PADDY LOWE: MY NEW MISSION

Why F1 tech great is fast-tracking synthetic fuels

INTERNATIONAL

Driving Technology Into Pole Position

RACE TECH

Motorsport Engineering

JUNE 2021 No. 247 UK £5.95 USA $12.75 racetechmag.com

Bernoulli

Autonomous at 200 mph

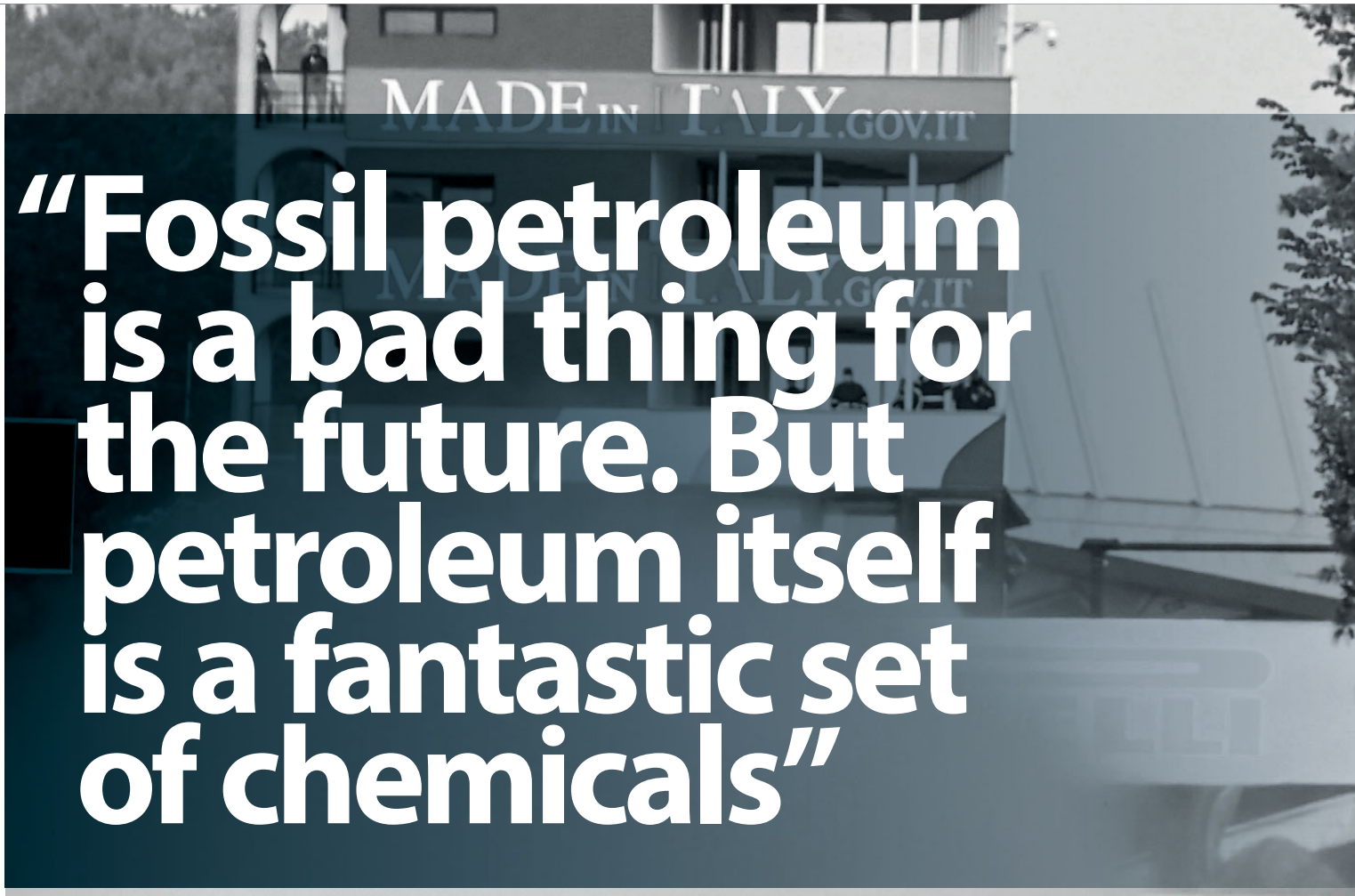
$1 Million Indy shootout to transform AV industry

Plus

World-first mobile hydrogen refuelling rig

Opel turns up the (artificial) volume!

www.racetechmag.com



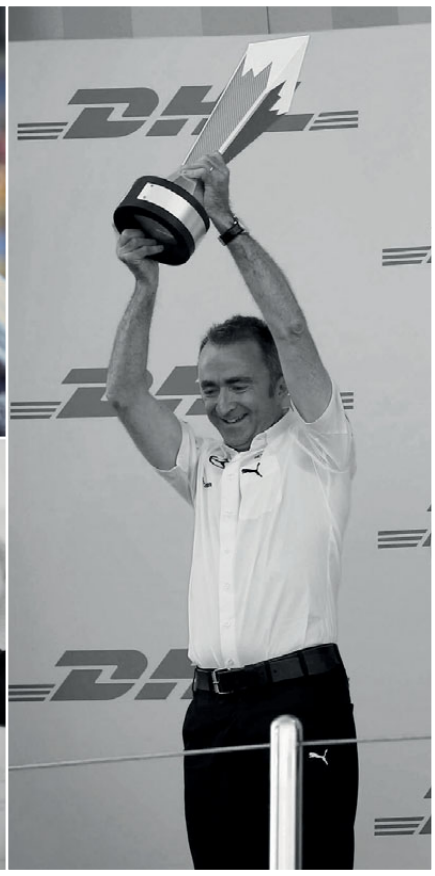
"Fossil petroleum is a bad thing for the future. But petroleum itself is a fantastic set of chemicals"

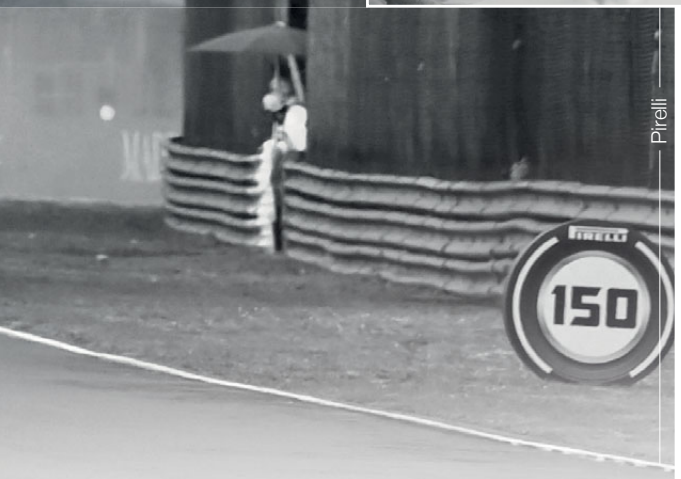
The architect of so much success in Formula 1, Paddy Lowe is now bringing that same demanding mindset to a far more important challenge. **Chris Pickering** finds out more

PADDY Lowe is a man on a mission. His Formula 1 career spanned more than three decades, during which time he oversaw the development of no less than seven world championship-winning cars. At Williams, he masterminded the active suspension system that allowed the FW14B to blitz the competition in 1992; at McLaren he helped to tip the balance in Mika Häkkinen's favour during his epic World Championship battles with Michael Schumacher in 1998 and 1999 and was engineering director for the first of Lewis Hamilton's world titles in 2008; and as executive director at Mercedes from 2013 to 2017, he laid the foundations for the team's crushing dominance of the V6 turbo era.

But his latest quest is bigger than any of those feats. As the world faces up to the threat of catastrophic climate change, the former F1 technical boss has set out to break society's dependence on fossil fuels. And he's going to do it with the combustion engine. Or to be more precise, he's going to do it with petroleum (the collective term for fuels and petrochemicals based on hydrocarbons).

"We're all hardwired to consider petroleum and fossil fuels as one and the same thing, but they're not," he comments. "Fossil petroleum is a bad thing for the future, and it's becoming abundantly clear that we need to move





ABOVE The drive and winning mindset that earned Lowe such phenomenal success in F1 is now being applied to issues that are bigger still

LEFT Formula 1's ambition to showcase synthetic fuels and retain the Internal Combustion Engine could act as a template for the rest of the motorsport pyramid

away from it. But petroleum itself is a fantastic set of chemicals, both for energy and as the basis of everything from plastics to pharmaceuticals. It simply isn't feasible to move away from petroleum, so the question is how do we make it synthetically?"

This is a question that comes back to motorsport, as well as the wider world. Although the actual carbon footprint of motorsport is tiny – certainly when you look at the cars themselves – it's an industry that is already having to work very hard to retain sponsorship money in an increasingly environmentally-aware world. Big brands simply can't afford to be associated with anything that's perceived as polluting.

There's also a practical problem when it comes to decarbonising motorsport, as Lowe explains: "There are basically three types of process that you can use to store energy. Atomic processes where you split or fuse atoms; molecular processes where you burn a fuel; and then there are electrochemical processes like batteries. There is a practical limit to how far you can go with each of those.

> *"You can't sit on your great ideas and wait for them to be perfect"*

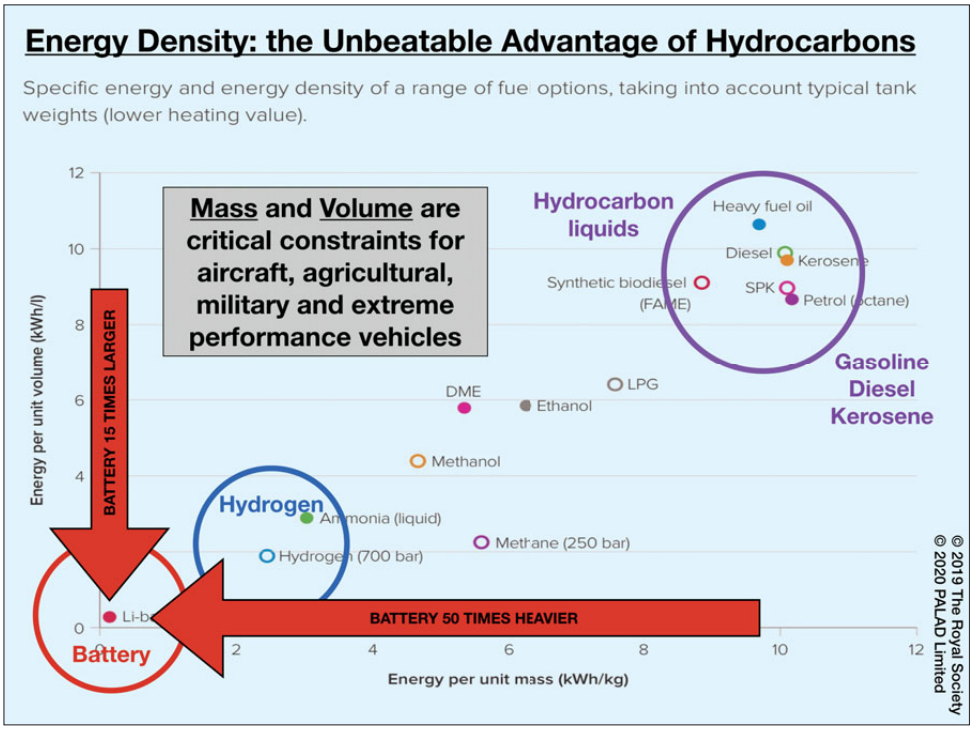
ENERGY DENSITY

"Electric powertrains are not an appropriate answer in high-end motorsport. Formula E does a very good job under the circumstances, but those are not cars that would look at all interesting on a proper racetrack. And they won't get there either, because the energy density isn't possible with electrochemistry. Plus, for motorsport to be exciting we need a visceral experience, and that includes noise."

This brings us back to the concept of liquid fuels. With around 50 times the energy density of battery storage and steeped in over a century of automotive tradition, they remain pretty much the ideal solution if you can overcome the environmental concerns. ▶

Chief among these is CO2 production. But if your fuel is based on CO2 that's been extracted from the atmosphere, you can burn it without any net increase. Instead, your engine – be it a thumping NASCAR V8 or a screaming naturally aspirated V12 – is purely recycling that which already exists. Not only does that make the fuel carbon-neutral, but it raises the very real prospect that the powertrain could have less environmental impact than a battery electric system with rare metals extracted from opposite ends of the globe.

That's not to say that synthetic fuels are a straightforward solution, but that's where Zero Petroleum comes in – Lowe's new venture with Nilay Shah, Professor and Head of Chemical Engineering at Imperial College London. Founded in 2020, the company aims to upscale the production of synthetic petroleum and establish its own production facility.



ABOVE First time around at Williams, Lowe oversaw the development of the active suspension that was responsible for the team becoming such a dominant force and Nigel Mansell winning the 1992 World Championship

LEFT The politicians might love them, but the issue of energy density ensures that batteries cannot always be the go-to answer

CARBON CAPTURE

This isn't the first time that someone has looked at producing synthetic fuel on a commercial scale. Nearly a century ago, German chemists Franz Fischer and Hans Tropsch developed a process for creating liquid hydrocarbons from carbon monoxide and hydrogen. This was used extensively in Germany during World War II to produce synthetic fuels from the country's vast coal reserves, with production peaking at 124,000 barrels per day in 1944. The same process was later used in South Africa when sanctions on the apartheid regime made natural oil hard to come by.

Zero Petroleum is one of a number of organisations that now plan to harness the Fischer-Tropsch process to produce sustainable hydrocarbons. Instead of getting carbon monoxide and hydrogen from the gasification of coal, they use electrolysis (for the hydrogen) and direct air capture (for carbon dioxide, which is then put through a reverse water-gas shift reactor to create carbon monoxide).

The end result, according to Zero Petroleum's calculations, is that 1.46 kg of water and 3.07 kg of carbon dioxide can be used to create 1 kg of hydrocarbon (and 3.53 kg of oxygen). Both the electrolysis and the direct air capture require significant amounts of energy, but this is taken from renewable sources, which would most likely be located on-site with the facility itself.

> *"Talk to people about making clean gasoline from air and water and they look at you like it's alchemy"*

Initially, the company is targeting relatively small volumes, but the intention is still to function as a commercial supplier rather than simply a technology developer, Lowe explains: "Our priority is to produce actual fuel and start to give industries non-fossil alternatives that aren't available today. It's very much not about spending 10 years in the lab."

FAST-TRACKING CONCEPTS

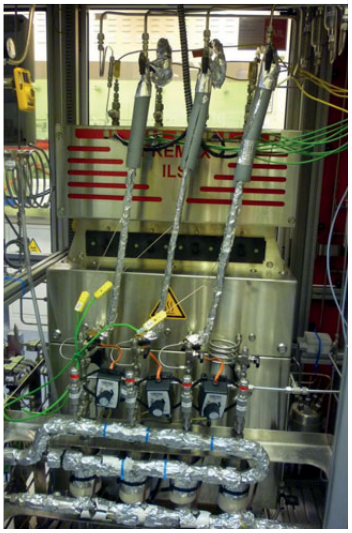
This philosophy of fast-tracking concepts through to production is part of the F1 mindset he says: "Engineering in Formula 1 is all about making the car faster and bringing out those improvements as quickly as you can. You can't sit on your great ideas and wait for them to be perfect, because the other teams will be out there winning races. If your analysis says a new idea will deliver lap time, you get it on the car, and then perhaps you can get another 10 per cent of that improvement by refining the concept once it's out there. And that's what we want to do with Zero Petroleum – get out there and start developing the market."

The company has a number of live R&D projects currently. The scale of the operation will depend on how those pan out and how the enterprise is funded, Lowe notes, but the scenarios range from two or three barrels a day up to maybe 100 barrels a day [roughly 500 litres to 16,000 litres per day]. That's minute by oil company standards, but even at the lower end of that spectrum it could theoretically supply a whole motorsport series.

In terms of chemical processes, the weakest link in the chain at present is the direct air capture of CO2. There are already commercially available technologies that will do exactly that, but they tend to be expensive and inefficient.

Earlier this year, Tesla and SpaceX founder Elon Musk announced a $100 million prize for carbon capture solutions. The Carbon Removal X Prize will run until April 2025. It's believed to be the richest prize incentive in history and it's aimed at systems that can be scaled to the gigaton level.

"Direct air capture of carbon dioxide is the biggest gap in our current technological repertoire on this planet," comments Lowe. "Over the next decade we expect to see these systems start to become much more practical and economically viable at scale. And synthetic fuels will be one of the drivers for that ▶



> *"It will be quite easy to overcome this growing concept that combustion engines are bad"*

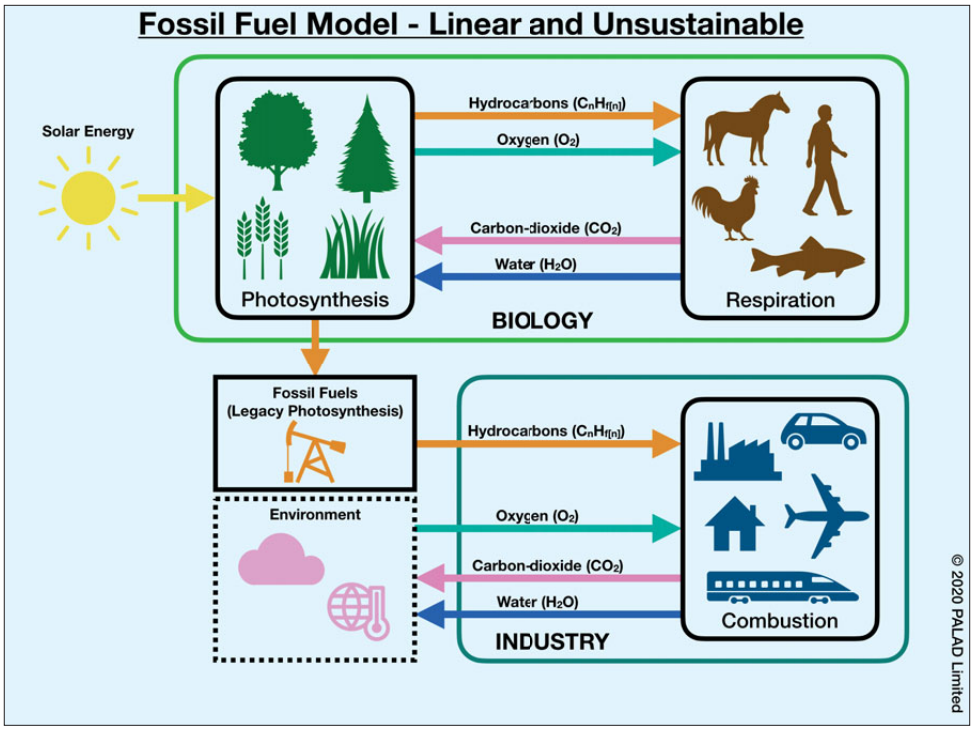
because you need more than prizes; you need actual use-cases to drive the technology and the investment."

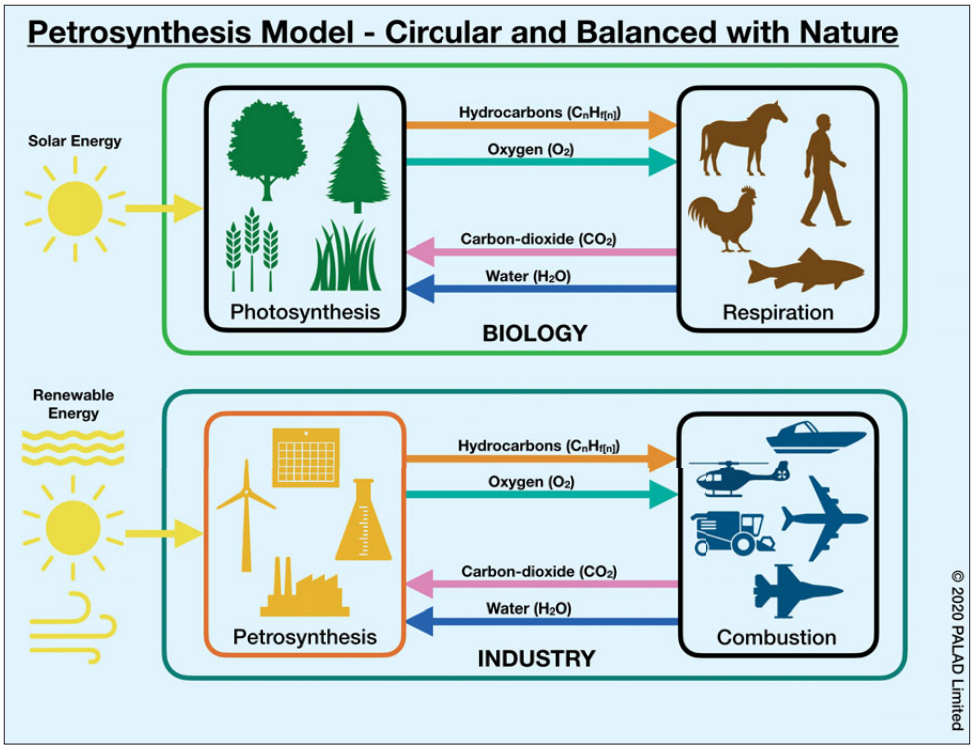
While direct air capture remains in its infancy, Zero Petroleum is also looking at CO2 captured from industrial sources. In most cases this would normally be vented to the atmosphere, so it still has the same net effect, the company points out.

MORE POWER

The other challenge is the sheer amount of energy that's required, especially with the renewable electricity infrastructure remaining quite limited in much of the world. Consequently, Zero Petroleum's plans chiefly focus on small-scale plants that are matched to relatively small-scale distributed power generation. As such, the hydrogen and carbon dioxide could

LEFT Zero Petroleum has a number of live R&D projects currently ongoing





BELOW Lowe was McLaren engineering director when Lewis Hamilton won the first of his world titles

be captured, combined into hydrocarbons and distributed as a fuel, all from the same site.

That's not to say it couldn't be upscaled, however, notes Lowe: "In some respects, it's actually harder to do this sort of thing on a small scale because the economics aren't in your favour. I think there's a model for renewable power generation on the sort of scale we now see with coal or gas, but it will be deployed in more remote locations that aren't suitable for other purposes – perhaps where heat or desertification has rendered the area inhospitable. We're already seeing huge solar farms spanning many, many square kilometres in India, China and the Middle East."

The MBR Solar Park in Dubai's southern desert, for instance, covers a total site area of 77 km² and plans to ramp up to a capacity of ▶

> *"Direct air capture of carbon dioxide is the biggest gap in our current technological repertoire on this planet"*

5,000 MW by 2030. This would put it at a similar level to the world's largest gas-fired power stations.

Of course, having all that electricity at your disposal begs the question of why you wouldn't simply use it in its existing form. By Lowe's own estimates, only around 15 per cent of the energy generated by the renewables plant will actually reach the wheels of a vehicle running on synthetic fuel, once all the various losses have been cascaded. In contrast, that figure for a battery electric powertrain might be 70 per cent.

"It's what I call the displacement argument," he says. "And for some applications it makes a lot of sense. For normal everyday road cars, I think electrification will be a much better route, if we can make it work. But there are some applications where I simply can't see it happening. The obvious one is air travel, but there are also lots of others. A combine harvester, for example, is a machine with very high power demands that works for long periods without a break [which means it needs dense energy storage]. On top of that, it has to drive on loose ground where soil compaction is a problem, so you can't just keep adding weight. There's no real alternative to a petroleum-based fuel in that sort of application."

SYNTHETIC FUELS ADVOCATE

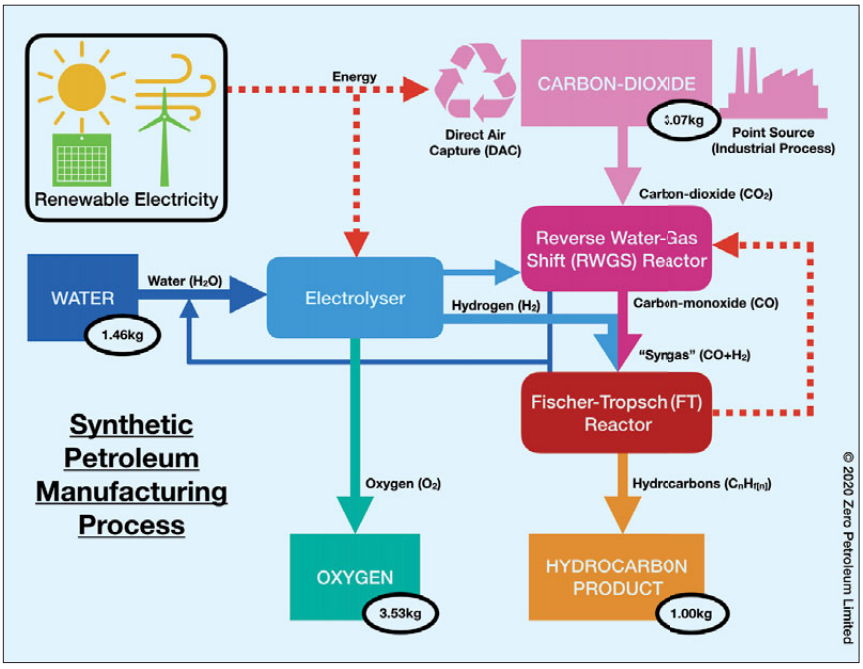
The same very much applies to motorsport. At an estimated 650 kg, the 93.4 kWh battery pack in the Porsche Taycan Turbo weighs more than an entire V8-era F1 car. It's hard to imagine such technology ever completing an hour-long grand prix, let alone a 24-hour endurance race in the format that we know today.

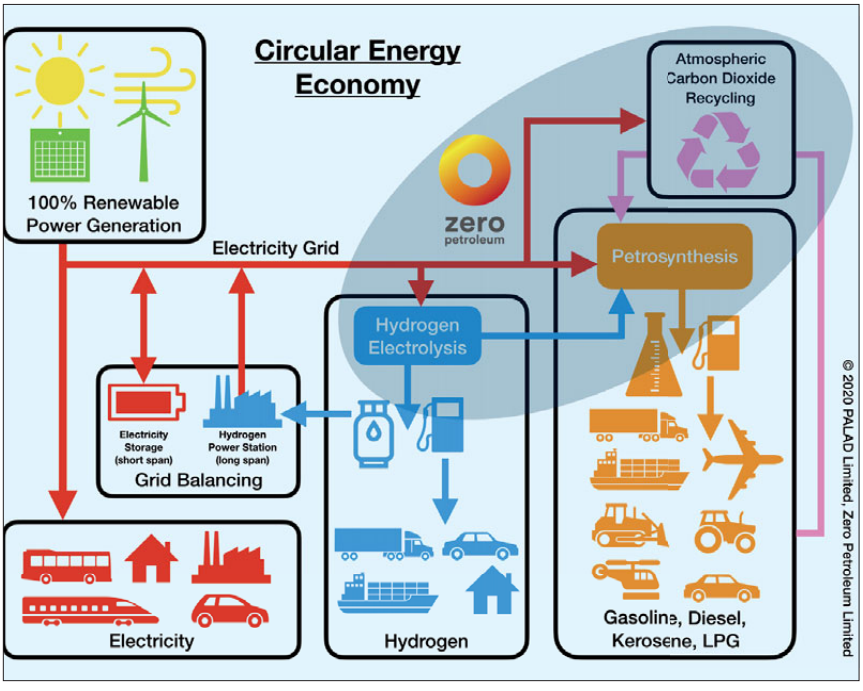
Ironically, Porsche is another keen advocate of synthetic fuels. Last year, the company announced it was investing €20 million in a joint project with Siemens Energy to produce synthetic fuels in a new plant in South America. The facility, which is set to open in 2022, hopes to produce 55 million litres of synthetic fuel per year by 2024, and roughly ten times that amount by 2026. Motorsport has been cited as one of the first uses of the fuel, along with the vehicles at Porsche's Experience Centres, with road-going applications to follow.

In a recent interview with BBC Sport, Porsche Motorsport vice-president Fritz Enzinger mentioned that a return to Formula 1 would "be of great interest" if the implementation of synthetic fuels was to be included in the new engine regulations due to be introduced in 2025.

As with Porsche's project in South America, Zero Petroleum's aim is to produce drop-in fuels that don't require any modifications to the engine itself. However, there is scope to tailor their formulation to provide specific attributes, such as increasing knock resistance to enable higher compression ratios.

Although these fuels can be completely





Mercedes-AMG F1

ABOVE Toto Wolff, Niki Lauda, Lewis Hamilton, Paddy Lowe, Andy Cowell and Nico Rosberg celebrate the third consecutive Drivers' and Constructors' Championship for Mercedes-AMG Petronas Motorsport at the end of the 2016 season

carbon neutral, careful attention would still need to be paid to other emissions such as nitrogen oxides (NOx). However, synthetic fuels are inherently free of contaminants such as sulphur, which are involved in the formation of many of these pollutants. As such, they are inherently clean-burning and unlikely to cause issues with air quality – particularly if they're used away from towns and cities.

"When you talk to people about making clean gasoline from air and water they look at you like it's alchemy," comments Lowe. "But once you break it down, it's actually quite easy to understand, and the next question they ask is 'when can I have some?' So I think it will be quite easy to overcome this growing concept that combustion engines are bad.

"We need to start by getting synthetic fuels out into the market and putting up the message that petroleum isn't actually bad; it's the sources of the petroleum that we're using currently that cause all these unwanted problems. In fact, there's nothing wrong with noise, with a visible display of energy or even with what we currently think of as waste energy [such as heat] if it's going back into a circular system."

He's clearly lost none of his enthusiasm for the visceral world of motorsport, so could Lowe be tempted back to F1? "Not really, no," he replies. "I spent more than 30 years in Formula 1 and achieved a lot, but I've been very busy doing this work, which I really enjoy.

"It's great to actually embark on some new ventures. I still love motorsport, though. And I still love cars, engines and horsepower. So to find a way to bring the two together is very interesting."

If his F1 career is anything to go by, you can expect this latest project to be pursued with the same zeal and determination. It may not scoop any world championship accolades, but there's a possibility that this work could be more important still – particularly for those of us who look forward to enjoying combustion engines for many decades to come. RT