tyre can have a tread as slim as 2-3 mm which results in a blowout. Sometimes F1 tyres can last more than 50 miles but do not. That's where the term giving up comes in. It is when a tyre hardens, and it can't sink into the rough road surface anymore to produce grip. For consumer tyres, this is not an issue because giving up happens because of rapid heating and cooling which is very unlikely to happen under normal driving conditions. The average consumer tyre is already soft enough to produce grip when the person gets in their car to drive whereas, the F1 soft tyre does not reach its grip producing temperature range unless it is as hot as 200 degrees Fahrenheit. That grip is maintained only until 240 F. Similarly, the hard compounds operating range is from 230 to 285 f. This explains why F1 cars have less grip when tyres are cold, and it is also the reason why teams keep tyres in heated blankets when they are not on the car. So, an F1 tyre that has lost grip at 50 miles, probably hasn't worn out its tread, it has just given up.

F1 has specific degradation rates that are necessary to make racing exciting. For any race, the hard compound is the baseline for lap times. FIA wants medium compound tyres, that are 1.2 seconds per lap quicker and soft tyres that are 2.2 seconds a lap quicker. But the FIA also wants the soft tyre to exhibit 2 seconds of degradation after 10% of the race distance. A similar restriction applies to the medium compound as well. The FIA mandates that F1 teams use at least two different tyre compounds during a race to make racing exciting. FIA says that rapid degradation maximizes the potential number of race strategies to create variety. Pirelli has five compounds of tyres named C1 to C5 with C1 being the hardest and C5 being the softest. Based on track conditions at the venue, Pirelli chooses 3 compounds that are given to every team.

F1 targets to achieve sustainability as there are a lot of carbon materials as well as non-eco-friendly synthetic materials involved in the making of tyres. It is surprising to see how many tyres are used during the course of a full season. Ordinarily, teams are issued 13 sets of slicks, four sets of intermediates and three sets of full wet tyres in a race weekend alone. Extra tyres can also be supplied for testing purposes and/or in response to wet weather. This calculates to about 36,800 tyres for 23 race weekends in a season or 160 tyres per team per race weekend. Many ideas are being proposed to reduce the carbon footprint coming from the tyres. One proposal involves reducing the number of tyres teams can use during a race weekend. Ross Brawn, F1 motorsport director commented on this matter saying F1 and FIA are collaboratively trying to reduce the carbon footprint coming from the usage and the logistics of tyres. He said that they aim to introduce weekends where teams are given a fewer number of tyres without impacting the show, but is considering what "unintended consequences" may arise from the change. He further added that Tim Goss at the FIA has been working very hard with Pirelli and the teams to come up with a proposal of how we might assess a different way of using the tyres to reduce quantities. He was optimistic about the statement and was ready to adopt the idea for the future if it worked.

IV. EVOLUTION AND SUSTAINABILITY OF ENGINES

F1 engines have undergone many changes in the past few years in terms of their design, power output, capability and most importantly, their emissions and fuels used. FIA mandated regulations have seen teams designing different power units throughout many seasons. The 2006 F1 season saw the introduction of the mighty 2.4L V8 engines which ran till 2013 with a rev-limiter. This period saw the introduction of many new technologies as well as the dominance of many teams. In 2009, teams were allowed to use Kinetic Energy Recovery Systems (KERS) also called regenerative brakes. Energy could be stored as mechanical energy (fly-wheel) or electrical energy (battery/supercapacitor). 2014 saw new engine regulations and the dawn of the turbo-hybrid era when the FIA announced to change the 2.4L V8 engines to the 1.6L V6 hybrid engines for the 2014 season. The new engines allowed kinetic and heat energy recovery systems to be introduced along with the turbocharger being included in the power unit as well. FIA allowed forced induction and restricted the fuel flow to 100kg per hour. The engines sounded different too due to the lower rev limit at 15000 rpm and the turbocharger.

The turbocharger increases the efficiency of the engines through turbo-compounding by recovering energy from exhaust gases. This purpose of new engines was not welcomed by racing teams hence a compromise was reached allowing V6 forced induction engines instead. These engines rarely exceed 12000 rpm at any time due to the fuel flow restrictions. KERS was renamed Motor Generator Unit – Kinetic (MGU-K) and the heat energy recovery systems were renamed Motor Generator Unit – Heat (MGU-H) [1]. This heavily benefitted engine manufacturer Mercedes making them the most powerful engine of the lot. However, the end of 2021 marked the end of the turbo-hybrid Mercedes led era with new regulations from 2022 onwards.

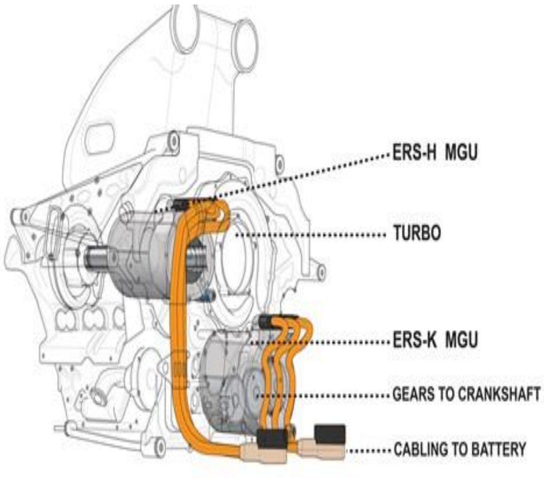

Fig. 1: Components of the Turbo-Hybrid Engine

In 2017, the FIA began negotiations with existing constructors and potential new manufacturers over the next generation of engines. The initial proposal was to simplify engine designs, cut costs, promote new entries and address criticisms directed at the 2014 generation of engines. This new regulation emphasized the power of the MGU-K and stressed the removal of the MGU-H. Changes to the driveshaft were also proposed mirroring the system developed by Porsche for their 919 Hybrid race car where the cars would be all-wheel drive and the front axle driven by an MGU-K unit that functioned independently of the MGU-K providing power to the rear axle.

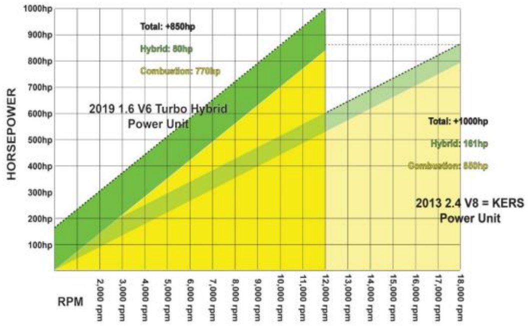

Fig. 2: Comparison of the power output of different era's engines

V. COMPOSITION AND SUSTAINABILITY OF FUEL

The F1 car uses a special fuel. It contains 5.75% bio-sourced alcohol content, called biofuel, and High-octane unleaded fuel. The 2022 car ups the requirement to 10% Ethanol called E10. Early GP cars ran on a fierce mixture of powerful chemicals and additives, often featuring large quantities of benzene, alcohol and aviation fuel. Over the years more and more regulations have been introduced regarding the composition of the fuel. The modern fuel is only allowed tiny quantities of 'non-hydrocarbon' compounds, effectively banning power-boosting additives. Each fuel blend must be submitted to the FIA for approval of its composition and physical properties.

Since 2014, the fuel load has been limited to 100 kg of fuel per race. In 2017, this was increased to 105 kg. Engine oil is also monitored closely to deduce engine wear rates, being analysed after every race or test for traces of metals.

As mentioned, 2022 cars will run second-gen E10 made from food waste and other biomass rather than crops grown to make fuel. By 2030 F1 wants third-gen biofuels in cars denying any plans to go electric. Instead, synthetic fuel will work to power the internal combustion engines (ICE) which will probably feature some sort of hybrid component. The engines currently used are the most efficient engines on the planet with 50% thermal efficiency. In simple words, 50% of the energy in the fuel is actually used to propel the car rather than being wasted as heat or noise. Pairing sustainable fuels with these engines is a dream come true.

ISSN No:-2456-2165

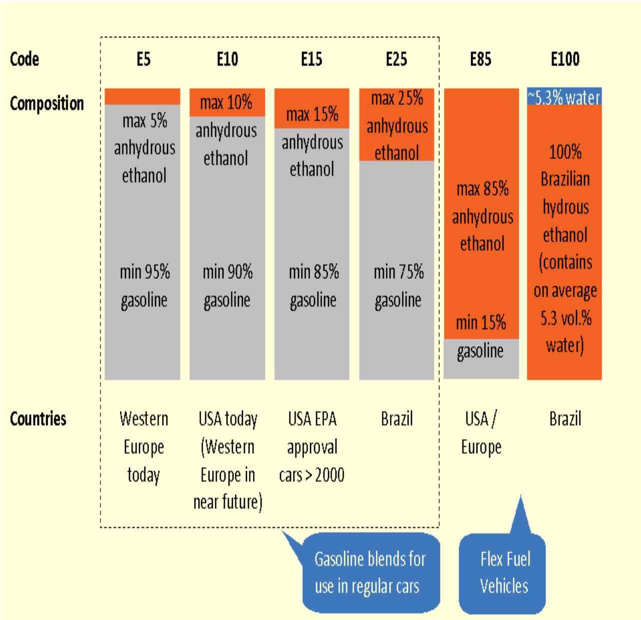

Fig. 3: Composition of common fuel mixes

F1 along with Aramco is continuing to study synthetic fuels. Porsche is another noticeable name invested in this type of fuel. They are already running their ‘e-fuel’ in race cars after partnering with ExxonMobil to create the synthetic gas [2].

VI. SUSTAINABILITY OF LOGISTICS AND OTHER OPERATIONS

F1 is a global sport. Teams have to travel to up to 23 countries each season for the races to be held at different venues. In 2019 Formula One calculated their total amount of Carbon emissions, which came out to be 256551 tonnes CO_2E.

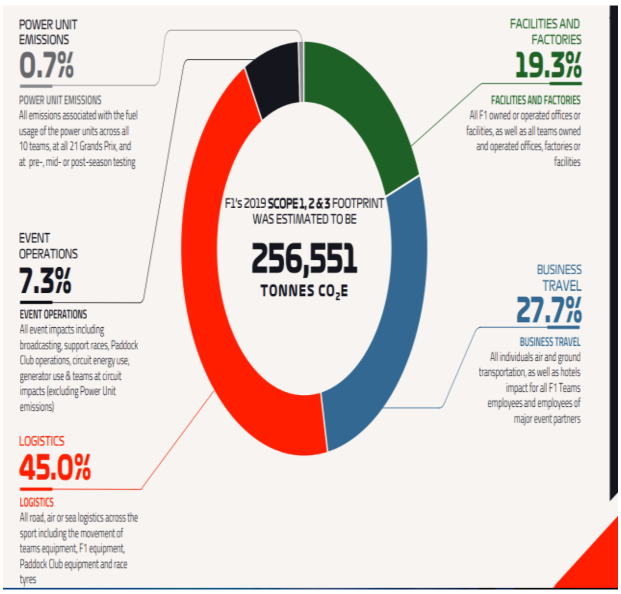

Fig. 4: Total Carbon Emissions and distribution

This is the same amount of emission as some countries. In the exact breakdown, 45% of the emission was from logistics. This includes road, air or sea logistics across the sport including the movement of teams’ equipment, motorhomes, F1 equipment and race tyres. 27.7% of it was from business travel, which includes all individuals, air and ground transportation as well as hotels and impact for all F1 teams’ employees and employees of all their major event planners. 7.3% of total emission was from all event impacts including broadcasting, support races, circuit energy and generator use and impact of teams at the circuit (excluding PU emissions). F1 has announced basic measures to tackle these problems. They plan to prioritise fan well-being and the local environment by enhancing biodiversity, improving air quality and offering healthier food options. They also plan to build partnerships that plan to give local people greater access to the events and positive benefits for local businesses and causes. F1 plans to use only recyclable and composite materials and ensure that 100% of waste is reused, recycled or composted. They plan to enable fans to reach the race by lower/zero-carbon transport methods or credibly offset emissions created by their travel [3]. Let us consider the 2019 race calendar for example.

Fig. 5: 2019 F1 race calendar

For F1s case, one of the most obvious solutions to reduce carbon emissions. This includes clustering all European races on adjacent race weekends, so road transportation is the main method of travel. International races should also be undertaken at closer proximity to the last race enabling shorter distances travelled by air and ocean freight. The table below shows an alternative solution to the original race calendar for 2019 keeping in mind temperatures as well as seasonal changes.

ISSN No:-2456-2165

Round	Race	Date	Climate	High/Low(C)	Transport
1	Azerbaijan	March 15-17	Windy/Dry/Chilly	9.8/4.2	Fly from UK
2	Bahrain	March 29-31	Cool/Sunny	25/18	Drive
3	Abu Dhabi	April 12-14	Warm/Dry	34/22	Drive
4	Japan	April 26-28	Rain	19/8	Fly
5	China	May 10-12	Mild (Spring)	24/17	Fly
6	Singapore	May 23-26	Warm/Tropical	32/26	Fly
7	Australia	June 7-9	Cool (Winter)	15/8	Fly
8	Brazil	June 21-23	Cool/Dry	25/19	Fly
9	Mexico	June 28-30	Warm/Dry	26/7	Fly
10	USA	July 12-14	Hot/Humid	35/24	Fly
11	Canada	July 26-28	Mild	26/18	Fly
12	Spain	August 2-4	Hot/Humid	35/24	Fly
13	France	August 30-Sep 1	Warm/Dry	25/18	Drive
14	Monaco	September 6-8	Mild	24/19	Drive
15	Italy	September 20-22	Warm/ Relatively Dry	24/16	Drive
16	Austria	September 27-29	Warm	19/7	Drive
17	Hungary	October 11-13	Mild	16/8	Drive
18	Russia	October 25-27	Mild/Rain	20/12	Drive
19	Germany	November 1-3	Chilly	9/3	Drive
20	Belgium	November 15-17	Cold/Rain	7/3	Drive
21	UK	November 29-December 1	Cold/Mild/Rain	8/6	Drive

Table 1: Updated race calendar to reduce emissions

The results of Carbon emissions from the alternative calendar are:

Road Freight Journey	WTW CO_2e (tonne) per truck
Spain - France	1.57
France - Monaco	0.55
Monaco - Italy	0.95
Italy - Austria	1.81
Austria - Hungary	1.12
Hungary - Russia	6.55
Russia - Germany	8.80
Germany - Belgium	0.88
Belgium - UK	1.15
Azerbaijan - Bahrain	6.33
Bahrain - Abu Dhabi	2.32

Table 2: Emissions from road freight

This new schedule generates 32.03 tonnes of CO2e for one truck in the 2019 season.

Sea Freight Journey	Distance (km)	WTW CO_2e (tonne)
UK - Azerbaijan	9,143	69.94
Abu Dhabi - Japan	13,920	58.58
Japan - China	2,018	16.32
China - Singapore	4,738	23.80
Singapore - Australia	8,817	43.37
Australia - Brazil	18,011	114.53
Brazil - Mexico	12,351	86.13
Mexico - USA	2,195	31.40
USA - Canada	8,054	79.60
Canada - Spain	8,881	45.55

Table 3: Emissions from Sea Freight

The new sea freight emission is 569 tonnes showing 44% improvement from the original model, with fewer journeys taken alongside an efficient route.

Air Freight Journey	Distance (km)	WTW CO_2e (tonne)
UK - Azerbaijan	4,130	4,016
Abu Dhabi - Japan	7,979	7,758
Japan - China	1,534	3,405
China - Singapore	3,926	2,407
Singapore - Australia	6,185	3,791
Australia - Brazil	13,314	8,161
Brazil - Mexico	7,597	4,657
Mexico - USA	1,275	782
USA - Canada	2,785	2,708
Canada - Spain	6,062	5,895

Table 4: Emissions from Air Freight

Airfreight generates 43,580 tonnes of CO2e also showing a 44% improvement from the original model.

If fuels used for transport through land, sea and air are changed to sustainable options, F1 could reduce a lot of carbon footprint from their logistics. Electricity powered vehicles are already deployed and still developing. Biofuels for ships and aircraft could further reduce carbon emissions working towards the goal of sustainability. [4]

VII. CONCLUSION

In this paper, we saw the need for sustainability in Formula 1 and the steps being taken to achieve the goal. F1 is aiming to be net-zero carbon by 2030. F1 has a lot of aspects that produce a lot of carbon emissions. Logistics is the branch that deals with transport of equipment, vehicles etc. and contributes to approximately 46% of the total emissions with manufacturing, business travel and even organisation being the next branches with a big amount of emission. F1's drastic measures will see the change of motorsport in the next few years with FIA already introducing reforms towards the goal of net-zero carbon footprint. Big companies around the world working on stainable options such as bio-fuels are already in consideration for partnerships. FIA and Formula 1

Corporation are working closely with partners, teams and drivers to achieve sustainability and protect the Earth while providing it with thrilling fast-paced racing.

REFERENCES

[1.] WikiPedia, en.wikipedia.org, Formula One Engines.

[2.] CNET, Formula One aims to introduce sustainable fuel for racing mid-decade.

[3.] Formual One Corporation, Formula One Sustainability Plans.

[4.] Hope Ross, Future Sustainable Practice for Formula 1 Logistics, University of Strathclyde, Glasgow, 19-08-2020.

[5.] Misc.: Student Paper submitted to Swinburne University of Technology, f1chronicle, Student Paper submitted to International School of Geneva, Student Paper submitted to Southern Illinois University, Student Paper submitted to Cardiff University, Student paper submitted to Bromsgrove School CN-467134, ukmotor1, Student Paper submitted to Wilmington University, Student Paper submitted to Saint Laurence's College.