MEN ON A *MISSION*

Chris Pickering talks to the head of R&D at GreenGT, the company selected as sole powertrain supplier for Mission H24's hydrogen prototypes to be introduced at the 2024 Le Mans 24 Hours

IF anyone has any lingering doubts about the credibility of the Automobile Club de l'Ouest's forthcoming hydrogen class, they'd do well to take a look at the recently-announced supplier list.

The category, due to arrive in 2024, will operate on a similar basis to Formula E, with large parts of the car standardised, while others – notably the fuel cell stack – will be left open to the teams. Of those spec parts, the list begins with the chassis, which is jointly produced by F1 offshoot Red Bull Advanced Technologies and Le Mans legend ORECA.

French automotive giant Plastic Omnium will supply the high-tech hydrogen storage tanks, while the battery, motor and transmission will come from Swiss company GreenGT. Famous for its long-running series of experimental hydrogen prototypes, it's the only manufacturer to have lapped the full-length Le Mans circuit with a fuel cell vehicle.

GreenGT's role in the category extends well beyond supplying the powertrain components. As a technical partner to the ACO's Mission H24 programme, the company is heavily involved in laying down the framework for the rest of the hydrogen formula. It also runs the H24 Racing team that plans to campaign the latest GreenGT prototype (also called the H24) in a series of long-distance race events before the category is launched in three years' time.

For the moment, much of the focus is on developing the H24 so the team can fully understand the challenges of building and running an endurance racer powered by a hydrogen fuel cell.

"The H24 is a very good base to understand what we will need for 2024," explains Jean-François Weber, general manager and head of R&D at GreenGT. "Once the other teams start getting ready to race in the hydrogen class, we will switch to supporting them – we ▶

won't be racing in the series ourselves – but there is a lot of work to do first on developing the vision for the category."

The H24 is an impressive piece of engineering in its own right. With its LMP-style bodywork and ultra-aggressive aero kit, it appears to have taken a significant step forwards compared to its predecessors.

LIGHTER AND FASTER

The changes under the skin are equally significant, with the new car an impressive 110 kg lighter than the old LMPH2G. That's largely due to the decision to switch from four motors to two, which has allowed the development of a far more compact transmission design. Now each rear wheel is powered by its own motor, driving through a single-speed gearbox. As before, the internals for these units come from French transmission specialist Sadev, while the casing has been designed in-house by GreenGT.

> *"While the original motors revved to 9,000 rpm, the current designs spin to 17,000 rpm"*

The gearbox and power electronics are now integrated as one unit, including the cooling ("there are two cables coming out and that's all you need to operate the powertrain," notes Weber). This results in a very light, simple wiring loom and helps to minimise energy losses. Meanwhile, the old IGBT inverter has been replaced with a silicon carbide (SiC) design.

The motors have evolved significantly since GreenGT embarked on its first hydrogen-powered racecar. While the original units revved to 9,000 rpm, the current designs spin to 17,000 rpm as a result of a new design philosophy that delivers increased power density.

However, Weber and his colleagues are already working on the next generation design. This will take the integration concept even further, packaging the stator and rotors inside the transmission casing to create a truly self-contained drive unit.

For now, the H24 remains rear-wheel drive (as all of GreenGT's previous cars have been), but the company is already starting to look at a four-wheel drive version, which will increase the energy recovery capability.

"We know that we will need four-wheel drive for the 2024-spec cars," comments Weber. "At the moment, we have 560 kW (750 bhp) available on the rear axle, but we want to create a new layout. Our vision – it's just a concept at the moment – is to remove the mechanical brakes from the front end completely in the future. All the braking would be carried out by the motors and we would store that energy in the buffer battery to redeploy when the car accelerates. This will ▸

RIGHT With ORECA and RBAT on board, GreenGT will be free for the first time to concentrate solely on the intricacies of the powertrain

BELOW The H24, seen here, is already an impressive 110 kg lighter than its predecessor, the LMPH2G

reduce the size and weight of the hydrogen tanks that are needed. At the moment, we still need the mechanical brakes for safety, but maybe in the future this will be something we could do."

This increased focus on brake energy recovery is a factor in the motor design, with the materials and windings chosen to optimise their performance as a generator as well as a motor. Another big challenge on the front end will be packaging space, Weber points out. Again, the team is investigating the possibility of using smaller, higher-revving designs, with speeds of 20,000 to 30,000 rpm suggested.

"You have so much energy when you're travelling at

> ***"Our vision is to remove the mechanical brakes from the front end completely"***

300 kph [186 mph] that braking hard can generate energy at a rate of something like 1,000 kW for the first second," comments Weber. "You need somewhere to store all that energy. Right now, we're using a battery for the buffer system, but we can envisage maybe using a hybrid solution with a battery and a supercapacitor."

The original GreenGT used a 2.4 kWh battery, which has now been increased to 3.1 kWh. However, thanks to a new bespoke design from F1 KERS specialist Saft, this offers better energy density and more compact packaging than the unit it replaces. Despite a capacity increase of nearly 30 per cent, its weight only rises by 10 kg (from 78 kg to 88 kg, including the casing, BMS system and cooling).

"The new battery will be a major advantage on the track; we can sustain the power down the whole straight, which we couldn't do with the old one," comments Weber. "That's partly because the battery is more stable. We did around 10,000 km of testing with the old one and we saw some thermal problems." ▸

TOP Pierre Fillon, president of the ACO, prepares to find out what the LMPH2G is like for himself

ABOVE The LMPH2G laps the Bugatti circuit at Le Mans. Before long, the technology developed within it will have to cope with the demands of the full circuit

FUEL CELL

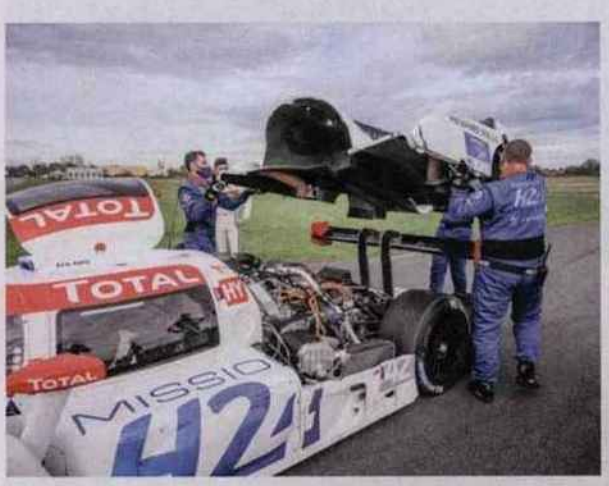
While the design of the H24's fuel cell – a new item supplied by French firm Symbio – won't necessarily feed directly into those used by the teams in 2024, it will provide valuable data. Its job is to act as a generator, providing a steady stream of electricity to top up the buffer battery.

In its present form, the H24's fuel cell stack operates at 240 kW (322 hp), but GreenGT currently has a new derivative on the testbench. This is primarily designed to be more efficient, but it may also offer a higher output, thanks to new surface geometry, a revised coating and improved seals on the bipolar plates.

"We had very positive results from the fuel cell technology that we'd used in the LMPH2G. It was stable. The car went through all the testing for more than a year with the same fuel cell stacks," explains Weber. "So we decided not to change the structure. We've kept the same basic layout with four stacks, although we've changed some parts to be more efficient. This includes the recirculation system, which helps us to retrieve more hydrogen and reduce the fuel consumption. The overall weight of the fuel cell is lower and the cooling flow is more efficient too."

Cooling was never particularly an issue on the old car, but the GreenGT team were keen to further optimise the system. The cooling package has been re-designed so it all sits around the middle of the car, near the powertrain (the radiators for the fuel

ABOVE & BELOW The current test mules are two-wheel drive, but already plans are taking shape for the transition to four-wheel drive needed for the 2024-spec cars



LEFT GreenGT will supply the battery, engine and transmission for the hydrogen cars. The fuel cell, power control hardware and software, compressors, and cooling system will be open to development by the teams

cell were mounted in the nose of the previous car). This has reduced the weight of the system, decreased the volume of coolant inside and removed the pipes that previously ran half the length of the car.

Further refinements are planned for the H24. For instance, it still uses the hydrogen tanks from the LMPH2G at present, but the team will be switching to a new design from Plastic Omnium shortly. This will provide a greater internal volume for the same packaging space, increasing the car's range.

The tanks are run at up to 700 bar in private testing, although race-style rapid refuelling has only been carried out at 350 bar so far, Weber explains: "The refuelling becomes more complicated at 700 bar. When you finish the run, the temperature inside the tank is around -40 deg C, but if you refuel fast you increase the temperature very rapidly. There's a limit of 85 deg C, which restricts how fast you can refuel. That's something that our refuelling partner Total is working on at present. The decision is in the hands of the race organisers, but I hope that we will see 700 bar when the cars race at Le Mans in 2024."

There's still plenty of work to do before that point, however. And that will include at least one more experimental prototype from GreenGT.

"We've gone step by step through the development," comments Weber. "We started with two-wheel drive to keep things simple. Now we understand how to manage the energy recovery, the next step is to move to four-wheel drive. Obviously, this is something that we will have to test extensively before the cars race for 24 hours."

GETTING SERIOUS

This next step will necessitate a whole new car, as the current chassis is built around a modified ADESS LMP3 tub, which is not designed to accept a drivetrain on the front. In the meantime, the two-wheel drive H24 will be used to develop the fuel cell, the control strategy and the rear drivetrain.

All this takes the hydrogen class another step closer to reality. GreenGT can justifiably claim to have kicked off the ACO's journey towards hydrogen motorsport when it demonstrated its first prototype, the H2, at Le Mans in 2016. Now the company is working alongside an endurance racing legend and an offshoot from a team with four consecutive F1 manufacturers' titles under its belt. Things have definitely got serious. RT

LEFT The GreenGT LMPH2G seen in action at Luncy-Lévis. The project represents a massive step towards sustainable mobility for the ACO.