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ACCELERATING A JUST TRANSITION: THE MOTOR SPORT AND MOBILITY PERSPECTIVE

A WORLD IN TRANSITION

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GLOSSARY

AEPB	Abuja Environmental Protection Board
BEV	Battery Electric Vehicle
CCS	Carbon capture at source
CCU	Carbon capture and use
CF	Carbon footprint
CITA	International Motor Vehicles Inspection Committee
CO	Carbon monoxide
CO2	Carbon dioxide
DAC	Direct air capture
DRC	Democratic Republic of Congo
ETI	Energy Transition Index
EV	Electric Vehicle
FIA	Fédération Internationale de l'Automobile
FC	Fuel Cell
FCEV	Fuel Cell Electric Vehicle
FT	Fischer Tropsch
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GNI	Gross National Income
GSM	Green Slow Mobility
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IRENA	International Renewable Energy Agency
LCA	Life cycle assessment
LDV	Light duty vehicles
LIB	Lithium-ion battery
NAF	Norwegian Automobile Federation
NESREA	National Environmental Standards & Regulation Enforcement Agency
NPI	National Pollutant Inventory
OEM	Original equipment manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate matter
PPM	Parts per million
SDGs	Sustainable Development Goals
SDC	Smart Driver Challenge
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNRSF	United Nations Road Safety Fund
WEF	World Economic Forum
WHO	World Health Organization

EXECUTIVE SUMMARY

The Fédération Internationale de l'Automobile (FIA) has been the governing body of world motor sport and the federation of the world's leading mobility organisations for almost 120 years. It gathers 243 Member Organisations from 147 countries, is a trusted organisation for the 80 million road users it represents, a thought leader for local, national and international policy-makers, and an effective partner to academics, manufacturers and motor sport teams.

This gives the FIA the unique ability to support and promote sector-wide transformation at every level – from grassroots Clubs to international organisations.

Our in-depth understanding of users' specific needs has been integral in our work promoting the transition to a just, sustainable, accessible and inclusive mobility.

We know that our future success depends on engagement and user-centric policies. We will not achieve net zero if users do not or cannot access efficient mobility solutions. With this in mind, the FIA and its Member Clubs are supporting varied research and efforts across the mobility landscape. We are looking into everything from EV user surveys to biofuel research, cycle mobility surveys and green sustainable public mobility offerings – so that we can find answers which work for everyone.

This White Paper will explore some of that research and showcase the initiatives that the FIA and its Members have explored in the pursuit of a global sustainability transition.

Transformation is needed everywhere, including within our organisation. We are not just going to take a backseat and direct change – we are also committed to playing our own part in the transition towards a more sustainable future. We have set ourselves ambitious targets – including one to reach net zero by 2030. Achieving carbon neutrality in 2021 was a first step, but we know there is still a lot to be done and we are embarking all our motor sport and mobility stakeholders on the journey.

While high-level, top-down targets are critical if we, as a global community are to meet our climate goals, it is the individual transport users that need to make carefully considered mobility choices if these goals are to be attained. The FIA is the one organisation with the reach and understanding to work within these communities to help deliver a just transition. This we can help achieve with structured and sustained bi-directional communication.

These solutions, bring about consumer driven and consumer centred behavioural change, not with sticks or carrots but with understanding. Transferring learnings and knowledge between consumers in different markets and taking those actions and learning to local, regional, and national governments to drive large-scale road user behavioural change.

Global change comes from regional understanding, and it is this reason that the FIA supports its Members in encouraging sustainable activity through the FIA Environmental Accreditation Programme, as well as a series of grants and awards schemes, particularly in the global south, which have a material impact on helping sustainable initiatives reach consumers at the grassroots level.

DRIVING TECHNOLOGICAL CHANGE

Motor sport is a hub of innovation. Every season, audiences watch championship cars undergo thousands of changes – both large and small – to create something that is faster, safer, and more responsive. These innovations can and should be brought to the road, where they can benefit users in their everyday journeys.

At the crossroads of motor sport and mobility, the FIA is uniquely placed to help transfer knowledge between these two sectors. The federation has already helped improve safety features in road cars, by sharing knowledge about crash data and prevention. In recent years, it has started a similar journey for decarbonisation.

To champion innovation and pave the way for transformative change, we are challenging our World Championships to be powered by sustainable fuels by 2026, and to reach carbon neutrality by 2030.

This kind of work is essential in our journey towards our sustainability objectives. By sharing research, findings, and approaches, we hope to ensure that a wide variety of sustainable technologies hit the marketplace, and become available to the users who need them.

THE FÉDÉRATION INTERNATIONALE DE L'AUTOMOBILE (FIA)

Founded 120 years ago and headquartered in Paris, the Fédération Internationale de l'Automobile (FIA) is a not-for-profit association best known as the governing body for world motor sport. The FIA however also plays a vital role as the global federation of the world's leading motoring organisations.

These FIA Member Clubs are composed of 243 unique and dedicated international motoring and sporting organisations from 147 countries on five continents, representing millions of commuters and their families. The mission of our Mobility team is to empower our Members to be relevant for the future of smart mobility through collaboration, knowledge sharing, and advocacy. Using global lessons from the latest developments and research between our Members to support their positions as trusted thought leaders in their own communities. In parallel, the FIA is also empowering its Motor Sport Members to understand and account for climate actions, fostering and funding new technologies.

This unique access to a grass-roots membership base with its size and geographic spread through high income to developing nations provides the FIA and its Member Clubs unprecedented access to the real-world concerns and challenges that face every-day commuters, the ability to work with governments to address these challenges in a positive way and critically the ability to help governments craft local solutions with a global perspective that work for their individual populations while meeting the larger challenges that we face as a global village.

Over several years, the FIA name has become synonymous with safety, enforcing the highest levels of protection for drivers, teams, and supporters in the motor racing world. Over the decades, the FIA has been taking these learnings and introducing them into the world of everyday road users, working on a global level and with local governments to make roads, cars, and road users safer. Innovating and pushing every day to reduce the global road death-toll. Making sure that drivers, their passengers, and vulnerable road users are safer.

It is this same approach of placing a challenge at the core of our identity that the FIA and its Members are taking as a leading responsible organisation to decarbonise personal mobility, working with governments and commuters to find long-term affordable, sustainable solutions, making the world a better place for the generations to come.

"Tackling the environmental challenges our planet is facing is a priority for us all. This is why the Motor Sport and Mobility Communities have endorsed an ambitious Environmental Strategy focusing on three pillars (Climate Action, Technology & Innovation, Sustainable Practices) and aiming at reaching carbon neutrality in 2021 for the FIA, in the transition towards a state of net-zero emissions in 2030. As we reduce our environment impact and lead sustainable innovation, we are confident that we will accelerate the transition towards a sustainable future for all." - Felipe Calderón President of the FIA Environment and Sustainability Commission and Former President of Mexico.

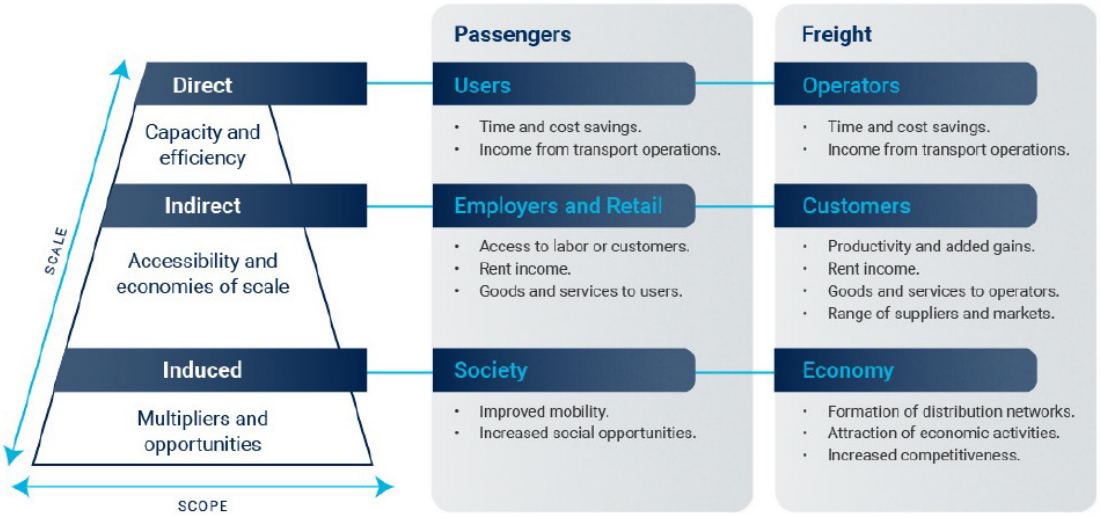
BACKGROUND AND CONTEXT

THE IMPORTANCE OF MOBILITY

The transportation sector holds a pivotal role within societies and economies, serving as a fundamental instrument for fostering development. This significance becomes even more pronounced in today's interconnected global economy, where economic prosperity increasingly hinges on the seamless mobility of people, goods, and information and communication technologies.

Significant correlations exist between the quantity and quality of transportation infrastructure and the overall level of economic development (Rodrigue, 2020). Regions with high-density transport networks and robust connectivity often experience increased levels of development. The efficiency of transportation systems engenders a cascade of economic and social advantages, setting in motion positive multiplier effects. These include enhanced market accessibility, increased employment opportunities, and an increase

in supplementary investments. Conversely, when transport systems grapple with issues like inadequate capacity or reliability, they impose an economic toll, manifesting as missed opportunities and a diminished quality of life for communities affected.



Source: Rodrigue, 2020

The advancement in transportation since the Industrial Revolution has been closely linked to expanding economic opportunities. At each stage of the global economy's development, specific transport technologies have been either developed or adapted, with significant impacts (Rodrigue, 2020).

Following the conclusion of the Second World War, individual transportation became increasingly accessible to middle-income segments of society. This accessibility ushered in substantial economic prospects, especially in facilitating dependable deliveries to serve industrial and commercial markets (Rodrigue, 2020). In addition, the advent of the automobile enabled fresh social possibilities, notably through the phenomenon of suburbanization. From a macroeconomic perspective, the significance of transportation and its associated mobility cannot be overstated in terms of their impact on a nation's economic output, employment rates, and overall income levels. In the context of developed economies, transportation can typically represent a substantial share of the Gross Domestic Product (GDP), ranging from 6% to 25% (Rodrigue, 2020)

On the microeconomic scale, transportation assumes a crucial role in influencing the costs incurred by producers, consumers, and distribution networks. Typically, higher income levels are associated with a more substantial portion of transportation expenses within overall consumption budgets. Household expenditures, for instance, often allocate between 10% and 15% to transportation (Rodrigue, 2020). In the realm of manufacturing, transportation accounts for approximately 4% of the costs associated with each unit of output.

Direct economic benefits of transportation systems are easily seen. They encompass enhanced capacity, enabling the efficient movement of goods and people. Moreover, the increased accessibility to markets and resources brought about by improved transportation infrastructure fosters economies of scale, further enhancing economic efficiency. These benefits extend to various sectors, such as healthcare, education, and employment, by reducing geographic constraints and enabling greater access to critical services and opportunities. This, in turn, spurs economic growth and development by harnessing the full potential of human capital and resources (Rodrigue, 2020).

Furthermore, transportation systems exert an induced economic influence through multiplier effects and newfound opportunities. As transportation networks expand and improve, they stimulate additional economic activity by creating new markets, employment prospects, and investment incentives (Milewski, 2013). These ripple effects lead to a more dynamic and resilient economy, as transportation-induced growth fosters innovation, entrepreneurship, and the diversification of industries.

The ability to be mobile is an underlying characteristic of all human activities. Regardless of the aim, transport allows for social, cultural, political, and economic activities to occur. Hence, transportation stands as a cornerstone of societal well-being, profoundly impacting the daily lives and holistic health of communities in multifaceted ways (Stanley et al., 2011). Beyond its utilitarian role in connecting people to essential services and employment, transportation also plays a crucial part in enriching individuals' lives through access to friends and family, leisure activities and cultural experiences.

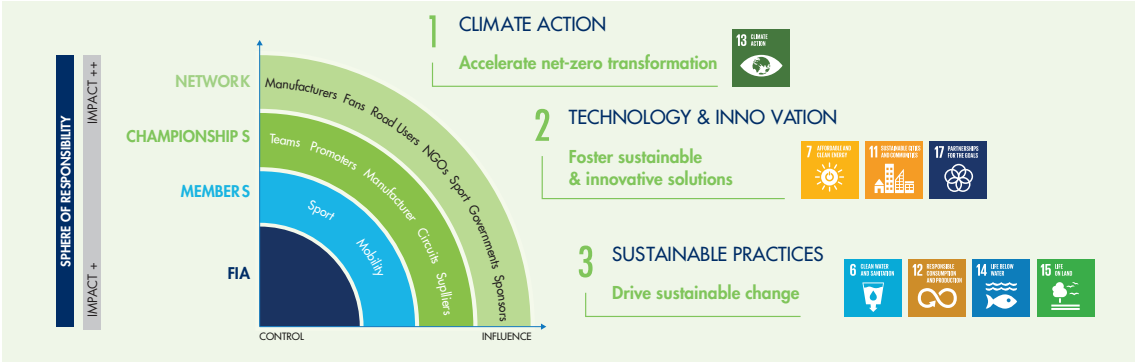
ALIGNING THE FIA WITH SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The UN's 2030 Agenda for Sustainable Development is comprised of 17 Sustainable Development Goals. These goals provide a common framework for organisations to explain how they plan to contribute to sustainable development.

STRATEGY SUMMARY

/ FIA ENVIRONMENTAL STRATEGY - SUMMARY

3 STRATEGIC GOALS



Source: https://www.fia.com/sites/default/files/fia_environmental_strategy_v4_web.pdf

The FIA recognises that no one sustainable development goal can stand alone and each one is interconnected. Some with a positive relationship where a move towards one goal has a direct positive impact on another, such as protecting water related systems (6) and promoting clean energy technology (7). Others though, if not carefully managed can have unintended negative impacts on one another as may happen with some developing economies between Decent Work and Economic Growth (8) and Affordable and Clean Energy (7) or Sustainable Cities and Communities (11).

Within the area of its influence, the FIA has identified eight SDGs that are most applicable to its activities linked to the environment, and where the FIA and its Members can best make a positive global contribution:
> protecting water-related ecosystems (6)
> promoting clean energy technology (7)
> advocating access to sustainable transport (11)
> promoting efficient use of natural resources (12.2)
> reducing waste generation (12.5)
> taking urgent action to combat climate change (13.3)
> reducing marine pollution (14.1)
> reducing the degradation of natural habitat (15.5)
> enhancing global partnership for sustainable development (17.6)

The FIA is making use of such influence and its global sporting and mobility network to convert these goals into actions, for example through numerous funded projects within its global network including rolling out the FIA Environmental Accreditation Programme.

The FIA Environmental Accreditation Programme is a certification system for sports teams, venues, promoters, event organisers, suppliers, as well as Sport and Mobility Clubs that is based on a one-to-three-star rating. This approach brings our network stakeholders on an evolutionary journey of continual improvement of their environmental performance, enshrining sustainability processes and practice within their strategic planning and goals.

THE FUTURE OF PERSONAL TRANSPORT AND GHGS

Climate scientists have been growing increasingly concerned at the rapid rate at which both land and ocean temperatures have been increasing (Kemp et al., 2022). The sustained heatwaves that have been experienced across the globe, from the United Kingdom to Spain and Greece, and from China to the United States are a testament to the impact of climate change.

According to the IPCC, the transportation sector is responsible for around 20% of global greenhouse gas emissions (IPCC 2022), making it a major contributor to climate change. The widespread use of petrol and diesel-powered vehicles is a primary driver of emissions as the demand for personal vehicles and goods transportation continues to rise.

It is estimated that there are currently 1.4 billion vehicles on the road, road transport contributions to GHG emissions are expected to grow with increased demand for passenger transport of 40% between 2010 and 2050. With such a high number of vehicles on the road, any expected replacement period for the current fleet of internal combustion engine (ICE) vehicles to a lower or zero emission fleet will take a number of years. This transition driven in large part through legislation is moving at a different pace in different regions of the world. Without concerted effort, we can still expect to see many of the current vehicles on the road between 2035 and 2060.

To comply with Science Based Targets (SBT), which set emission reduction pathways to reach net zero emissions, ensuring limiting global warming to 1.5°C, the automotive sector alone needs to reduce its emissions by 90% by 2050.

Growth within the areas of active mobility and changes to urban planning will offset some of this growth in GHG emissions but will not deal with the overall challenge of the increase in the growth of passenger vehicles and how best we resolve this as a collective.

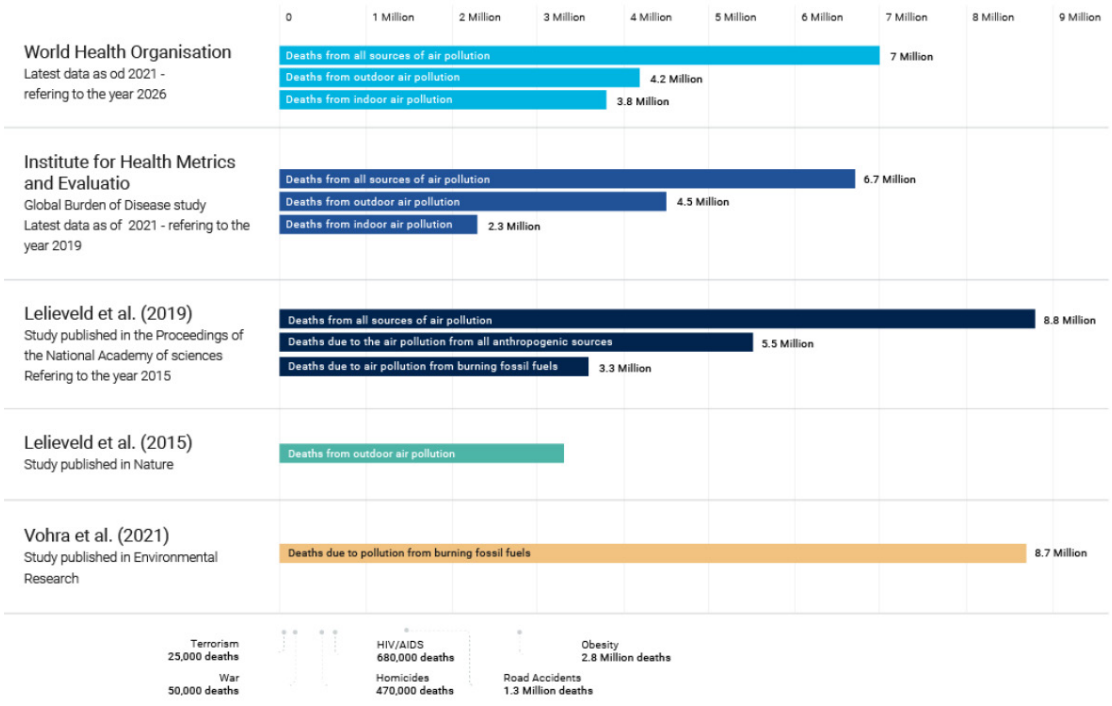
THE CHALLENGE BEFORE US

In an era marked by burgeoning environmental concerns and the pressing need for sustainable solutions, the global transportation sector has emerged as a key contributor to climate change and environmental degradation, and nations grappling with the multifaceted challenge of decoupling economic growth from carbon-intensive practices (IPCC, 2022). There is no option but change.

Rapid urbanization is a hallmark of the 21st century, resulting in increased metropolitan areas and heightened connectivity requirements (OECD, 2015). Personal vehicles embody a sense of autonomy and convenience, allowing individuals to navigate their surroundings on their terms (Mattioli et al., 2020). This demand however exerts considerable pressure on a nation's transportation infrastructure and environment (Rodrigue, 2020), necessitating comprehensive planning and innovative solutions. The proliferation of private vehicles has exacerbated traffic congestion, increased energy consumption, and elevated environmental externalities. Furthermore, the sector also faces the challenge of energy security, as its heavy reliance on fossil fuels exposes nations to geopolitical uncertainties and price fluctuations. As the global demand for oil and gas continues to strain resources, exploring alternative energy sources becomes imperative for long-term sustainability.

The World Health Organisation (WHO) has stated that 9 out of 10 people breathe polluted air with 7 million deaths globally attributable to this. One-third of all deaths associated with strokes, lung cancer, and heart disease are associated with pollution. Asthma and respiratory disease have been shown to be linked with air pollution and particulate matter (Kuiper et al., 2021) Particulate matter of 2.5 microns or less (PM2.5) can penetrate the barrier in the lung and enter the blood system and have these effects. Fossil fuel combustion is the major contributor to air pollution. In the 15 countries that contribute the most GHGs, the health impacts are the equivalent of 4% of their GDP (WHO, 2018). Hence, comprehensive strategies that promote cleaner technologies and sustainable practices, such as electric vehicles and

e-fuels are pivotal solutions contributing to reduced emissions, improved air quality, and enhanced human well-being (IPCC, 2022).



Source: Our World in Data (2021)

Increased low-carbon use across multiple transport modes will be key to reducing Greenhouse Gas (GHG) emissions (Brynolf et al., 2022). The urgent need to meet the climate goals of The Paris Agreement has encouraged technological innovation in the transportation sector, from electric battery technology in vehicles to engine efficiency and alternative fuels, as well as accelerated advanced materials innovation and new infrastructure technologies. Further challenges arise in the need for infrastructure that can support the use of such technologies, as well as imbalances in technological readiness, consumer acceptance and policies or supporting regulations across different regions, leading to slower and unequal global emissions reductions. Ultimately, the challenge is to forge a technology agnostic trajectory that harmonises economic prosperity, environmental stewardship, and societal well-being.

REGIONAL PREPAREDNESS

The world is a complex place, and the FIA recognises that there can be no one single solution to decarbonising personal mobility for all countries. Regional differences create a situation where countries find themselves at varying levels of readiness for the transition to clean energy, without which there cannot be a solution, regardless of the approach. For this reason, it is critical that while we consider global impacts, we do this with a firm local understanding of the needs of all those individuals impacted by our decisions.

Various factors exist that can influence a country or region's ability to switch to lower carbon solutions. The World Economic Forum (WEF) (2023) has developed an Energy Transition Index (ETI) that looks at the regulatory and financial environments incorporating elements of equity, access to affordable clean and modern energy, security, including a diverse energy mix, and sustainability.

High-Income Countries: According to WEF's ETI, the top 13 countries are high-income states, of which the top 11 are in Europe. These countries account for only 2.0% of the global population, 2.0% of CO2 emissions and 4.0% of the total energy supply. Importantly, some of the common features across these countries are:

> Reduced levels of fossil fuel energy subsidies – which were globally at a record high level of USD1trn in 2022 (WEF, 2023)
> Strong policies and a political will supported by regulations towards a cleaner environment.
> Carbon pricing schemes
> High levels of clean energy in the fuel mix
> A diverse set of import partners for energy sources (WEF, 2023). Across many high -income countries, urban centres are restricting vehicles from entering certain parts of cities and imposing tariffs.

Middle-Income Countries: Unlike high-income states, both upper and lower-middle income countries have become large centres of energy demand due to the pace of their economic growth, with the energy demand per capita expected to double by 2050. Importantly, India, China, and Indonesia, with their substantial growth trajectories, have simultaneously improved their ETI scores by more than 10%.

While several middle-income countries have strengthened their environmental policy and financing frameworks, carbon intensity use is prevalent and fossil-fuel subsidies are common. Demand for ICE-powered vehicles is still high, and the affordability of clean tech vehicles poses a major challenge due to generally lower disposable incomes. Nevertheless, several countries have the potential to not only increase their use of cleaner vehicles but also become production hubs and sources of exports for clean energy technology due to their abundant space and natural resources.

Low-Income Countries: These nations must balance their socio-economic development with their overall ability to transition effectively to low-carbon economies. Low energy mix diversity, coupled with weak availability and development of transport infrastructure, means that many basic mobility needs are unmet. When it comes to a clean energy transition, low-income countries are faced with higher costs of electricity, have challenges promoting circular economy in mobility, and are locked into fossil fuel dependency. While attempting to support rising energy demand, these groups require around USD 1 trillion a year for their power sectors to meet climate goals. These energy transition risks are further fuelled by inadequately targeted subsidies, challenges in governance and weak planning and capacity.

According to the World Bank (2023a), strong government leadership and commitment are key to break the poverty and energy trap and there needs to be strong sets of policies and regulations,

progressively capable institutions, and transparent project allocations to start the momentum. The power transition virtuous cycle, initiated by the World Bank, is started by low-income governments receiving the support of low-cost climate finance, upgrading power networks and utilities, and kickstarting a pipeline of affordable clean energy investments. It is also key to prepare for a just transition for workers and communities impacted by the economic change (World Bank, 2023a), and for the effective harnessing of abundant key natural resources and leveraging public-private partnerships (WEF, 2023).

THINKING GLOBALLY, ACTING LOCALLY

Strategies and actions for addressing the challenges of GHG transport emissions are different across countries and regions, partly dictated by their socio-economic positions. The World Bank (2023b) segregates countries into four groups based on Gross National Income (GNI) per capita as a broadly available indicator of economic capacity.

The world's middle-income countries are the most diverse and plentiful group, encompassing 54 countries each in the lower middle-income and upper middle-income categories, with 83 economies in high-income and 26 in the low-income group.

As the largest motoring organisation in the world, The FIA finds itself in a unique position, working locally in all these diverse markets through its Member network and globally operating as a hub, connecting road users, local governments, NGOs, and car manufacturers.

Taking time to understand each regional and individual groups unique needs and views allows the FIA to work through those Member Clubs developing innovative people-based solutions.

THE FIA AS A CONTRIBUTOR TO SUSTAINABLE PERSONAL MOBILITY

A wider collaborative effort is essential if we are to half global emissions by 2030 to achieve the 2050 target of limiting global warming to 1.5°C compared to pre-industrial levels is to be achieved. Understanding this responsibility and as a global governing body for motor sport and mobility, the FIA uses its platforms to advocate for sustainable motor sport while showcasing its technological innovation toward sustainability.

Research undertaken by the FIA on global reductions in CO2 emissions from cars in terms of the consumer's perspective has highlighted the need for a consistent approach from governments regarding setting long-term visions for CO2 reductions and the implementation of effective structural policies. The FIA uses such research to add value and provide potential solutions to the key findings and recommendations of COP27 particularly, regarding the need to hold businesses and institutions to account, provide financial support to developing countries, and critically, make the move towards grassroots implementation of climate and energy policies.

The FIA's unique global membership network generates a dynamic exchange of ideas around issues such as climate change adaptation and the rollout of new technologies to lower carbon emissions contributing to achieving the net zero target. The FIA represents consumers from both developed and emerging economies. The piloting of new technologies in various markets at the grassroots motoring level allows for rapid adoption of cost-effective sustainable solutions to reduce emissions.

WALKING WITH THE CONSUMER ON THE JOURNEY

In this so called "Post Truth World" the gap between expert advice and public acceptance has widened. People do not want to be told what to do and how to do it. They want choice and the ability to have a say in the solutions to the problems that they face. This is evident in the push-back that we see in the reductions of speed limits in cities or adoption of low (or zero) emission zones. These objections are often not founded on science but a feeling that the government is overstepping its mandate and enforcing changes on a public that hadn't asked for them.

Effecting positive consumer change cannot be achieved using big words and jargon from the hilltop. It must be done with care and understanding of the consumer's needs and challenges and with the consumer at the heart of the conversation.

Positive change requires positive relationships. Positive relationships require bi-directional communication. This can only be undertaken from a point of integrity and trust.

It is here that the FIA's understanding of end consumers and their role in developing a sustainable mobility system comes to the fore. As we have shown with our track record on safety initiatives, there are few organisations that are in such a fortunate position as the FIA. Our own specialists and those in our Member Clubs can meet at one table with our consumer specialists. As a team they work together to develop consumer facing solutions and communications campaigns. Campaigns that translate key academic messaging into elements that matter to and motivate consumers to make safer and more sustainable choices.

MOVING TOWARDS CARBON NEUTRAL MOBILITY

With no easy single path to decarbonising personal mobility, there are three critical elements required to facilitate the transition.

1. TECHNOLOGICALLY AGNOSTIC SOLUTIONS FOR FUTURE POWERTRAINS
2. EMBRACING THE CIRCULAR ECONOMY
3. THE ROLE OF THE CONSUMER GROUNDED IN A TRUSTING RELATIONSHIP

1. TECHNOLOGICALLY AGNOSTIC SOLUTIONS FOR FUTURE POWERTRAINS

Most powertrain systems in production today are based on the internal combustion engine powered by petroleum or diesel fuel. The advent of electric vehicles has however, increased the number of both hybrid (electric combined with traditional internal combustion engine) and fully electrified vehicles in circulation.

In the hybrid vehicle, the energy for the motor is stored in onboard batteries which are charged by the traditional internal combustion engine or, as in the case of a fully electrified vehicle, plugged into an external charger. These hybrid systems require technology for both electrified and traditional internal combustion engine powertrains.

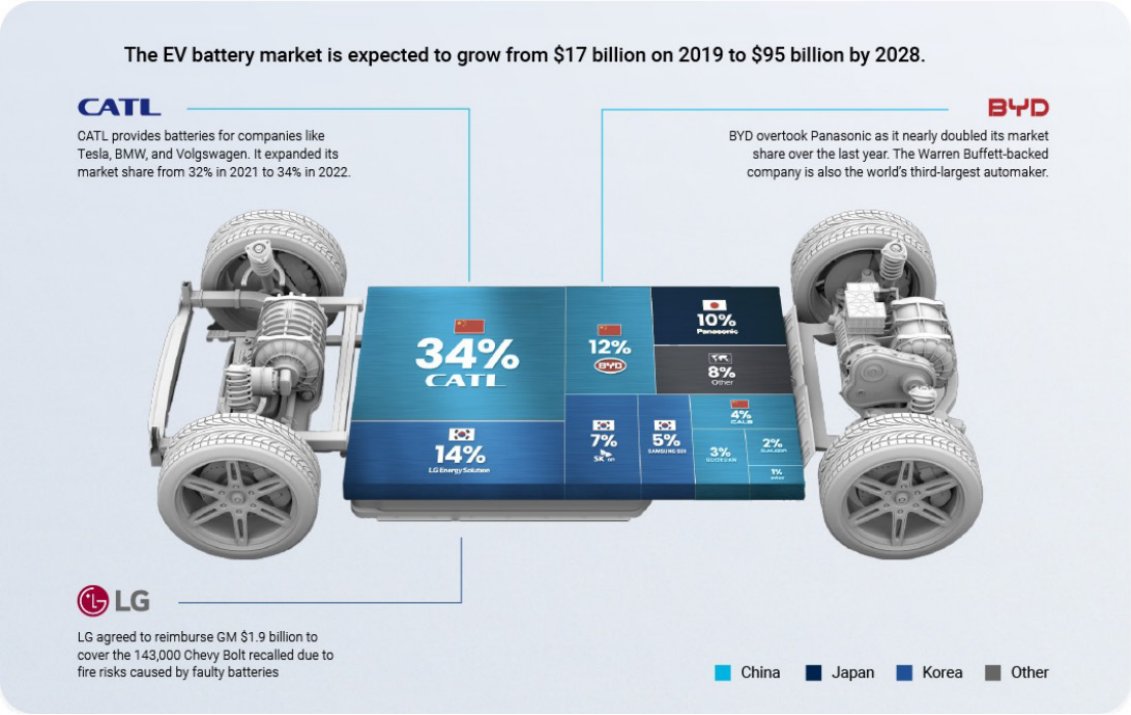
Fully electrified vehicles on the other hand require the technology for an electrified powertrain system and rely on external chargers, and therefore to external infrastructure availability. The environmental, especially related to air quality, benefit of electric vehicles is well documented as they emit fewer greenhouse gases and air pollutants than petrol or diesel cars.

ELECTRIFICATION AS A CONTRIBUTOR TO REDUCING CARBON EMISSIONS.

The popularity of electric vehicles (EV) is rising at an exponential rate. According to McKinsey's projections, the desire for EVs is expected to experience a sixfold increase between 2021 and 2030. This surge in demand is estimated to lead to annual unit sales soaring from 6.5 million in 2021 to approximately 40 million by the year 2030 (McKinsey, 2022).

Discussed in detail below, over 16,000 residents were surveyed by the Canadian Automobile Association on their preferences and experience of EVs 92% say they were extremely likely, with a further 5% saying they are likely, to replace their EV with another EV. Their concerns prior to owning the vehicle and after experience of ownership decreased on each measure. However, it is important to note that the issue that generated the most concern for drivers was insufficient public charging capacity. This has been recognised as a scalability and practical issue and is one of particular concern to customers.

The EV market is experiencing remarkable growth in sales. Starting from 120,000 units sold in 2012, global sales escalated to 6.6 million in 2021 and surpassed 10 million in 2022. The percentage of total car sales attributed to EVs increased from over 10% in 2021 to 14% in 2022, highlighting rapid expansion. The first quarter of 2023 saw over 2.23 million EVs sold, a 25% increase compared to the same period in the previous year (IEA, 2023). Projections suggest around 14 million sales in 2023, signifying a potential 35% increase, particularly in the latter half of the year. This growth could lead to EVs representing 18% of total car sales by year-end.



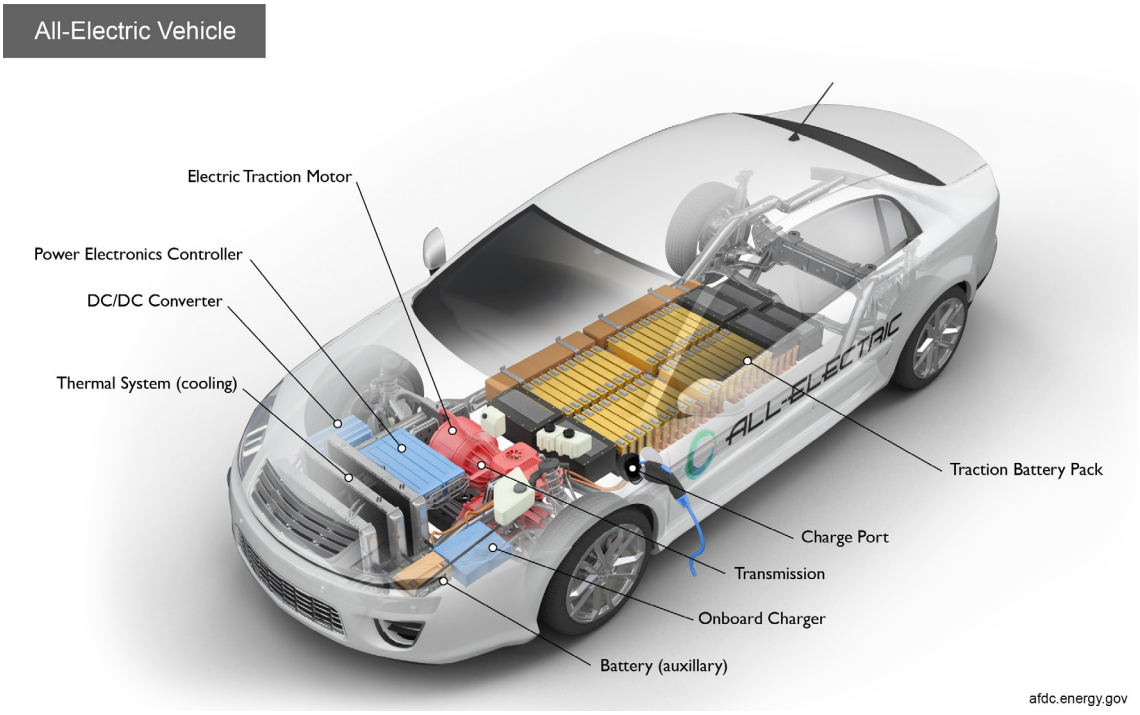
Source: Venditti (2022)

The surge in EV sales has been driven by national policies, incentives, and rising oil prices. The use of EVs has shown significant potential in reducing CO2 emissions but also significant potential gains in powertrain efficiency through improved system design and on-board management and therefore potential financial savings in the long term, which represents a significant advantage in the marketplace when trying to encourage wider usage of this new technology (Pardhi 2022).

The FIA and its Member Clubs play a pivotal role, providing evidence-based consumer information through conducting comparative studies, such as the annual real-world testing of EVs in cold weather by Norges Automobil-Forbund in Norway (discussed in detail below), where for four years they have tested the range and charging speed of 29 EVs available in Norway.

BATTERY ELECTRIC VEHICLES (BEVS) are fully electric and use a battery pack to store electrical energy which powers the electric motor of the vehicle. The batteries are charged by plugging the vehicle into an electric power source. The source of electricity used to charge EVs is a considerable point of contention as non-renewable electricity production still contributes to air pollution and GHG emissions. Regardless, these all-electric vehicles are classed as zero-emission vehicles because they produce no direct exhaust or tailpipe emissions contributing to GHG emissions (EERE, 2023).

All-Electric Vehicle



Source: EERE (2023)

HYBRID ELECTRIC VEHICLES (HEVS) use a combination of an ICE, batteries, and at least one electric motor to provide power to the vehicle. The ICE of the vehicle is the primary source of power while the electric motor of the vehicle assists the ICE. This combined system allows the vehicle to emit less CO2 while providing better fuel economy without sacrificing vehicle performance. Additionally, the batteries are charged through regenerative braking, however, the vehicle cannot be plugged in to charge the battery (EERE, 2023).

PLUG-IN HYBRID ELECTRIC VEHICLES (PHEVS) use a combined approach of an EV and an ICE vehicle. The vehicle is powered by an ICE engine which uses fuel to generate its energy and an electric motor which uses electricity from a set of batteries. The batteries can be charged using a wall outlet or charging equipment, by the ICE itself, or through regenerative braking. The vehicle usually is powered by electric power until the battery is nearly depleted, and then the vehicle automatically switches over to use the ICE. The combination of the ICE and batteries of the vehicle allows the engine to save fuel, improve performance, and enable longer range (EERE, 2023).

PHEVs can usually run in at least two different modes: (Agnew Group, n.d):

> Hybrid Mode: Both electricity and fuel (petrol/diesel) power the vehicle.
> All-electric Mode: The vehicle is powered by the electric motor and battery power.

The PHEV will usually start in hybrid mode and the driver is responsible for switching the vehicle over to all-electric mode.

HYDROGEN AS A CONTRIBUTOR TO REDUCING CARBON EMISSIONS

The use of hydrogen-fuelled technology in vehicles is as clean as the source of energy and production method used to make molecular hydrogen. Most of the hydrogen production currently comes from steam reforming of natural gas or coal gasification, both with carbon dioxide (CO2) emissions.

Future demand will principally be for zero-carbon or 'green' hydrogen produced from renewable feedstocks, such as wind and solar, and net zero for production and end-use. Green hydrogen represented only 0.03% of total hydrogen supply in 2020 (IEA, 2021). Plans for increased hydrogen production rely on electrolysis using electricity from intermittent renewable sources (World Nuclear Association, 2021).

Hydrogen offers an advantage over electric vehicle battery storage by being able to utilise excess renewable energy which can then be stored for a longer duration. (Albatayneh 2023). Hydrogen has potential as a pathway to help drive the future of mobility as the efficiency of hydrogen-powered internal combustion engines is comparable to traditional internal combustion engines and potentially more cost-effective.

BIOFUEL AS A CONTRIBUTOR TO REDUCING CARBON EMISSIONS

Second generation biofuels, or "sustainable biofuel", being biofuels that do not compete with crops for food resources, do not degrade the land, and which are compatible with existing internal combustion engine technology offer another option for sustainable personal transport. These biofuels are made from biomass and are therefore renewable.

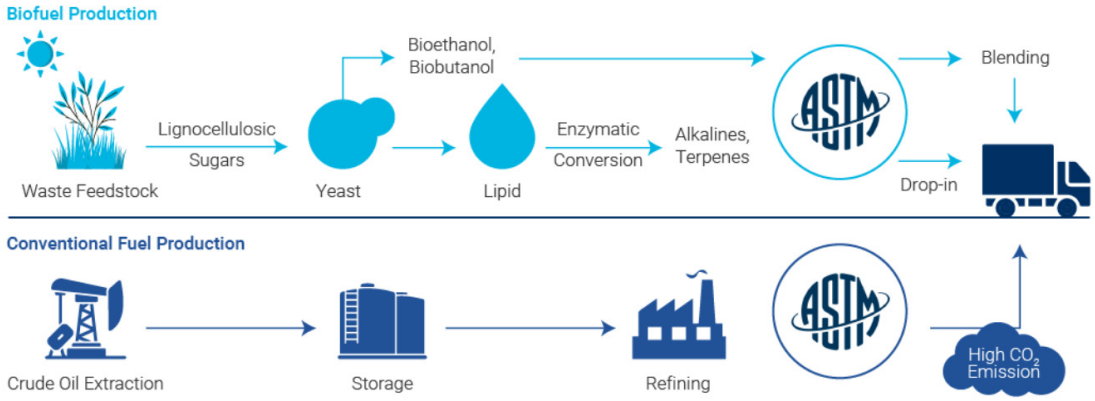
Biofuels play an important role in transportation, especially in emerging and newly emerged economies, by providing a decarbonising solution, and they are readily used in existing infrastructure and engines with little modification needed. Vehicles that run exclusively on biofuels are not widely produced commercially but rather blend biofuels with petrol and diesel to decrease their CO2 emissions.

Biofuel releases as much as 90% fewer CO2 emissions than traditional fossil fuel, and each kilogram of biodiesel employed translates to a reduction of about 3 kilograms in CO2 emissions (Xavier 2022). Engines powered by biofuel also emit notably fewer pollutants, resulting in decreased discharges of particulate matter, carbon monoxide, and hydrocarbons. In the pursuit of achieving a 90% reduction in transport emissions by 2050, along with a 55% decrease in total CO2 emissions by 2030, biofuel assumes a pivotal role.

The International Renewable Energy Agency (IRENA) envisions that most of the required energy-related CO2 emission reductions up to 2050 will be fulfilled by increased renewable energy adoption and enhanced energy efficiency, contributing to over 90% of the reduction. In this scenario, bioenergy accounts for 22% of the world's total energy demand for transportation. If more ambitious climate goals are pursued, the significance of biofuel is expected to grow further, especially in bio-based fuels linked with carbon capture, storage, or reuse. Biofuel possesses the significant capacity to contribute to the forthcoming transportation

sector, albeit not as the primary source. Diverse scenarios show that biofuel has the potential to provide an average of 42 EJ/yr. (with a variation spanning from 5 to 85 EJ/yr.) by 2100 for transportation, compared to the 3.7 EJ recorded in 2018. This predominantly stems from lignocellulosic fuels and has the potential to represent 9-62% of the ultimate energy consumption for transportation.

Current biofuels are manufactured from biomass crops, to achieve complete sustainable biofuel the fuel needs to be manufactured using the waste from biomass crops (Bhardwaj 2015).



Source: Malode et al. (2021)

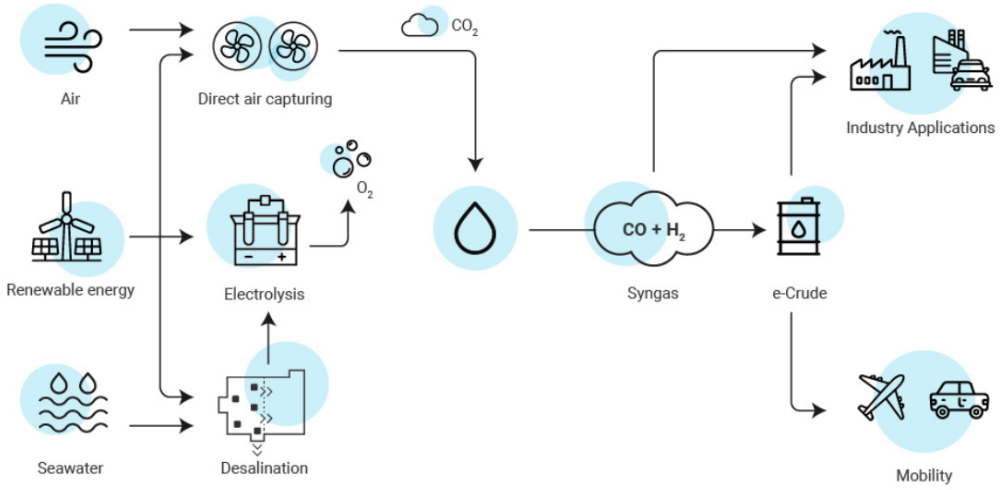
CARBON BASED E-FUELS

Carbon-based e-fuels have two essential requirements – green hydrogen produced from hydrolysis of water using renewable energy and a source of carbon dioxide. Carbon dioxide can be obtained by a process known as carbon capture at source (CCS) from a source of higher CO2 concentration such as air over a cement factor or a gas-fired power plant. Alternatively, it can be obtained through direct air capture (DAC).

Hydrogen can be reacted with CO2 to form other gaseous fuels – methane or syngas (carbon monoxide and hydrogen). Syngas can then be transformed into liquid e-fuels like diesel or petrol using Fischer-Tropsch synthesis (FT). Carbon-based e-fuels cover a broad range of renewable fuels including e-diesel, e-gasoline and e-kerosene, where the e signifies that is an electro equivalent of the fossil fuel.

Fossil fuels have a high energy density and through the use of the internal combustion engine have served as the energy source for most forms of transport. E-fuels, which have properties similar to fossil fuels, also have a high energy density. Adopting the latest in e-fuel, the FIA will be making use of e-fuels to power the Formula 1 championship, at the top end of motor sport racing from 2026.

The method for Direct Air Capture was developed by Professor Klaus Lackner in 1999 as a climate change mitigation strategy to capture carbon dioxide from ambient air. This is a negative emission technology as it removes existing material. However, when it undergoes the FT synthesis process and is used as an e-fuel, it reverts to being a carbon.



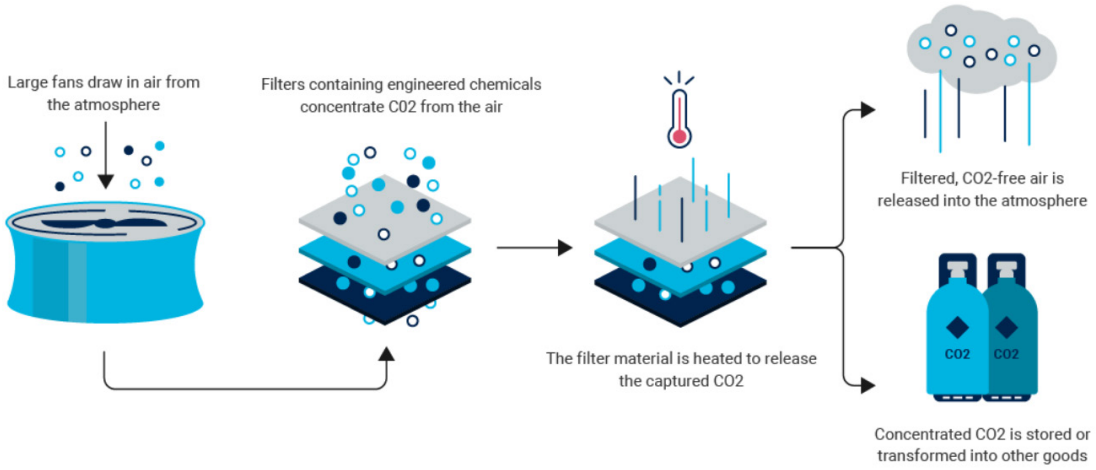
Source: Adapted from The Royal Society (2019)

CARBON CAPTURE AT SOURCE

Approximately one-third of anthropomorphic generated carbon dioxide is from fossil fuel plants. Capturing the carbon from these sources prevents it from getting into the atmosphere and it can be used to produce carbon-based e-fuels. These sources of carbon are expected to be reduced as climate change mitigation strategies are implemented. Hence the capture of carbon from sources of lower density and in ambient air is also considered essential for the long-term production of e-fuels.

DIRECT AIR CAPTURE

Carbon in the atmosphere has increased from pre-industrial levels of 260-280 ppm to the current levels of 416 ppm (Senecal and Leach, 2021). Although this is having catastrophic effects, the levels in the atmosphere are still remarkably low in terms of capture. In comparison to the concentrations in the air above factories. Carbon dioxide is a very inert gas, making it more difficult to capture it from the atmosphere.



Source: CB insights (2021)

Government policies and subsidies for personal vehicle transport have to date all promoted the use of electrification as a route to meeting the Paris Agreement. Policy support across a broad platform could help support innovation in a range of arenas and allow the flourishing of alternative solutions. Tax reform on energy would also help create a level playing field for all technologies (Ueckerdt, 2021).

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THE RIGHT FUEL FOR THE RIGHT CHALLENGE

One of the key challenges in meeting net zero targets in road transport is the affordability of these innovative technologies for consumers combined with potential concerns over performance and practicality.
EVs for example are currently more expensive to buy than petrol or diesel vehicles due in part to the fact that they are produced in smaller numbers and use expensive recent technologies. Despite this, they can work out less expensive in the longer term by being cheaper to run, requiring less costly maintenance, and due to direct financial incentives, such as lower road tax, etc. Studies show that sales of EVs are increasing worldwide with the World Economic Forum, announcing in 2021 that sales of electric vehicles had doubled from 2020 with more being sold per week than had been sold in the entire year of 2012.

FIA AND TAKING THE LEAD ON TECHNICAL SOLUTIONS FOR FUTURE POWERTRAINS

The FIA, working with academics, start-ups, manufacturers and its Member Clubs conduct extensive research and fieldwork to understand sustainability within the realm of future mobility. This research is applied in two primary ways.

1. To educate and inform end consumers to assist them with their own decision making
2. Shared with our global network that it may be similarly used and or replicated.

While many of these projects are self-funded by the regional Mobility Clubs, much of this work is also funded by the FIA through sustainability grants in order to develop a world-view that encompasses the Global South, developing and developed nations.

Examples of our most recent work to develop consumer information and present it in a manner that resonates on a road-user level includes:

MAKE CARS GREEN

As early as 2008, the FIA was using its media muscle to advance the need to make fundamental changes to the way cars are made and how they are driven to highlight how environmental challenges can be addressed if manufacturers and consumers consider the impact of their decisions.

Launched at the Japanese Formula1 Grand Prix and in conjunction with the Japanese Mobility Club JAF, the campaign made use of key drivers, Felipe Massa, Kimi Räikkönen, Lewis Hamilton and Heikki Kovalainen to deliver messaging on how consumers can reduce their carbon footprint.

TRACK-TO-ROAD EV SOLUTIONS - FORMULA E GEN3 RACING CARS

Demonstrating the cutting edge of electric mobility, the Formula E 3rd Generation are smaller and lighter than the previous generation with batteries that run a full race distance. Recharging their 600 KW in under four minutes. By comparison, the first-Generation batteries (200KW)lasted half of the race. It is this rapid innovation and development that allows the FIA and its partners to develop fast-paced track-to-road sustainability solutions.

TRACK-TO-ROAD - SUSTAINABLE LIQUID FUELS

The FIA adopted the definition of sustainable biofuels made from municipal waste or biomass (Gen2) or algae (Gen3). Its diesel version is generally FAME (Fatty Acid Methyl Esters) or HVO (hydrotreated vegetable oil). Sustainable biofuel's life cycle results in a minimum 65% GHG emissions reduction compared to fossil fuel (sourcing and production). The plan is to increase this reduction over time as the technology and sources become more available.

In 2021 the FIA introduced E10 fuel, this being a mixture of 90% fossil fuel and 10% ethanol. However, by 2026, Formula 1 will create a 100% sustainable 'drop in fuel' to be used in standard internal combustion engines, critically, without the requirement to modify the engine. This fuel will make use of carbon capture, municipal waste, or non-food biomass and shall achieve greenhouse gas emissions savings relative to fossil fuel created petrol of at least 65%.

The FIA is requiring all its championships to be powered by 100% sustainable energies by 2026 – from advanced sustainable drop-in fuels to battery and hydrogen technologies. Advanced fully sustainable fuels are already in use in in WRC, WEC, ETRC, Karting, and by some individual teams in Cross Country. By using sustainable fuels in motor sport, fuel and engine manufacturers can observe and adapt according to any issues experienced with their use under extreme conditions. If sustainable fuels can be used successfully under the conditions of motor sport, then the technology should easily be transferred to road cars.

Regardless of the development of the EV market, in most countries, particularly in developing countries, the infrastructure is not sufficiently robust yet to provide the amount and distribution of electricity needed. Governments need multiple approaches to decarbonisation, and sustainable fuels are clearly a major option. Even after the ban on the production of cars with ICEs on some markets, there will still be over a billion cars on the road worldwide that will still need liquid fuels. The use of sustainable fuels as an alternative to fossil fuels must be therefore encouraged.

Through this use of sustainable fuels in motor sport, fuel and engine manufacturers hone their offerings, testing in extreme conditions, making for a safe transfer to road cars having a direct and immediate impact on their sustainability.,

Targeting all aspects of decarbonisation, through the creation of alternate fuels, the FIA is working with a range of solution providers to find track-tested mobility solutions that can be applied to multiple markets around the world.

TRACK-TO-ROAD - HYDROGEN

Since 2019, the FIA is working along manufacturers, including Toyota, to pilot the use of hydrogen-powered (compressed gas and liquid storage) internal combustion engine cars in FIA sanctioned motor sport events such as touring cars and endurance races.

These projects serve as a basis for the FIA's work in developing the regulations for championships and our objective is to help manufacturers in their development in the application of the regulations.

Technological developments are specific for racing cars, however technical challenges are very similar than encountered in road cars (notably regarding thermal insulation, materials and lifespan of components).

Exposure and testing of this kind foster more avenues for collaboration with other manufacturers, research institutions, and governments to accelerate the development and adoption of hydrogen for the decarbonisation of road transport.

Of importance to the FIA team is that racing takes place around the world, meaning that solutions developed for the application of hydrogen as a clean fuel source have to work in all regions, regardless of their local challenges. These solutions address all aspects of hydrogen as a fuel, including, production, storage, transport, refuelling, engine management and overall sustainability.

Working with manufacturers, the FIA has multiple projects developing regulations to support the introduction of Hydrogen fuel solutions. Initial projects include:

CHAMPIONSHIPS
Extreme H : 2025
Endurance : 2027
Truck racing : TBC

UPCOMING VEHICLES USING HYDROGEN AS A FUEL

Toyota Touring car Corolla, source: TOYOTA

Mission H24, source: DPPI

Toyota is working on a prototype car, source: TOYOTA

HySE-X1Mockup image, source: TOYOTA

> Toyota launched a Touring car (Corolla) in 2022 that uses a compressed gas storage system but with a combustion engine which was updated Liquid hydrogen storage system in 2023.
> Mission H24, which is a prototype car to be introduced in 2025 using a compressed gas storage system fuel cell.
> Toyota is working on a prototype car for introduction in 2027 that is using a compressed gas storage system but with a combustion engine.
> The HySE (Hydrogen Small mobility & Engine technology) research association T3U, being introduced in 2024 with a compressed gas storage system and a Combustion engine.

ROYAL AUTOMOBILE CLUB OF WESTERN AUSTRALIA(RAC) INTELLIBUS® TRIAL

The RAC Intellibus® was Australia's first and longest-running automated vehicle (AV) trial launching in 2016. While being a significant brand icon for many years, the trial helped foster a better understanding of driverless vehicle technology, enabling Western Australia to take an informed and leading role in developing initiatives to facilitate, regulate and understand these systems and potential road safety benefits while providing its members and the community to experience it firsthand. The RAC Intellibus®, broke new ground in the autonomous vehicle space in Australia, putting WA at the forefront of emerging

technology, and proving driverless travel can be safe and accessible for the entire community. Travelling more than 38,000kms, and transporting more than 28,000 passengers in the Perth metropolitan area and regional WA.

REAL WORLD EMISSIONS TESTING

Cars are responsible for 11 per cent of Australia's CO2 emissions. This program focused on educating consumers about vehicles that failed to deliver promised environmental benefits, improving motoring affordability, and reducing Australian vehicle emissions.

Running again between 2023 and 2027, the Australian Automobile Association (AAA), the Real-World Emissions Test Program has stepped up to address the consumer concerns raised by the so-called Diesel-gate scandal, highlighted that vehicle emissions standards had incentivised carmakers to optimise performance for laboratory-tests, rather than real-world performance. It became clear that car-buyers were at risk of being misled by vehicle fuel consumption labelling and the claimed emissions-reduction benefits of some new cars.

To address this challenge, the AAA tested 30 cars in 2017 and will be testing 200 cars from 2023 onwards. Reporting their real-world environmental performance, comparing the results to each vehicle's mandatory laboratory test result. The initial AAA-funded 2017 pilot study found the tested vehicles were using up to 59 per cent more fuel than advertised (meaning they were emitting up to 59 per cent more CO2 than currently being accounted for by carmakers and regulators).

AIR HEALTH MONITORING

For more than a century, the Royal Automobile Club of Western Australia (RAC) has worked in Western Australia, advocating for change, community development, and organisational impact.

The Club, which was launched in 1905, is committed to achieving its vision, to create change that will lead to a safer, sustainable, and connected future for Western Australians. To achieve this, RAC has worked collaboratively with the government, industries its members, and community.
In line with its commitment, the Club launched an air health monitor to measure the pollutants from vehicles, buildings, and industries. This is a step further to know the level of harmful air particulate present in the air and decarbonise the city including its transportation sector.

The health monitor is powered by hundreds of sensors, showing hourly changes in the quality of air. Measuring particulate matter and nitrogen dioxide emitted from vehicles, buildings and industries. This is measured using an interactive model that blends air quality data from the sensory network with other data, including real-time traffic data from main roads and motor vehicle emissions modelling from Copert Australia. The model also includes emission data from the Department of Climate Change, Energy, the Environment and Waters National Pollutant Inventory (NPI) database.

Sharing the methods and processes, the Club has enabled other organisations in different regions to complete comparable research into their own environment while using the data in Western Australia to educate their own communities while advocating for proactive measures to decarbonising their cities.

SUSTAINABLE FUELS

Türkiye Turing Ve Otomobil Kurumu, the FIA Club in Türkiye, with a series of specialist partners is currently undertaking a research project, funded by the FIA Foundation, to produce neutral/negative carbon-based fuel from algae after which a representative journey is to be undertaken to showcase the ease and benefits of switching to carbon neutral fuels.

From here their Opening Sustainable Mobility Academy will be arranging workshops (Eco-Driving, New Generation Vehicles and Fuels, Drive for Future etc.)

The research work is also supporting scholarship students from different universities within the Body of Turing (Turing is also an institution that provides education & scholarships to students) to encourage further academic research and development into Sustainable Mobility.

ELECTRIC HIGHWAYS

Encouraging the uptake of clean mobility and reducing harmful emissions from vehicles, the Royal Automobile Club of Western Australia (RAC) Electric Highway® opened up the road to the South West for EV drivers ensuring they could confidently travel, able to charge when needed whilst on their journey. This innovative project was an investment into the future of sustainable mobility in Western Australia (WA) providing positive environmental, social and economic outcomes.

Built on an idea by a WA community-based committee and initially comprising 12 EV charging stations covering 520 kilometres from Perth to Augusta. The Electric Highway® was a collaborative project involving nine local governments; the Cities of Bunbury, Busselton, Fremantle and Mandurah; and the Shires of Harvey, Augusta-Margaret River, Nannup, Bridgetown-Greenbushes and Donnybrook.

The RAC Electric Highway® was a catalyst project to encourage investment by government and others in much-needed infrastructure to support greater uptake of low and zero emission vehicles. Today, the highway consists of 16 locations from regional towns Monkey Mia to Pemberton that features a combination of publicly accessible ultra-rapid, fast and destination charging options.

To help reduce the broader emissions from vehicles, RAC transitioned all fast and ultra rapid locations to green energy, with the only exception being the destination chargers in RAC's parks and resorts. Since the opening of the RAC Electric Highway®, there has been a significant increase in EV infrastructure, thanks to government and private investment. In 2015, when RAC launched the RAC Electric Highway®, there were just 174 registered EVs and by the end of June 2023, it was 10,062 in WA.

RAC funded the RAC Electric Highway® to inspire investment into charging infrastructure across the State, as part of the transition to a cleaner and more sustainable transport system in WA. RAC chargers continue to be a popular choice amongst the community and have welcomed the State and Federal governments investments into a comprehensive network for WA. For example, the allocation of almost $60 million in the 2022-23 State Budget to accelerate the use of zero emission vehicles, which included $23 million to expand WA's EV charging network, in addition to the $15 million Charge-Up Workplace EV Charging grants program.

2. EMBRACING THE CIRCULAR ECONOMY

The circular economy in relation to passenger road transport encompasses rational use of resources and energy, integration of renewable and recycled materials, ecodesign for increased lifespan and sustainable end-of-life solutions. As Murakami et al. (2022) illustrate, this also needs to consider the use of material that reduces the release of carbon into the atmosphere, for example, the exhaust. Exhausts use platinum in their construction, which occurs as a few ppm in ore, leading to large amounts of mining, energy use and emission of CO2 for the production of a catalyst.

Similarly, photo-voltaic panels and lithium-ion batteries, which are used for the generation of renewable electricity and its storage, use materials in their production which are energy-intensive to produce and require mining for access.

A circular economy requires the reuse and recycling of material such that resource losses and energy use are minimised. Key to this is the level of energy required in the recovery process for material re-use (Saidani et al., 2019). A circular economy relies on the use of renewable energy sources for electricity (Murakami et al., 2022).

CASE OF EVS

Electric vehicles have an efficient conversion of solar, wind or other renewable energy to electricity and mechanical energy at levels five times higher than carbon-based e-fuels.

The more significant impact of EVs is in the areas of use of resources for battery production and their recycling. To increase the circularity of EVs, recycling batteries is important.

Lithium-ion batteries, the most common battery solution for EVs, use lithium and cobalt in their production. By 2040, lithium demand is expected to grow 40-fold, largely driven by EV growth. Supply of these minerals is geographically concentrated and rapidly falling short of demand.
Lithium supply either comes from hard rock, such as in Australia, from where it is mined or from countries such as Chile where it is extracted from brine. The environmental impact of the two extraction

processes varies with the first having similar impacts to other mining processes and the brine extraction being water intensive. Demand for cobalt is expected to grow 5-fold by 2030. Half of all cobalt reserves are thought to be in the Democratic Republic of Congo (DRC) and the DRC has two-thirds of global cobalt production. Other negative environmental and social impacts such as child labour has been documented in this sector.

Current recycling rates are low but rising. Laws such as EU Regulation concerning batteries and waste batteries, which came into effect in August 2023 (2020/0353 COD), have the potential to accelerate the rate and level of battery recycling. To improve information collection on composition and condition of batteries through their life cycle, and hence improve recycling efficiency, the European Commission proposed in 2022 to mandate Battery Passports that will store data to predict end of life of batteries and their suitability for recycling (Deloitte, 2023). This follows regulation that was introduced in China in 2018 that forced battery manufacturers to collect waste batteries for recycling. Extraction of the key metals from waste batteries will reduce the need for mining and new extraction efforts, reducing the environmental impact. Cobalt extraction from batteries can be achieved with a 95 – 98% recovery rate (Amjad et al., 2022).

LIFE CYCLE APPROACH

Considering efficiency in relation to sustainability and climate change also needs to consider the level of CO2 and other particulates that are generated from the production and use of vehicles. The life cycle assessment (LCA) methodology as defined by the ISO (2006) standards, is a critical tool that provides information on potential environmental impacts of a product throughout its life cycle. It could take into account sustainability and pollution – namely, energy, water, waste for removal, volatile organic compounds and CO2.

Through embracing a data-informed "R-strategy" in the mobility sector, encompassing reuse, remanufacturing, and recycling , a circular economy not only aids businesses in achieving their sustainability goals but also opens fresh prospects within the industry. This involves the integration of renewable, recycled, or reused materials within vehicle components and exploring solutions to increase the duration of use and end-of-life management of vehicle components. Development of circular economy strategies in mobility and transport, such as vehicle sharing, smart charging, refurbishment, repurposing, and recycling, reduces both the environmental impact and costs throughout the lifecycle of products (World Economic Forum, 2022).

Circularizing the automotive sector is another crucial approach to the decarbonization of the transportation sector. Incorporating circular economy approaches can reduce the lifecycle carbon emissions per passenger km by up to 75% by 2030 (Accenture 2021).

Currently, within the motor vehicle industry the evolution of environmental regulations and economic factors has led to a rise in the use of renewable, recycled, or reused materials within vehicle components however barriers to the adoption of a full circular economy model are consumer trends and concerns

over potential performance and costs (Catana 2022), education of, and engagement with, consumers can address these issues.

FIA PROMOTING CIRCULAR ECONOMY IN MOBILITY AND MOTOR SPORT

With direct intervention and network focused sustainability grants, the FIA invests extensively in driving net zero targets through the promotion of a circular economy approach for and with consumers, within motor sport and mobility focusing on the sustainable use of materials in the design and manufacturing of vehicles and components.

UNEP USED VEHICLE TRADE AGREEMENTS AND A HARMONISED APPROACH TO USED VEHICLE EXPORTS/IMPORTS

The circular economy collapses when industries lose track of the raw materials that make up their products. Furthermore, while there are clear benefits to moving vehicles from developed to developing countries, this cannot be a matter of dumping good and must form part of a larger sustainable and circular approach to mobility.

Starting with the Promoting Safer and Cleaner Used Vehicles for Africa 2020 Report, the FIA raised awareness on the necessity for promoting a safer and cleaner market for used vehicles in Africa. It was conducted in support of the United Nations Environment Programme's (UNEP) project which promotes the development and implementation of (used) vehicles standards.

UNEP's project brought exporters (mainly from the European Union and Japan) and African importing countries together to agree on minimum standards for used vehicles. It also supported African countries in developing national standards and regulations in relation to emissions and safety.

Among the findings highlighted in the Promoting Safer and Cleaner Used Vehicles for Africa 2020 Report are that 22 African countries had no restrictions on the importing of second-hand vehicles, while 27 countries have age limitations of between three and 15 years on the vehicles they are importing.

The FIA further supported the implementation of the Safer and Cleaner Used Vehicles for Africa project. The project is led by the UN Environment Programme (UNEP), UN Economic Commission for Europe (UNECE) and implemented together with the FIA and the International Motor Vehicles Inspection Committee (CITA). The project was funded by the United Nations Road Safety Fund (UNRSF). The Climate and Clean Air Coalition, and FIA Foundation are also supporting the project.

Throughout 2020, two workshops were organised with exporters of used vehicles. Moreover, Institutional stakeholders and members of CITA, a partner in this project, met on the control of used vehicles. In June 2021, CITA, held a webinar on Safer and Cleaner Used Vehicles for Africa. In the same month, the first

African used vehicles importers meeting was organised with the participants from 27 African countries, the UN, and regional African bodies. In November, an updated Used Vehicle Report was published. Safer and Cleaner Used Vehicles also appeared at a working session in COP 26.

The FIA Region I oversaw the production of communications materials and delivered visuals on the project's ambition. Videos were produced on the importance of regulating trade in used vehicles, and on how we can monitor trade in used vehicles. Factsheets and visuals were developed. The involvement of the FIA to the production on communications deliverables, the dissemination and update of project information and progress to its wide network of Member Clubs in Europe, Middle East, and Africa will help raise awareness within both circles of importers and exporters in different regions.

Since 2020 the number of countries with 'good' or 'very good' policies for better quality used vehicles increased from 47 to 62. 15 countries of ECOWAS sub-region adopted a Vehicles Directive for Euro 4/IV equivalent emission standards (implementation from January 2021). Cambodia adopted Euro 4/IV emission standards (implementation by end of 2021). Ethiopia introduced higher taxation for used LDVs (up to 500%) to discourage import of older used LDVs.

Recently, the project also contributed to the new European Commission proposal to improve regulation on waste shipments.

The project continues with efforts being made in the areas of engaging in open discussions on potential approaches for global harmonisation which will allow easier coordination and enhanced predictability for exporters and solidifying global efforts to improve the quality of used vehicles.

TRACK-TO-ROAD: PARTNERING TO DEVELOP TYRES FOR THE CIRCULAR ECONOMY

Tyres are often overlooked as a key element in the quest to decarbonise personal mobility. The FIA with their tyre manufacturer partners, have long used motor sport to push the envelope on new technology, accelerating the transfer of innovation to road cars. Standing at the forefront of sustainable development. Working with manufacturers and other automotive stakeholders to develop technologies that contribute to emission reduction targets and achieving net zero.

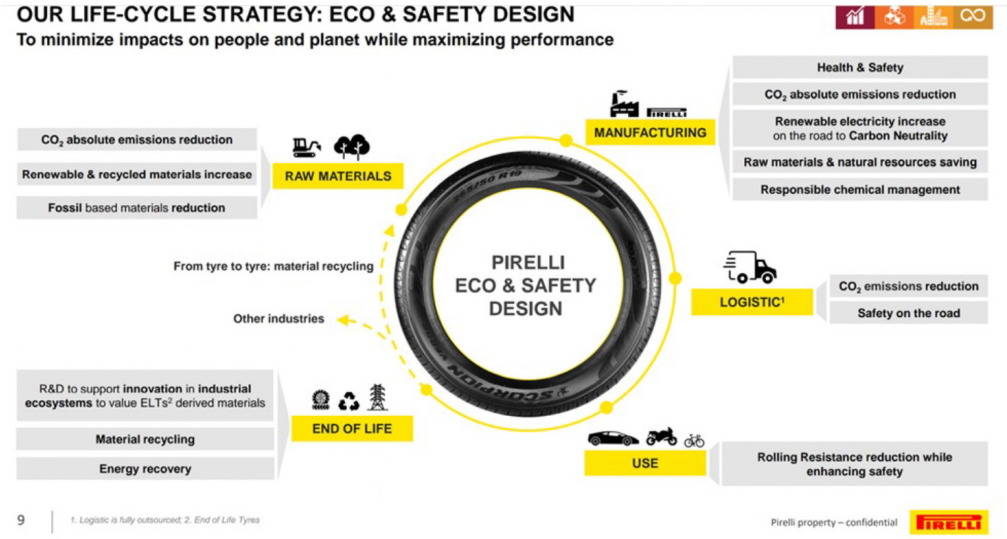
The FIA's target is not only to meet new environmental standards but to redefine them. Introducing and designing the minimum requirements for all stages of the tire life cycle: from manufacturing and distribution to use, end of life cycle, carbon footprint calculation technique and other criteria.

Using a Reduce-Reuse-Recycle-Regenerate approach, the FIA has specific set targets to strengthen overall environmental tyre performance, adopted and enforced by multiple manufacturers, specifically:

> Promote sustainable and bio sourced materials
> Reduce considerably the number of tyres used in FIA championship
> Increase tyre efficiency and reduce friction
> Reuse tyres used in truck racing with retreading
> Recycle tyres used in FIA championships
> Reduction of particles made by tyre usage
(WIP, new project)

FIA partner, Michelin analysed six categories of materials used in motor sport tyres, including polymers, plastics, textile, enduring features, metallic cables, and chemical additives. All of these categories must include either a bio-tech material alternative (resin), a recycled element (green carbon) or a sustainably sourced primary material (e.g. sustainable rubber). With this mix, Michelin has achieved 53% a mix of sustainable materials in the tyre mix fitted to the H24 GreenGT hydrogen racing car. Future focused, Michelin has set goal of 100% sustainable materials by 2050.

Our partner, Hankook, on the other hand, is approaching the challenge of reducing production related GHGs and focuses on energy saving techniques and the use of renewable energy sources throughout the entire tyre value chain. By 2030, Hankook Tire will achieve a 46.2% reduction in the total amount of direct and indirect GHGs generated during production, as compared to 2019.



Pirelli has adopted a framework to reduce its environmental footprint in the manufacturing processes. Working with reference organisations at national and international levels to enhance the circular economy framework in the tyre production industry (e.g. UNCAP, WBCSD etc.). All Pirelli used tires are returned to treatment plants for energy and materials recovery. End-of-life tyres are valuable sources of secondary raw materials that can be reused in other industries such as road infrastructure. Through optimisation of secondary materials sourcing and quality testing, Pirelli has built a so-called "industrial ecosystem" to reuse, recycle and reinvent core tyre production processes and materials.

The FIA never sees these steps as the end, simply a step in the process and with strong, ongoing, collaboration with research institutions, testing labs, universities and manufacturers allow further evolution of the circularity concepts and higher environmental standards across all levels of the industry.

DEVELOPMENT OF LEGISLATION FOR USED VEHICLE TYRES MANAGEMENT IN UZBEKISTAN

As a trusted consumer representative for road users in Uzbekistan, our Member Club, The National Automobile Club of Uzbekistan (NACU), funded by the FIA Foundation, has initiated a programme of to address their concerns around used tyre management. To address this issue, the Club meets with multiple national authorities to support the development of legislation on used vehicle tyre management.

RAISING AWARENESS OF RESPONSIBLE BUSINESS CONDUCT WITH USED TYRES IN NIGERIA

The Automobile and Touring Club of Nigeria (ACTN). With funding from the FIA Foundation, recently concluded a partnership with the National Environmental Standards & Regulation Enforcement Agency (NESREA) and The Abuja Environmental Protection Board (AEPB). Spearheading a project to apply extended producer responsibility (EPR) principles to automotive waste, specifically focusing on used tyres.

This project highlighted the wealth that could be created and generated through applying the principles of the circular economy. It also highlighted the risk of improper disposal of waste tyres to health and wellbeing.

A number of participants indicated interest in developing the project further to better understand how to recycle waste tyres into furniture and other household items.

The project culminated in a collaboration to collect over 3000 tyres a week for recycling, rescuing them from burning, reintroducing them into the economy and starting a sustainability revolution in this sector.

TYRE ABRASION STANDARDS FOR UNECE

Sustainable mobility goes far beyond CO2 and into all aspects of environmental concern. To this point, iin the Summer of 2023, one of the FIA's Mobility Clubs in Germany, Allgemeiner Deutscher Automobil-Club (ADAC), with funding from the FIA Foundation, conducted research into tyre wear and its impact on sustainability and safety.

Theorising that reduction of tyre wear not only ensures a low environmental impact, but also ensures lower resource consumption and extends the lifetime of a tyre until it is worn out. However, the reduction of tyre wear must not have the consequence that the original tasks of the tyre - namely as a safety-relevant link between vehicle and road - are negatively influenced.

The results of the ADAC testing of 50 summer tyres in the dimension 205/55 R16 showed, that in principle, tyres with low abrasion do not have in general any disadvantages in other (safety) relevant criteria. Specifically; Low-wear and safe tyres are possible with the latest tyre technology, but, such tyres are still significantly more expensive today and care must be taken to ensure that mobility remains affordable in this area as well.

Customers are not yet aware that tyres with low wear can have a longer service life and that the higher purchase price is sometimes more than amortised and herein lies an opportunity for consumer education.

There is a tendency for tyres with low wear to have reduced new tread depth. This advantage of a long service life through the combination of low wear/high new tread depth must not be neglected. This reduces the consumption of resources and at the same time further increases the service life, which can be another important component for the customer in terms of affordable mobility.

3. THE FIA'S ROLE IN A TRUSTED CONSUMER RELATIONSHIP

Overall, with the best technology, policies and intentions, nothing is resolved without a trusting bi-directional consumer relationship. It is here that the FIA's position as a thought leader in the automotive world, network of Mobility Clubs and extensive road user base becomes a key driver in the road to sustainable mobility.

With a global view, thinking and operating at a local level, the FIA, through its Members finds itself in a position that it can work with and understand consumer needs from the richest and most developed economies just as easily as it does those that are still growing and developing. Each with its own challenges to be overcome and each with its own views and priorities in terms of sustainable mobility. Bringing the voices of the most vulnerable to the table to be listened to and heard.

It is this dualistic view and reach that allows the FIA to digest the key global messaging, localise it and open discussions regarding important touchpoints for each market to drive a sustainability agenda while sensitive to the overall situation on the ground, individual challenges and motivations.

Change will not happen on its own, this grass-roots approach is how the FIA works with road users to understand their needs and tailor solutions with them that support them on their journey to a more sustainable future.

It is through listening and collaboration that we, as a global organisation, work with our sporting organisations and our Member Clubs and they in turn work with the people most affected to find affordable, sustainable solutions.

Using our grants and awards programmes, we effect real-world change, engaging local, regional, and national governments as well as our membership base to pilot and then roll out consumer change programmes, testing in different markets, then localising and growing the messaging into larger more impactful campaigns.

FIA AND TAKING THE LEAD IN A TRUSTED CONSUMER RELATIONSHIP

With our Member Clubs representing 80 million road users and one of the largest media followings in the world, the FIA is applying its resources to listening, thinking and acting to make this world a better place for all.

Carrying out extensive research and communication campaigns, the FIA demystifies, educates and informs road users about sustainable mobility.

FIA SMART DRIVING CHALLENGE

Perhaps the fastest and most efficient way to reduce energy consumption is direct intervention at a personal level with AI driven driver coaching. To this end, the FIA introduced its Smart Driving Challenge (SDC) in 2018.

The FIA SDC is a collaboration between the FIA and Greater Than, a driving data analytics company that specialises in understanding driver impact on the roads, was selected as a partner as they have their outlook and objectives align so well with those of the FIA, making the roads safer and mobility more sustainable.

The FIA SDC makes use of an app to run an annual competition that pits drivers from around the world against each other to subjectively identify the safest and most economical driver in the competition. The app automatically detects when someone is driving and provides feedback on how they handle their vehicle.

The FIA SDC will be displayed at the FIA's stand in the COP28 Blue Zone throughout the conference. This display is available as an information point for anyone looking to discover more about the importance of behavioural change in the journey to net zero and demonstrates the FIA's call to prioritise mobility users in sustainability policymaking. Additionally, The FIA and Greater Than, with the support of the Emirates Motorsports Organisation (EMSO) and UAE Integrated Transport Centre (ITC) have sponsored 10,000 cars from fleets in the UAE to drive the change today, over the period of the conference. Applying the solution throughout the period of COP28, making an immediate and direct contribution to GHG emissions reduction during the conference.

The scoring system in the FIA SDC relies on how safe and eco-friendly a driver is. Feedback is provided on level of focus, on how well the driver anticipates and handles situations in traffic as well as on your eco-driving skills.

Taking a continuous improvement approach, the driver's score evolves and changes over time, depending on driving performance.

To date, as measured, the average saving in emissions from drivers participating in the challenge is 20%, this extrapolated across the world fleet would have an immediate impact on global emissions.

A key benefit of the FIA SDC solution is that it is delivered at a commuter level as a personal improvement tool. Further, being an app-based solution, it can drive immediate change over multiple and diverse markets at any scale.

Similar tools can support organisations' objectives to increase transparency and accountability while identifying and mitigating potential risks such as health of employees, supply chain disruptions, etc. In that respect, telematics technologies embedded in the FIA Smart Driving Challenge can facilitate sustainability reporting according to existing international standards within organisations, including the private sector, highlighting the positive impacts of their operations.

GREEN NCAP AND VEHICLE LIFE CYCLE ANALYSIS (LCA)

The FIA and four Mobility Clubs are members of the Green NCAP consortium. Green NCAP is the independent consumer oriented test and rating programme and is part of Euro NCAP, which is a non-profit organisation.

Green NCAP uses a broad range of tests that exceed the levels for current approval tests, beyond legislative requirement and, through consumer education, rewards those manufacturers whose vehicles go beyond the minimum requirements and offer excellent, robust, real-world performance. Regulatory testing is a good starting point. Green NCAP's more challenging tests are an addition and complementary to these legislative requirements.

To understand the true ecological impact and sustainability of a car, it must be viewed in the context of its whole life cycle. This means that all processes and flows of resources, materials and energy associated with the car's production, usage, and recycling must be considered. Life Cycle Assessment is the method that estimates these individual contributions to analyse the car's environmental impact over its entire lifetime 'from cradle to grave' and in a next stage even from 'cradle to cradle' by including circularity aspects.

Green NCAP's Life Cycle Assessment involves estimations based on the available data and state-of-the-art scientific methodology, developed by JOANNEUM RESEARCH and peer-reviewed by a group of renowned scientific experts in the field. A unique feature of the approach is the use of realistic, comprehensive, and precise vehicle measurements to estimate the impact of the vehicle's use phase. The average, best and worst measured fuel and energy consumptions from Green NCAP's tests serve as input data for the LCA calculations, revealing the potential effect of driving style and ambient conditions on the LCA results. Beside vehicle test data, the LCA methodology includes the forecast about changing electricity mix in various countries and the estimated evolution of the energy supply for the next two decades. Green NCAP's Life Cycle Assessment hence sets the stage for the first true long-term harmonised vehicle LCA platform for the European market.

To demonstrate the value of the LCA approach, Green NCAP has calculated the estimated total life cycle greenhouse gas emissions and primary energy demand tested in the programme in the period 2019-2023 in static overview tables. This includes vehicles of all sizes and types, including conventional petrol and diesel, full-electric and hybrid-electric cars. For the comparative analysis, a nominal vehicle lifetime of 16 years and a total driven mileage of 240,000 km are assumed. The calculations are based on the current forecast about changing average energy of the 27 European Union member states and the United Kingdom, cancelling out the effect that local energy supply has on the cars' LCA values. For each model, the transportation process flow and the output are summarised in a LCA factsheet.

The static analysis is based on publicly available scientifically accepted information about vehicle production or recycling processes and does not consider specific data of single vehicle manufacturers or models yet. Some manufacturers may calculate results differently from the values estimated here using in-house data. Green NCAP's target is to provide LCA estimations using verified vehicle-specific LCA values as soon as possible. In this way, the programme will be able to provide an assessment which

can offer better differentiation between manufacturers and the efforts they are making to produce their vehicles in ways which are less harmful to the climate.

In order to custom-tailor to the web user's personal conditions (incl. in which European country the car is used) and help to explain LCA in a more dynamic, interactive way, Green NCAP launched an interactive webtool in 2022 that allows to calculate and visualise the GHG emissions and Primary Energy demand for most of the vehicle types (30,000+ models) that can be purchased on the EU market, also including the UK and Switzerland.

EV NATIONAL SURVEYS TO DETERMINE PUBLIC ACCEPTANCE

Funded by the FIA Foundation, two projects were undertaken in different markets to gauge the current level of public acceptance for electric vehicles highlighting the importance for localised communication and customer education.

The Canadian Automobile Association surveyed Canadian EV Drivers to understand their experience and preference for their electric vehicles. A total number of 16,232 EV drivers were sampled and surveyed across all Canadian provinces and territories.

Two distinct types of electric vehicle drivers were interviewed. The battery-electric vehicles (BEVs) operate solely on battery charge for their usage, and plug-in hybrid electric vehicles (PHEVs) which operate using both plug-in battery power charge and internal combustion.

The survey evaluated the concerns about electric vehicle ownership including battery degradation, cold weather performance, availability of public charging, and driving range. To effectively carry out this study, the CAA enlisted the services of PlugShare Research to survey their group of Canadian electric vehicle (EV) drivers, along with users of the PlugShare app in Canada.

The main objective was to understand consumers' behaviour towards electric vehicles and the level of repurchasing. Through this survey, the Club/association aimed to understand and support the UN/FIA transition to net zero.

The information from this report is to be utilised to propose new electric vehicle policies and for further research regarding this area, bringing consumers' perspective to federal strategies and policymaking. Thus, being a bridge between the automotive industry, environmental groups, and the government to advance towards achieving set environmental goals.

The study also revealed that Canadian electric vehicle (EV) owners exhibit remarkably high levels of contentment. 97% of Canadian electric vehicle owners express their intention to buy another EV once it's time to replace their current vehicle. Nearly 90% derive more satisfaction from driving their EV, while 95% find it to be a more cost-effective option. Additionally, 92% state that their EV offers a quieter experience compared to their conventional gasoline-powered vehicle.

This shows that there will be an increase in the purchase of electric vehicles in years to come, thus leading to the potential decarbonisation of the transportation sector.

However, a significant portion of respondents are not self-assured about embarking on extended journeys with their EVs (Electric Vehicles). Over 35% of the participants in the survey admit to feeling uncertain about using their EVs for long road trips. Furthermore, most EV owners (67%) possess a gasoline-powered vehicle as well, which they are inclined to choose for longer expeditions.

THESE SURVEY RESULTS ARE BEING USED FOR:

1. Awareness building and advocacy for EV infrastructure Investment – The survey is utilised as evidence to advocate for an increment in the investment of electric vehicle infrastructure. By taking the concerns and preferences of consumer needs into consideration.
2. Recommendation of Policies- The survey is to be shared with policymakers and used to recommend regulations and incentives that support the adoption of electric vehicles.
3. Consumer Awareness and Education- The CAA has thousands of members and is a well-recognised organisation in Canada. The survey results help raise awareness among consumers to the benefits of EV ownership.
4. Research and Development- The survey findings guide further into improving electric vehicle technology, while addressing the concerns of the consumers such as range, charging speed, and convenience.
5. Collaboration with the Automotive industry- The CAA collaborates with automakers utilities and other stakeholders to address the challenges highlighted by the survey.

In Croatia, Hrvatski Autoklub (HAK) conducted a nation-wide survey to understand the challenges of the transition from ICE to EV in the country.

Publishing their results, HAK noted that local EV knowledge was fairly low making the EV transition difficult in Croatia. The Club is using this result to advocate and inform consumers as to the value and benefits of EVs.

NORWEGIAN AUTOMOBILE FEDERATION (NAF) AND THE WORLD'S LARGEST WINTER ELECTRIC CAR TEST

For four consecutive years, the FIA Member Club NAF and Motor magazine have tested the range and charging speed in winter weather of 29 electric cars available in Norway.

The 2023 run Tested 29 electric car models on a route starting from Oslo and going through Lygnasæter, Gjøvik, Ringebu, Dombås, Hjerkinn, Folldal before heading south to Venabygdsfjellet and then to Ringebu again. The cars started with a fully charged battery, without preheating, from Skur 13 in Oslo where the temperature overnight was between -10°C and -15°C.

The test determined the effective range of electric cars in the winter weather, what happened when the electric cars go into power saving mode, and how quickly the electric cars charged from 10 to 80%.

This is the fourth winter range test NAF and Motor have conducted. Previous test results showed a deviation from the official range between 4 and 32% and in this year's test, four cars had a greater deviation between their advertised and actual range.

The results for each vehicle in the test are presented to the press and published in an easy to use format for consumers to be able to evaluate the real-world performance of new electric vehicles prior to purchase. They are also used to advocate for improved testing and OEM published data that better reflects real-life driving.

GREEN SLOW MOBILITY

The Japanese Automobile federation (JAF), working with Yamaha Motor Co., Ltd. offer "Green Slow Mobility (GSM)", which is a small scale mobility service using road-legal electric vehicles with a maximum speed of less than 20km/h, as one of the solutions for providing mobility in rural areas.

GSM is modified from a "golf-cart" and features electric powered, small-sized, slow speed and open-air cabin. It needs a driver at this moment, but it will be autonomous soon. The project is focusing on providing a new mobility service by deploying GSM as an alternative or supplement to public transportation in the poorer public transportation areas.

The concept of GSM was originally developed by the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of the Environment.

JAF agreeing with the concept actively worked on GSM in collaboration with YAMAHA. Taking advantage of the nationwide network of JAF offices and its contracted garages, and the knowledge and experience in Road Service, JAF takes care of intangible elements like preliminary inspection of operation route, driver training, and establishing maintenance network, while Yamaha takes care of tangible aspects like sales and delivery of GSM. Daily operation and management of GSM is left to the other organisations or companies.

RIDE SAFE AND GREEN

Working with a wide range of partners on the ground, the AIP Foundation in Vietnam, funded by the FIA Foundation, is using youth-driven technology to improve road infrastructure and promote green and active transport.

Vietnam's 2030 Road Safety Strategy and 2050 Net Zero commitments emphasise safe and sustainable mobility. This partnership with the FIA builds on this momentum. Nearly two-thirds of Vietnam's population use GHG-emitting motorcycles daily. Lack of safe bicycling infrastructure and public transit options being major factors.

The project collects data to identify high-risk zones for provincial governments to prioritise investments in bicycling infrastructure through developing and piloting Ride Safe GPS trackers in consultation with the app developer and secure government approval. Applying the technology in 10 schools and using the data to map out student routes and travel times. The team is using this data in conjunction with local government to find infrastructure changes that can allow for more active travel, reducing the impact on the environment.

ADAC PENDLERNETZ POWERED BY TWOGO

Another project initiated by our Member Club ADAC in Germany introduced a digital carpooling service "ADAC Pendlernetz powered by twogo" that connects private drivers and passengers to travel together foe business or pleasure.

Newly launched in August 2023, within two months the app had attracted 33,000 registered users worldwide.

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COP28
DUBAI
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APPENDIX

WHITE PAPER
DECEMBER 2023

ACCELERATING A JUST TRANSITION: THE MOTOR SPORT AND MOBILITY PERSPECTIVE

A WORLD IN TRANSITION

HOW TECHNOLOGIES DEVELOPED IN MOTOR SPORT POSITIVELY CONTRIBUTE TO DECARBONISATION IN MOTOR SPORT, AUTO INDUSTRY AND MOBILITY – SELECTION OF CASE STUDIES

How technologies developed in motor sport positively contribute to decarbonisation in motor sport, auto industry and mobility – selection of case studies

The FIA should act as a platform for its championships to promote the future automotive technology in the context of climate crisis.

The aim is to give manufacturers and other automotive stakeholders proving ground for a range of technologies that ultimately contribute to emission reduction targets and achieving net zero.
The case studies below highlight innovative solutions that are being developed and tested in motor sport that will have benefit of potential decarbonisation in motor sport, automotive industry and mobility.

1. DEVELOPMENT OF ALTERNATIVE LIQUID SUSTAINABLE FUELS FOR ICE POWERED AND HYBRID VEHICLES

DEFINITION AND OBJECTIVES

Fully Sustainable fuel is a unique type of fuel composed of sustainable components derived from carbon capture, municipal waste or non-food biomass whose life cycle results in a minimum 65% GHG emissions reduction compared to fossil fuel (sourcing and production). It is important to differentiate the two following types of sustainable fuels, currently tested in production and distribution:

- E-fuel (or "synthetic" fuel) is made from carbon capture (from air, exhausts or stationary sources) and hydrogen (from water or air) electrolysis.
- Biofuel is made from municipal waste or biomass (Gen2) or algae (Gen3). Its diesel version is generally FAME (Fatty Acid Methyl Esters) or HVO (hydrotreated vegetable oil).

In addition, sustainable fuel does not degrade any land in its production and does not compete with the food chain. For example, first generation biofuels produced from corn result in an increase of the cost of corn in the food market and often provide little in the way of GHG reduction due to the fuel used in the harvesting.

The main objective of sourcing alternative sustainable fuels in motor sport series is to help minimise the environmental effect of racing and to create a "showcase" example for a broader application in road transport. Demonstrating a successful operation of highly specialised and sensitive motor sport engines running on alternative fuels proves the transferability of such fuels into road cars.

FIA AND SUSTAINABLE FUELS DEVELOPMENT

Under the existing technical regulations, the FIA requires all its championships to be powered by 100% sustainable energies by 2026 – from advanced sustainable drop-in fuels to battery and hydrogen technologies. Advanced fully sustainable fuels are already in use in WRC, WEC, ETRC Karting, and by some individual teams in Cross Country. Ongoing experience of using sustainable fuels in various racing conditions allows fuel producers and engine manufacturers to adapt the technology to different use case scenarios and technological needs. Although, the FIA has to be careful about infringing patents when defining fuel regulations for our championships.

Multiple fuel suppliers are involved in developing sustainable fuels. IFPEn, for example, has been analysing existing technical issues related to the use of alternative fuels, aiming to enhance certain composition and generation aspects. Higher octane sustainable petrol needed for racing proved to increase 'fuel dilution' (dilution of the engine lubricating oil with petrol). Indeed, the first version of sustainable fuels provided by all fuel suppliers, used in the pioneering Championships such as WRC and WEC, turned out to have a common weakness of oil dillution. After a year of investigation supported by the IFPEn laboratory, the FIA found that some of the base sustainable components were creating this kind of problem. Early 2023, an updated Fuel Specification regulation for sustainable fuel was issued by the FIA to ensure that the distillation curve for such fuels was keeping the oil dilution at a level in line with today's fossil fuel. Another issue is related to the impact of certain fuel components on engine materials. Special polymers are required for fuel lines, seals etc. These implications have been studied by the FIA, teams and manufacturers, and possible solutions are currently being developed.

In addition, it is challenging to verify conformity levels of various sustainable fuels available on the market. The most straightforward mechanism would be the application of conformity certificates based on fuel component types. Formula 1 will be working with a specialist environmental auditor to monitor each fuel type provided by individual fuel suppliers, although this process is highly costly and therefore not fully appropriate for other championships. Further work on the harmonisation of fuel standards is needed to ensure the highest quality and lowest environmental footprint of fuels used across various FIA disciplines.

POTENTIAL APPLICATIONS OF DECARBONISED FUEL IN TRANSPORT AND MOBILITY

Currently there is a large push by governments and the automotive industry towards electric vehicles (EVs). However, in most countries, and particularly in developing economies, the infrastructure is not sufficiently robust yet to provide the amount and distribution of electricity needed. Governments need multiple approaches to decarbonisation, and sustainable fuels are clearly a viable option.

Even after the ban on the production of cars with ICEs, there will still be over a billion cars on the roads worldwide which will require liquid fuels. There is a sound potential to replace a portion of fossil fuels used globally with sustainable sourced fuels and such transition needs to be supported with appropriate policies as well as infrastructure readiness.

If sustainable fuels can be used successfully under the extreme conditions of motor sport, then such technology has a high transferability potential towards road cars. Motor sport engines tend to be higher revving, holding a higher compression ratio, which means they require higher octane (102 RON) fuels than road cars. The components required to produce a high-octane fuel are more difficult to obtain from a sustainable source. The development of processes to make such components in an economically viable way would have a huge impact on the ability of fuel suppliers to produce sustainable retail pump fuel (95-99 RON) at a competitive price.

According to the FIA definition of sustainable fuel, there has to be a minimum of 65% GHG reduction across the entire life cycle. The plan is to increase this reduction over time as the technology and sources become more available. According to Statista, the market for biofuels nearly doubled between 2021 and 2023. This market, however, currently comprises mainly biodiesel and 1st Gen ethanol (from corn and sugar beet). The latest revision of the EU Renewable Energy Directive (RED III) targets 5.5% of advanced biofuels and RFNBO by 2030, of which 1% must be RFNBO.

In addition, the use of sustainable fuels does not lead to SOx emissions (no sulphur in biofuels and RFNBO). Most e-fuel RFNBO plants are being constructed with their own additional source of energy (wind or solar), which makes the process carbon neutral (100% GHG reduction in comparison with fossil fuel). These can be set up in relatively remote areas where there is plenty of wind (e.g. southern Chile) or where there is consistent sun (deserts). Dedicated crops could be grown in areas with marginal agricultural activity and little potential for cultivation of food crops. This could bring jobs and economic security to some of the poorest areas of the world.

POTENTIAL BARRIERS AND NECESSARY ADAPTATION MEASURES FOR SCALE UP

Limited availability of sustainable components – both type and volume, is holding up further industry-wide adoption. Although this is improving as some manufacturers are changing from 1st Gen to sustainable sources. More and larger facilities are coming on-line and are planned before the end of the decade.
The greatest barrier to the adoption of sustainable fuels is cost. Energy producers are in business to make a profit. It is challenging to incentivise fuel manufacturers to opt for a more expensive sustainable source rather than a fossil source if they cannot sell their product at a higher (less competitive) price. It is essential that they are encouraged by government incentives such as tax benefits, etc.

It is unlikely that much e-fuel will end up supplying fuel for road transport. E-fuel production is ideally suited for the production of methanol, which can be used in marine transport, and kerosine for aviation fuel. Aviation currently has little alternative, but to use a high energy-density liquid fuel.

The major drawback to e-fuels is the extremely high energy consumption. Currently, it takes five times more energy to produce an e-fuel than the energy generated by using this very fuel. Therefore, if such e-fuel is being produced for road cars, would it not be more sensible to use the energy to directly charge five times as many EVs?

Besides the energy intensity issue, there is also a paradigm of radiocarbon (14C) testing procedure and its limitations. Although suitable for pure biofuels, other sources of sustainable components may show the presence of fossil carbon. For example, RFNBO (Renewable Fuels from Non-Biological Origin which includes e-fuel), where the CO2 is obtained from industrial flue gas, or recycled carbon fuels (RCF) from municipal waste that contains non-recyclable plastics. Even for biofuels, 14C testing may be inadequate if the product has been co-processed with fossil equivalents and sold on a 'mass-balanced' basis. Thus, if the sustainable bio-sourced material only makes up 5% of the input to the refinery, 5% of the final product can be sold as a sustainable fuel but will still comprise 95% fossil components. This opens the potential of being accused of 'greenwashing' if an independent analysis is carried out of the final fuel.

FIA TO ADVOCATE FOR DEVELOPMENT OF SUSTAINABLE FUELS

Governments must be made aware of the potential of sustainable fuels, particularly to reduce GHG emissions in ICE cars remaining on the road after the ban on their new production. Their production can be encouraged by tax incentives.

According to the International Energy Agency (IEA) there will be about 350 million EVs on the road in 2030. Quite apart from the fact that this huge increase in EVs will require a substantial effort to make the electricity grids more robust and provide millions of additional charging points, it will still leave over a billion vehicles on the road with ICEs. The US EPA estimates that the average road car emits approximately 400g CO2 per mile. This equates to about 4 tonnes of CO2 per year if a car travels 10,000 miles per year. Therefore, worldwide an estimated 4 billion tonnes of CO2 will be emitted each year from a billion cars with ICEs. On this basis, if all these cars could use sustainable fuel with a 65% GHG reduction, a potential CO2 reduction of 2.6 billion tonnes could be made each year. If the technology improves the GHG reductions obtained from sustainable fuels this value will clearly increase.

2. DEVELOPMENT OF CARS FULLY FUELED WITH HYDROGEN

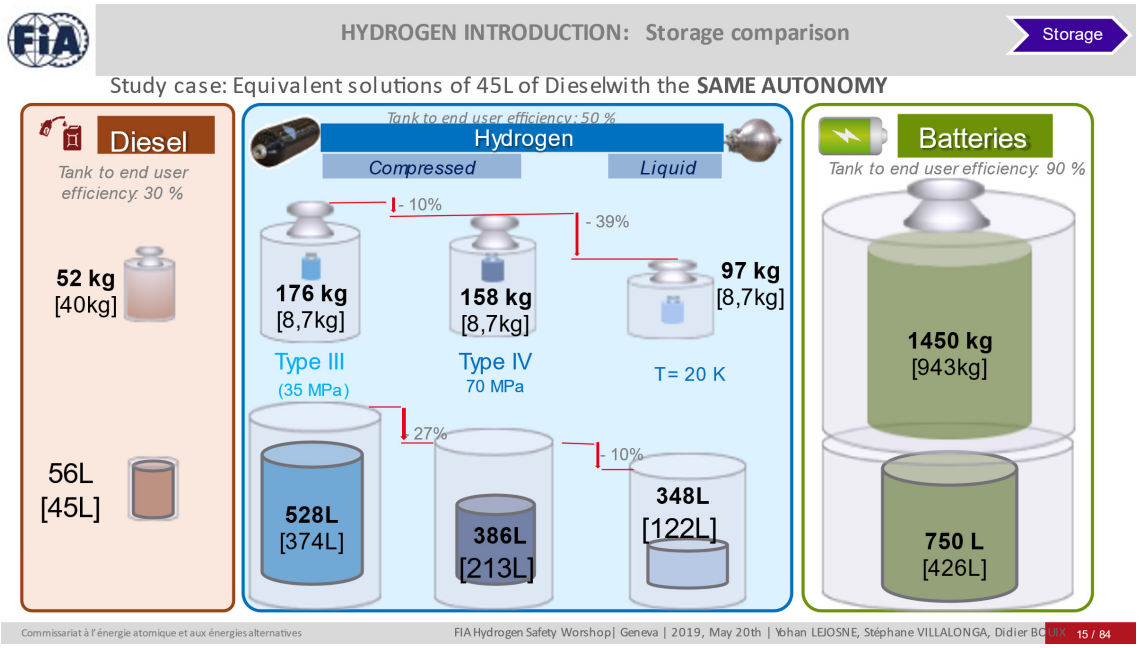
Arguably the most well-known track-to-road technological developments the FIA has been exploring on the road to net zero are the engine and fuel consumption improvements seen in Formula One with the upcoming move to more sustainable fuels along with the development of an electric racing series in Formula E. What is less well known, as part of the FIA's technologically neutral approach to decarbonisation of mobility is our work with other stakeholders in the development of safe, efficient hydrogen propulsion.

Hydrogen, the earth's most abundant element has the benefit of being a truly renewable, zero emission at the use fuel, when produced by renewable resources, and having minimal impact on the environment. One of the benefits that hydrogen offers the future of mobility is that it can be deployed in multiple ways to power a vehicle, being through an internal combustion engine, running a mixture of hydrogen and oxygen, or a fuel cell which is used to power electric motor, with fuel cells offering zero tailpipe emissions. Hydrogen is already in use in a number of markets, yet the deployment of hydrogen at scale is not without its technological challenges. This is where the FIA and its partner-network are currently focusing their efforts to ensure that for any solution forged in the heat of competition will be an application that benefits to mass personal mobility.

STORAGE SYSTEMS

Developing solutions that can be applied in any market, to test and perfect these options, the FIA will include within the regulations for hydrogen cars, 2 types of storage system, being:

1. Liquid, stored at -253°C
2. Compressed stored at 70 MPa



TECHNOLOGY TRANSFER:

In 2022, sales of hydrogen powered vehicles represented 20,500 units, compared with 10.5 million for electric vehicles. The number of fuel cell electric vehicles on the road worldwide increased by 40% between 2021 and 2022, totaling more than 72,000 vehicles. Within this space, the FIA is working with various international bodies to develop regulations that will support technology developers in their quest to provide sustainable mobility solutions to the market with a unique view of extremes that these vehicles can operate.

When considering hydrogen vehicles, this support and regulations need to take a holistic approach, including but not limited to:

1. Vehicle architecture, materials for the vehicle structure, testing and validation requirements and active safety, including the monitoring of storage systems.

2. Options for the deployment of hydrogen (ICE, Fuel cells), Vibration and environmental constraints (temperature, dust) factors applied to the development of technologies and set limits for their use.

3. Different types of storage (compressed, cryogenic), Cryogenic storage is new technology, leading the FIA had to launch upstream studies in order to define the requirements for competition and consider the specific development of cryogenic tanks for competition. This work will lead to the drafting of specific regulations for the use of liquid hydrogen.

4. Fueling procedures and associated infrastructures, Determining the gaseous hydrogen fueling capacity and the necessary infrastructures are specific to racing which in turn is shared with the various groups working on drafting international regulations.

5. Safety and race intervention procedures, most critically, in the event of an incident, the FIA is taking the lead in defining rules for intervention on the track is an important part of introduction of hydrogen into racing, as it involves both people and equipment control systems. A great deal of work has now been done on monitoring systems, vehicle signaling and equipment for this new source of energy. Supervision of onboard hydrogen systems is essential which implies major developments where motor sport will be able to play a key role.

Image: https://www.missionh24.fr/en/2021/03/09/the-new-h24-completed-its-first-2021-track-test-session/

REVISING RACING REGULATIONS APPLIED FROM 2024

1. Working with key players, tank manufacturers, test laboratories, the FIA is working on Defining the specifications for CGSS (compressed gas storage), including intervention procedures in collaboration with FIA Safety Department. Reviewing of existing international regulations and standards. Investigation into future regulations and car manufacturers requirements.

2. Aligning with GTR13 (Global Technical Regulations on Hydrogen and Fuel Cell Vehicles), the FIA is developing the technical specification for the motor sport application of LHSS: (liquid hydrogen storage).

Working with our international partners, considering the long term and safety implications of the application of hydrogen as a future fuel source. The FIA and its stakeholders lead the way in developing solutions that will quickly find their way into the world of personal mobility.

ONGOING RACING ACTIVITIES AND DEVELOPMENTS

MISSION H 24

The FIA is working with long-time partner, the Automobile Club de l'Ouest, (ACO) the founder and organiser of the 24 Hours of Le Mans. An advocate of mobility for all towards a sustainable energy transition now a fundamental issue, the ACO has been striving for several years to reduce the race's carbon footprint and find new energy solutions. MissionH24 a joint venture with GreenGT (H24Project today) to roll out the use of hydrogen in racing – was officially presented in 2018 to create a hydrogen class at the 24 Hours of Le Mans and in the FIA World Endurance Championship. Partners joining the programme include TotalEnergies, Michelin, Symbio, Plastic Omnium, Richard Mille, Dietsmann and Essilor.

VEHICLE TYPE: Prototype
STATUS: 1st Track running in 2025
PROPULSION: Hydrogen Fuel Cell (CGSS)

Based on existing hydrogen racing technology, another slated competitor for the 24 Hours of Le Mans, Toyota was the first manufacturer to reveal their concept for the hydrogen prototype class and is expected to be seen in action from the 2027 season.

VEHICLE TYPE: Prototype
STATUS: Competition in 2027
PROPULSION: Hydrogen Combustion Engine (CGSS)

Since May 2021, Toyota has also been competing in Japan with a GR Corolla H2 Concept using hydrogen gas. The switch to liquid hydrogen is a big step forward in development, making the car more competitive. Liquid hydrogen also makes pit stops faster and more efficient, as refuelling can be done in the pits, like gasoline powered vehicles.

VEHICLE TYPE: Touring Car
STATUS: Introduced in 2022
PROPULSION: Hydrogen Combustion Engine (CGSS)

Additionally, two projects are under development for the deployment of hydrogen solutions, these are:

1. The HySE (Hydrogen Small mobility Engine technology) research association, which will introduce the T3U in 2024 using CGSS associated with Combustion engine.

2. HySE X 1 hydrogen powered engine vehicle, a racing car with an overall length 3,530 mm x 2,070 mm x 1,700 mm, weighing in the region of 1,500 kg with a liquid cooled, 4 stroke, In Line Four supercharged engine.

3. ACCELERATION OF THE CIRCULAR ECONOMY OF TYRES

In the era when environmental impact matters more than ever, the FIA stands at the forefront of the sustainability development in the tyre industry. FIA aims at guiding manufacturers and other automotive stakeholders towards a range of technologies that ultimately contribute to emission reduction targets and achieving net zero.

The use and offset of tyres represent one of the biggest challenges in motor sport. It is often believed that higher performance is put beyond sustainability considerations in tyre management strategies. The ambition is not only to meet new environmental standards but to redefine them. This is how the FIA has designed and introduced the minimum requirement for all stages of the tyre life cycle: from manufacturing and distribution to use, end of life cycle, carbon footprint calculation technique and other criteria.

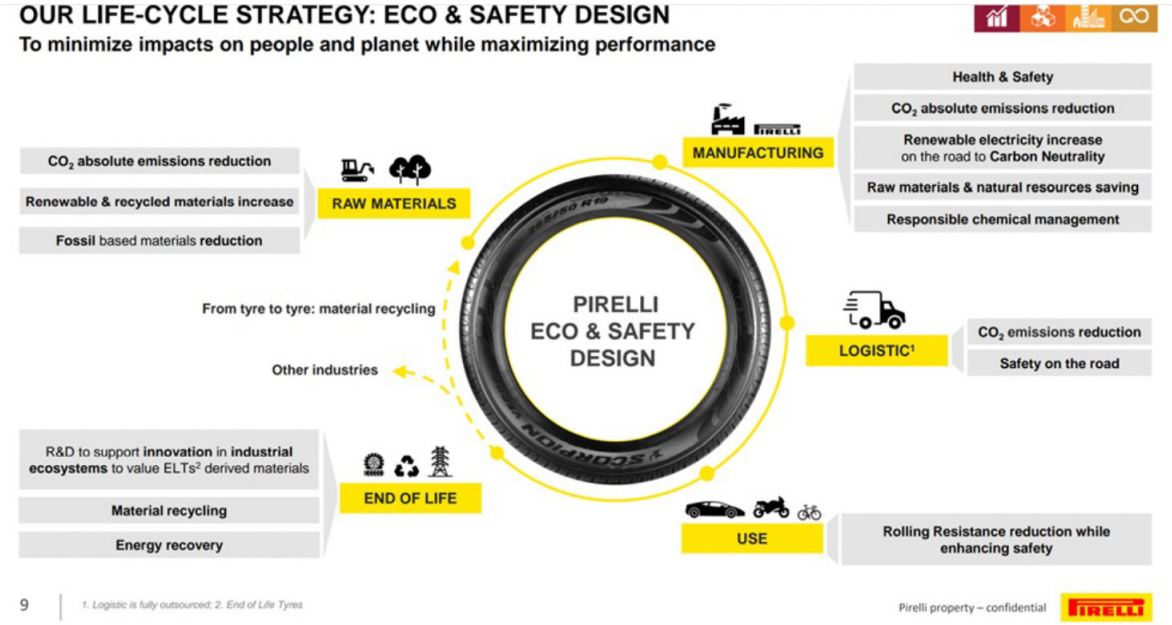
To achieve measurable results across all motor sport disciplines, the FIA has developed the following targets aimed at strengthening the overall environmental performance of the tyre industry:

- Promote sustainable and bio sourced materials in tyre technologies
- Reduce considerably the number of tyres used in FIA championship
- Increase tyre efficiency and reduce friction
- Reuse tyres used in truck racing with retreading
- Recycle tyres used in FIA championships
- Reduction of particles made by tyre usage (WIP, new project)

These targets were converted into the Reduce - Reuse – Recycle – Regenerate framework, also adopted and enforced by multiple tyre manufacturers. An example of minimizing the environmental impact of source materials is well demonstrated by Michelin who has analysed 6 categories of materials used in each motor sport-type of a tyre, including polymers, plastics, textile, enduring features, metallic cables, and chemical additives. All of them have to have either a bio-tech material alternative (resin), a recycled element (green carbon) or a sustainably sourced primary material (e.g. sustainable rubber).

With this mix, Michelin achieved 53% of sustainable materials in the tyre mix fitted to the H24 GreenGT hydrogen racing car. Going forward, Michelin has defined a rigorous goal of reaching 100% sustainable materials target by 2050.

Hankook, on the other hand, besides the use of eco-friendly materials, focuses a lot on the Energy Saving techniques and the use of renewable energy sources along all steps of the tyre value chain. By 2030, Hankook Tyre aims to achieve a 46.2% reduction in the total amount of direct and indirect greenhouse gas emissions generated during the production stage, compared to 2019 figures. An ambitious approach to the energy management strategy withing the manufacturing process can become a game-changer in the overall lifecycle assessment score of the final tyre product.



Pirelli has also adopted a robust framework to strengthen its environmental score in the manufacturing processes. The company works with reference organisations at national and international levels to enhance the circular economy framework in the tyre production industry (e.g. UNCAP, WBCSD etc.). All Pirelli used tyres are sent back to treatment plants for energy and materials recovery. End-of-life tyres are valuable sources of secondary raw materials that can be reused in other industries (road infrastructure mainly) . By optimising such secondary materials sourcing and quality testing, Pirelli has built a so-called "industrial ecosystem" to reuse, recycle and reinvent core tyre production processes and materials.

Most of the tyre manufacturers have long used motor sports to push the envelop on new technology and accelerate the transfer of innovation in road cars. Tyres can be one of the long-hanging fruit to offset pollution across the entire use life cycle and the FIA community will keep expanding the innovation boundaries to facilitate the adoption of even more rigorous environmental standards in the tyre manufacturing industry. Some of these applications include:

- Use of sustainable and bio sourced materials to manufacture high performance tyres
- Increase tyre longevity
- Develop low friction tyres
- Reduction and control of particles emitted by the use of tyres

Strong collaboration with research institutions, testing labs, universities and manufacturers will allow further evolution of the circularity concepts and higher environmental standards across all levels of the industry.

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