BEYOND MISSION H24

Chris Ellis believes the ACO's H24 initiative, bringing hydrogen-powered racecars to the Le Mans 24 Hours, should go further still

NEW regulations for the World Endurance Championship will soon come into force. They are spearheaded by a new class of 'hypercar', which should help to restore the original objective of Le Mans: proving which is the fastest road car round a track. 'Endurance' is just one of the qualities a car needs to impress those watching a 24-hour race, so the FIA Endurance Committee has issued this edict: 'Aerodynamics cannot take precedence over aesthetics', and the new regulations reflect this.

However, with the objective of containing costs, the new hypercar regulations specifically discourage the development of innovative powertrain components, and don't encourage, yet, the use of sustainable fuels produced using 'renewables' – solar, wind, etc.

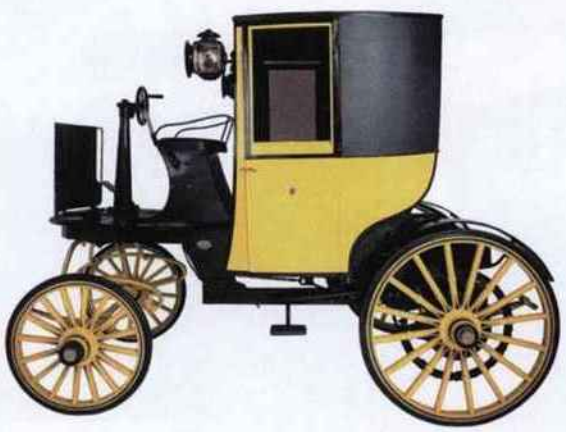
The good news is that the rest of a typical hypercar should provide a fine platform capable of supporting a wide range of alternative powertrains and sustainable fuels. So this is the basic idea behind my suggestion for the creation of a new category, 'Formula R' – tight rules governing most of the car, but real room to innovate and *directly compare the results* when it comes to powertrains and fuels.

In parallel to this hypercar revolution, the ACO and FIA have launched 'Mission H24', introducing hydrogen-powered racing cars to the 24 Hours of Le Mans in 2024, when a special class will be created for a zero-emission race. The initiative is designed to show the feasibility of fuel cells running on compressed hydrogen, with the suggestion that liquid hydrogen might also be allowed.

In some respects it is a motorsport 'moon-shot' and that is reflected in the ACO's assessment that "Mission H24 is not unlike the Apollo programme launched in the United States in 1961 and which, after a series of test flights, achieved its goal of putting men on the moon in 1969. Similarly, there will be several milestones to reach before hydrogen-powered cars can race at the 24 Hours of Le Mans in 2024.

"Hydrogen is a public-interest choice: it is a global challenge that addresses some of the major issues of our time, such as urban air pollution, and the need to find new sources of fuel to replace conventional hydrocarbons."

Although the ACO's hydrogen initiative



ABOVE Electric taxis were the future as far back as 1897!

ABOVE The H24 project aims to speed up research and development on the use of hydrogen, with the ultimate aim of taking it from track to the road to achieve zero-carbon mobility

is a welcome one, it is for me too limited technically. Hence my suggestion that we should introduce 'Formula R'.

Packaging the large hydrogen tanks needed to provide sufficient endurance is one of the biggest obstacles designers need to overcome for H24 to succeed. It's an issue mirrored in the wider automotive sphere too. The need to provide such large cylinders to achieve the endurance required is just one reason why using a fuel with a much higher energy density is preferable in almost any road car. And it's obviously desirable in a racing car.

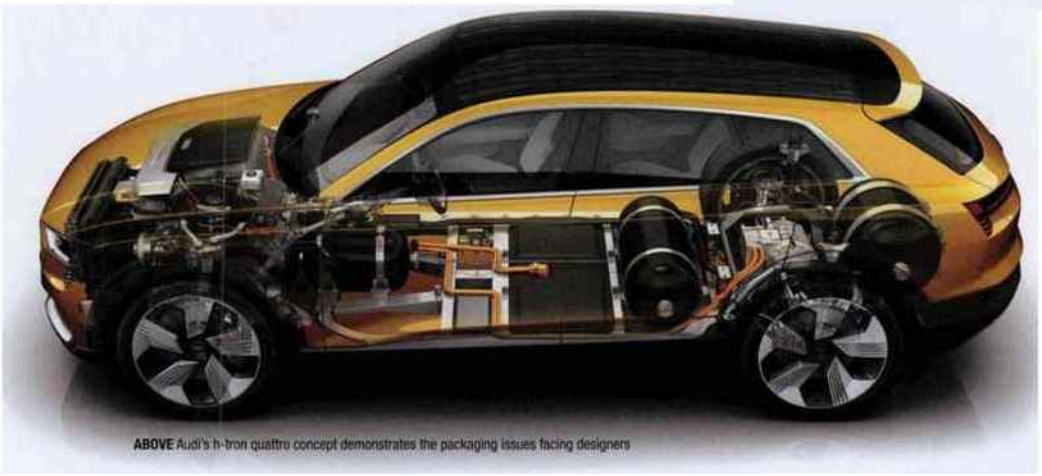
The image of Audi's h-tron quattro shows the space needed for the hydrogen cylinders in a large SUV concept. The Toyota Mirai, Honda Clarity and Hyundai Nexo saloons have a similar layout, with even more of a space problem.

The resulting reduction in luggage space and rear headroom usually generates criticism in road tests, making high-density sustainable liquid fuels an obvious attractive alternative. However, there is plenty of unused volume available under the beds of big trucks, so the economic advantage of compressed hydrogen when produced using solar with a bulk price of under two cents per kWh should make heavy-duty road vehicles the main global market for the direct use of hydrogen.

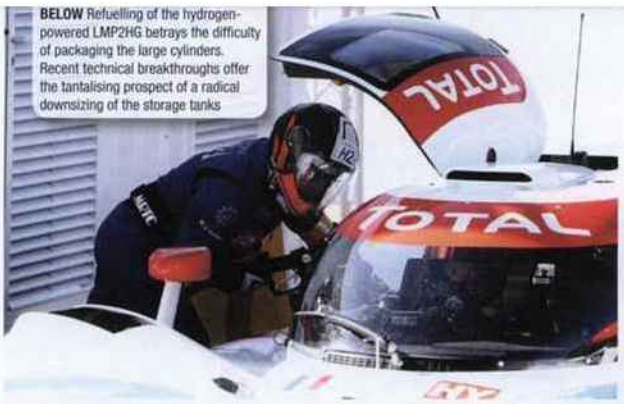
Liquid hydrogen has proved its effectiveness in space, where specific energy is paramount and cost matters little. But, even for large aircraft, it will require more storage volume than jet fuel, implying more drag and higher energy use. Also, the extra cost of liquifying it, and keeping it liquid, will undermine the simplistic arguments for it. And of course compressed hydrogen requires even greater volume, making it impractical in the air.

SUSTAINABLE FUEL

So, despite the fact that a renewable liquid fuel will inevitably cost more than 'green hydrogen' to produce because hydrogen will be just one of its two key ingredients, the value of the space saved will help to reduce the total lifetime costs in most light-duty vehicles. The BBC has just started its build-up to COP26 (the United Nations Climate Change Conference in Glasgow this November), and has already conceded that there is a strong case for compressed hydrogen rather than batteries in big trucks and buses. However, it does not seem to have realised, yet, that the lifetime cost of *untaxed* E85 in France ▶



ABOVE Audi's h-tron quattro concept demonstrates the packaging issues facing designers



BELOW Refuelling of the hydrogen-powered LMP2HG betrays the difficulty of packaging the large cylinders. Recent technical breakthroughs offer the tantalising prospect of a radical downsizing of the storage tanks

in a 'flexifuel' Ford Kuga is *already* only a small fraction of the total cost of running it, if it averages some 12,000 km a year. Say 500 euros per year.

Now cut that to around 300 euros, if it's powered by a fuel cell running on E85 or better. The BBC is still selling the idea that 'most cars should be electric', even if it has stopped advocating 'stick a battery in everything!' Hopefully, the media will soon explain that, by 2025 in France, most new 'family cars' could be powered either by batteries or run on a sustainable fuel. And my guess is – most owners will choose the convenience and lower overall costs of the latter...

But all of this needs proof, which is where Formula R could provide an ideal platform to establish the best, multiple, solutions, and demonstrate them side-by-side. In the end, it is likely to be the cost-per-mile over the life of the vehicle which will determine how each application is fuelled. This proved the case over a hundred years ago, when battery cars were selling almost as well as cars like the Ford Model T, then capable of running on ethanol or petrol.

Much though we tend to think of electric cars as futuristic, they were considered 'the future' as far back as 1897. Walter Bersey's electric taxis – featuring a top speed of 9-12 mph! – were the first self-propelled vehicles for hire on London's roads. And those early battery cars were almost as energy-efficient as modern BEVs. However, the arrival of cheap, untaxed, petrol swiftly resulted in battery-powered cars disappearing from showrooms.

The battery lobby in the UK is happy to claim the running-cost advantages of cheap, untaxed, electricity over heavily taxed petrol, but doesn't seem to realise, yet, how low the cost of sustainable, untaxed, 'R85' will become. Already, E85 is half the price of diesel in France. Hopefully, the rest of Europe, including the UK, will follow soon. And then impose Road Usage Pricing (starting with new ▸

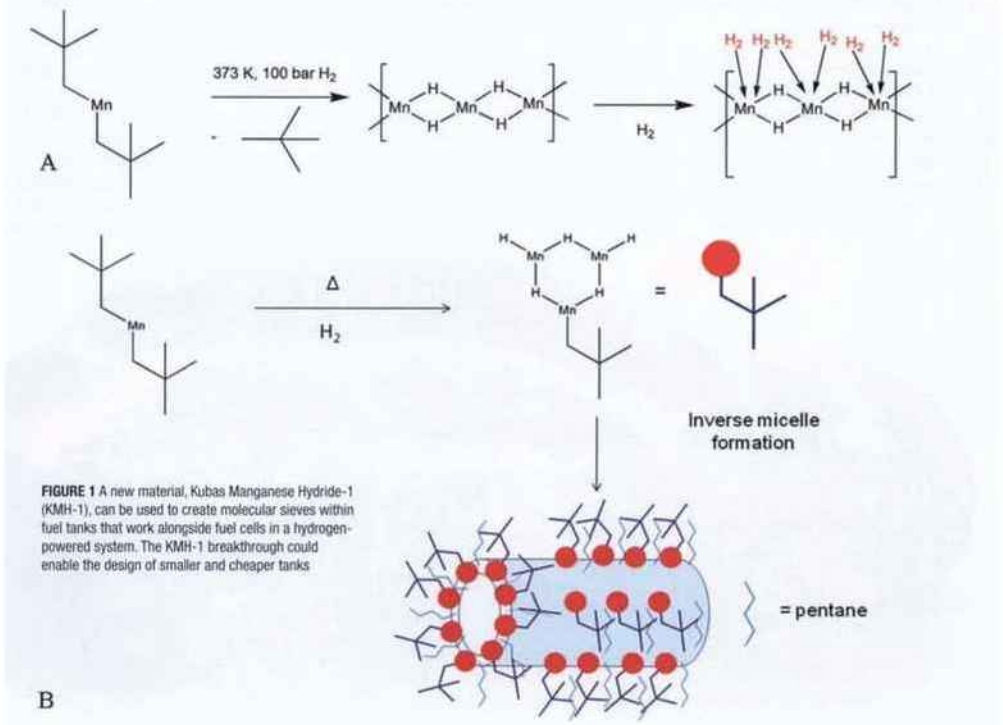


FIGURE 1 A new material, Kubas Manganese Hydride-1 (KMH-1), can be used to create molecular sieves within fuel tanks that work alongside fuel cells in a hydrogen-powered system. The KMH-1 breakthrough could enable the design of smaller and cheaper tanks

ABOVE Green GT's experimental LMP2HG has already shared the circuit – and pit lane – with conventional cars in the European Le Mans Series

electric vehicles, in 2023?) to level the playing field, and keep the massive taxes on cars flowing to help pay for the NHS – and reduce traffic congestion.

So a key role of Formula R could be to provide a 'training field', to prove which 'players' to pick, for which roles. 'Stick a battery in everything!' is an attractively simple mantra for politicians, but the readers of this magazine know better. There may be a big role for batteries in light duty vehicles, but when things get serious, other solutions (some of them liquid, naturally!) may prevail.

Here's an example of a novel way to store hydrogen which might soon feature in Formula R. Kubagen, a UK-based start-up, has discovered a new material that allows hydrogen to be stored in only a quarter of the volume of a conventional 700 bar cylinder. It works by exploiting a chemical process called Kubas binding that distances the hydrogen atoms within an H2 molecule, without the need to split the molecule. (See Figure 1.)

The process works at room temperature and at only around 120 bar. The material also absorbs and stores excess energy, so external heat and cooling is not required. The big reduction in volume promises to solve one of the key problems in using hydrogen in passenger cars, and should also make bulk static storage substantially less expensive. Formula R may become an ideal way to prove it.

ECONOMICS WILL OVERRIDE ECONOMY

One argument frequently used by battery-only proponents against sustainable fuels is based on the fall in overall energy efficiency as electricity from renewables is used in the various processes needed to produce a 100% sustainable fuel. This would make sense if the original source of energy was finite, like all fossil fuels, but sunshine is almost infinite, and free at source. So the real test is how much a 100% sustainable fuel will cost to produce in volume, supported by the additional value of almost instant and widely available 're-energising', and a small, light, low-cost, 'energy store' (usually called a fuel tank), which will normally last the life of the car.

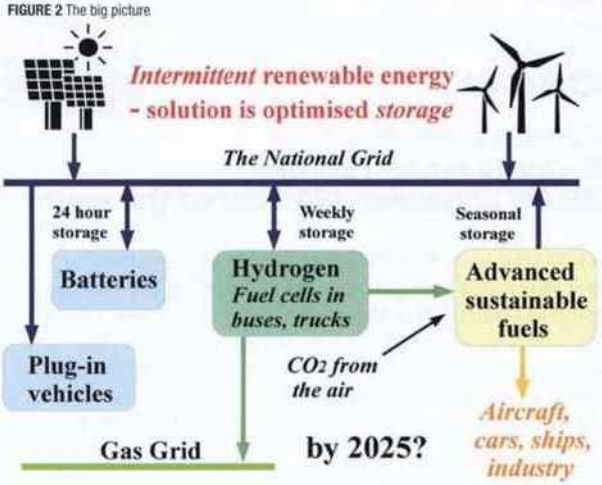
Here is a simple test – if your car could run on a widely available net-zero-CO2 fuel which cost half the price of diesel, why would you want an electric car? Especially if the BEV's battery cost more to replace than the residual value of the car when the battery eventually failed, or its range fell below 80%. And why would governments need to spend billions on recharging infrastructure if Big Oil was happy to upgrade existing filling stations? So here's a forecast: the 'end game' for many types of vehicles will be 100% sustainable fuels. What we don't know, yet, is – how much will be 'green hydrogen', and how much will be liquid fuels made from 'green hydrogen' and carbon dioxide extracted from the air? Let's begin to find out.

FORMULA R PROPOSALS

So what might Formula R look like? Ideally, the cars should conform to the WEC regulations for hypercars in all aspects except the powertrain. This would enable attention to be focused on developing technologically advanced powertrains.

For these 'hypeRcars', there should probably be an absolute limit on peak power, as there is for WEC from September. However, rather than adopt the complex power-limit curve relating instantaneous total power to engine rpm, the hypeRcar limit might simply be set at 580 kW. In WEC, the torque at each driveshaft is measured to calculate the combined power of the engine and the MGU-Ks (if fitted) – see Appendix 4b of the WEC regs. The power limit for hypeRcars should be measured in the same way, but should probably remain

FIGURE 2 The big picture



1,000 kW, only 1,600 kg, 170 mph continuous cruise, 60 to 180 mph in 10 secs

FIGURE 3 Above, the obvious hydrogen configuration. Below, a 2+2 becomes feasible if a sustainable liquid fuel is used

1,050 kW, 170 mph continuous cruise, engine-off in town, 2+2

the same at all speeds. So hypeRcars may be able to accelerate faster than 'ordinary' hypercars, if there is 'adequate' ERS power available, although their sustained top speeds will probably be similar. Which should suit most potential owners just fine.

There should be no limitations on the technology of the ERS, so any combination of batteries, flywheels and supercapacitors will be allowed, subject to mandatory safety checks during homologation, before the cars are permitted to race. 'Power unit' technology may similarly be free, potentially allowing Pat Symonds to prove that two-stroke engines might be a future option in Formula 1. Or Cosworth might want to demonstrate that a 5-litre V12 running on hydrogen would be a real crowd-pleaser. Fitted with electric superchargers to ensure an over-abundance of air to minimise NOx, consequently delivering, say, 'only' 500 hp at 10,000 rpm, and supported by two 150 kW MGU-Ks (one front, one rear), everyone might be delighted.

Or Ilmor might want to show everyone how effective a *5-stroke* engine could be, running on sustainable E85... Perhaps using a transverse straight-six? With space for a large hydrogen cylinder between it and the cockpit, for those who still prefer compressed hydrogen?

> *"Formula R could provide an ideal platform to establish the best solutions and demonstrate them side-by-side"*

To emphasise the practical penalty of compressed hydrogen, Figure 3 shows two imaginary Chirons, one using compressed hydrogen, while the other is a 2+2, with a 400 hp transverse straight-six running on a 100% sustainable fuel.

Formula R is likely to develop into a 'Battle of the Fuel Cells' on the one hand, and 'Hydrogen versus Sustainable Liquid Fuels' on the other. Right now, I am guessing that SOFCs running on various types of 'renewables' at over 70% efficiency will dominate eventually, in the air, on the ground and at sea. But let's prove it, and help make it happen as soon as we can.

So, after each race or demonstration, the first six(?) cars could be checked for fuel consumption at a steady 130 kph, and tested for emissions, and the results could then be published online. And compared with the equivalent numbers for a 'conventional' WEC hypercar...

Should Formula R be the 'morning race', before each Formula 1 GP, or a sub-class of WEC? Or both? I sent Ross Brawn a draft of this, so you know my initial preference.

Bottom line: as electricity from solar continues to fall towards one cent per kilowatt-hour under the Sun Belt (which covers some 60%, and rising, of the world's population), the cost of producing sustainable fuels capable of powering most new cars built from 2021 should soon reach a price directly competitive with diesel, before tax. It is now up to governments to determine the taxes which will guide the motoring public to make the right choices. Formula R could inform them, and help them back the right 'horses'.