

Generation H

Audi has launched its brand new R18, which couples the firm's tried-and-tested diesel engine with a electro-magnetic flywheel. And also, for the first time, a thermal energy recovery system

BY ANDREW COTTON



“This Audi R18 e-tron quattro represents a completely new generation of Le Mans prototypes. The principles of the LMP1 regulations have fundamentally changed”

Audi has given its first public preview to the car that it hopes will deliver it not only victory at the 2014 Le Mans 24 hours, but which will drive forward its understanding of hybrid technology to the next level as it introduces a thermal energy recovery system for the first time.

The car is completely new, including a brand new engine, although the diesel engine does retain its V6 configuration. The company has switched from Dallara to manage the monocoque build as it looks in all areas to optimise its package to face Porsche and Toyota in the World Endurance Championship next season. The kinetic energy recovery system, also completely new, will continue to drive the front axles, with the result

that the car will still retain its four-wheel drive characteristics. Also introduced on what is Audi's most complicated LMP1 car to date is a second hybrid system, with an electric turbocharger in the internal combustion engine.

Combined, Audi expects the new car to use 30 per cent less fuel than the 2013 car, although that did run last season with fuel economy that was compromised by up to 20 per cent to drive the now-banned blown diffuser. Meanwhile, the manufacturer will be able to continue to experiment with the use of exhaust gases.

For the first time, the turbocharger of the internal combustion engine (ICE) is linked to an electrical machine, which makes it possible to convert the thermal energy of the exhaust gas flow into



Audi's new car features a second hybrid system with an electric turbocharger in the internal combustion engine

Audi expects the new car to use 30 per cent less fuel, returning to economy over power in the 2014 car



electric energy, for instance when the boost pressure limit is reached. This energy also flows into the flywheel energy storage system. Power delivery can then be released to both axes, as the MGU-K delivers to the front axle and the ICE to the rear.

The chassis is completely new, to meet with new regs that require a higher cockpit, raised 20mm compared to the 2013 car, while the car is narrower by 10cm.

The front wheels are narrower, meaning that the bodywork can also too, helping to improve aerodynamic efficiency. The weight has also been reduced by regulation, from 925kg in 2013 to 850kg for a non-hybrid car, and 870kg for a hybrid car.

'The next generation Audi R18 e-tron quattro represents a completely new generation of Le Mans prototypes,' says Dr Wolfgang Ullrich, head of Audi Motorsport. 'The principles

of the LMP1 regulations have fundamentally changed. The idea behind this is to achieve similarly fast lap times as in the past with considerably less energy.'

WEIGHTY ISSUES

New cockpit regs and narrower chassis required all manufacturers to build new cars, but the weight reduction caused Audi to have to revisit every part of the car in a bid to get below the minimum and still have ballast to play with.

The switch from Dallara, to another Italian firm - Ycom - was just part of an overall review of the complete car. 'We reviewed the possibilities and kept the core technology of layout and packaging with the chassis, and the consortium of how to manufacture has always been a puzzle organised by Dallara,' says Christopher Reinke, head of LMP1 at Audi. 'We look at who is best, because we guide the process - and we felt that there was a more optimum possibility for us.'

'For sure the new weight regulation is very challenging, as we try to put more technology in the car, with a dual hybrid system,' adds Reinke. 'It goes in

“The idea behind the regulations is to achieve similarly fast lap times to the past, using much less energy”



hand with what the road car tries to achieve, trying to lower the weight spiral while increasing the hybrid performance.

‘The car is 10cm narrower and we have smaller wheels. After that it starts to get tricky. We had to apply the same theory when we created the ultra and e-tron. You have to look at everything, and to question every single thing. What might make sense from a technical point of view we always have to question for the weight.’

Audi engineers went through the chassis, the engine, gearbox, and all structures in a bid to save weight, and believe that they achieved it, although the final figure is yet to be announced.

MYSTERY ENGINE

While Porsche’s plan, revealed in a German newspaper to be a four-cylinder petrol engine in a V configuration, Audi would only confirm that it was running a V6 diesel, and kept the capacity under wraps.

‘It is a brand new engine,’ says head of engine tech Ulrich Baretzky. ‘It is a brand new rulebook - the conception is completely new. We could never do for next year what we did from 2012-2013 - that would be the wrong way to go. We always have to save weight, but I don’t know how much we saved, and I don’t care! The most important thing about the engine is that it has to last, and I don’t give a shit about

the weight. Car people hate me for that. We have saved some kilos, but we are not in Le Mans yet, tests are not finished yet, we have to wait until it is done.’

The MGU-H has to work with the turbo, but Baretzky would not confirm that the company has retained the VTG technology that was developed for the diesel V10. ‘It has a turbo, and that is all that I can tell you,’ said Baretzky. ‘The MGU-H is less of an influence in the design of the engine - it is more complex in terms of overall energy management in the car. You have an amount of energy then you have to use it, and if you waste it you are lost. You have to have the management to do

this, part of it by the driver, and some by the electronics. I am optimistic that the influence of the driver will be important.

‘The engine design methodology has not changed at all because it was always part of our job to run the engine efficiently. The only thing that has changed is the proportion - only economy or only power - and it has moved more towards economy. You have less quantities of pure performance in the lap than before to take the efficiency and to use the energy, because the energy is still used by the combustion engine, and nothing else.’

The engines have been testing on the bench, but so far

the manufacturers have yet to sample the latest ultrasonic fuel flow sensor. Gill Sensors has released its new fuel flow meter, and was scheduled to deliver them to the teams before the end of 2013. Previous sensors tested during the year were rumoured to be inaccurate by up to 10 per cent, far shy of the 0.25 per cent target set by the FIA, although it's expected that the new meter will reach this.

ENERGY RECOVERY

Audi continues with the flywheel system that is built for them by Williams, but there are two sources of input energy, one from the MGU-K from a single motor

at the front (compared to a dual motor system in 2012 and 2013), and one from an MGU-H, which works with the turbo.

'If you go to battery, you have far more energy there,' says Audi Sport leader of electronic systems, Thomas Laudenbach. 'A flywheel is very good at power, but the amount of energy is less, and in terms of the solution for what we need, this is the lightest one. I am not saying that the flywheel is the best solution, but for what we need and what we know so far, it is the lightest. Nobody would build one into a road car - it has different demands. We are looking at it, and at other solutions, but for



Larger crash structures are required in the new regulations, and in the case of the new R18, this extends beyond the end of the rear bodywork

HYBRID DEVELOPMENT

Thomas Laudenbach left his position at Porsche's head of powertrain and took up the job of heading up a new department within Audi to develop the hybrid system and its efficiency. His arrival was welcomed by the head of Audi's engine programme, Ulrich Baretzky, who famously dislikes electronics in any form.

Laudenbach was appointed to his post early in 2013, and believes that the regulations have been formed in such a way that the development of the new generation R18 will benefit the production car team.

'In general, we are always looking at the road cars,' says Laudenbach. 'That is where it starts, so the road cars we have the issue with CO2, that is not a new story and manufacturers are working on all sorts of solutions, and a very big area is electricity in a road car.'

'We're coming from a plug-in hybrid to an electric range, and racing has taken that challenge on, promoting technology. A racecar is used in a different way to a road car, but you still have a conjunction between the two. Then you look at the rules, and there is a clear tendency towards everything becoming too expensive, so we have to restrict. Not in the new technologies, but we restrict a lot of other things that we've had in the cars for many years, because the steps are not that big, and in general

they leave it open for all sorts of hybrid systems. This is an area that is growing, and the opportunities are great.

'If you look at the R18, it is integrated. For nearly 100 years, the driver was used to one source of power - the internal combustion engine. Now they have two or even more, but you still have one pedal so someone else has to take over the coordination of the power sources in an efficient way. The driver can't do it, or they would need two or three pedals. Since we have more than one power source in the car, you have to use it in the most intelligent and efficient way. Before it was more intelligent in power density and from 2014 on it is intelligent in efficiency - and there you need a lot of electronic control systems.'

'Now the work powertrain becomes a complete new definition because it is extremely complex system of various components, ICE, gearbox and some power sources, and obviously the units where the energy that they recuperate is stored. That makes it complex. It needs to be efficient and lightweight, and it's more

complex than we had. Compared to other technologies, this is relatively new. The electric motor is new in the automotive application, so hopefully the steps will be great and that is the whole story. That is where you have to make efficiency.'

An efficient race powertrain is going to be a complex feature, as not only will it have to deliver precisely the correct amount of fuel per lap under normal racing conditions, it will also have to cope with such variables as weather and safety car periods.

'You have got a playground of strategy and you have to use the fuel in the most efficient way, says Laudenbach. 'We all know that the ICE has losses - the efficiency is below 50 per cent, and the hybrid is more.'

'The efficiency of a hybrid system doesn't matter because you cannot release more energy than the regulations allow. With the energy release, there are certain megajoule classes and you choose which one you want to be in, because that influences the amount of fuel that you can put in. You can harvest as much as you want, but you cannot release it.'

'Software is a main area of development because the various electric motors in the car cannot be controlled by a single pedal. You have so many different situations, like when it is raining for example. It will have to be a very intelligent system onboard. You have a certain amount of energy per lap, and we want to use that amount of energy spot on. We don't want to be five per cent down, because then you will lose a lot of lap time. To make sure that on every lap you use the right amount of fuel, a difference of one or two per cent will cost you tenths of a second in lap time.'

As the fleet production car CO2 emissions fall towards 2020, when the average needs to be less than 95g/km, efficiency is key. Why, then, does the new R18 continue to feature a flywheel rather than the batteries that are sold in the production hybrids? 'Something that relates to the road car, you have the intelligent handling of energy,' says Laudenbach.

'First of all the car has to be good at the races. We chose the best possibility for the race, and not that much in terms of components that can be transferred to the road car. Software, strategy, and with certain efficiencies, they can be transferred to the road car. The storage system is different, but there is still a lot of synergy.'

"For nearly 100 years, the driver was used to one source of power - the internal combustion engine. Now they have two, or even more"

Different manufacturers have different solutions to the shape of the cockpit, as per the new regulations - here's Audi's.



what we need now it is the best solution, from a technical point of view.

'We had to fit another system in, and we had to get the weight out of the car. The biggest challenge is that the diesel will always be heavier than gasoline, so we made the biggest effort to use the rules in a proper way. Last year we had to gain weight, but before I came here they worked on every little bit. I can't tell you how much they have had to take out. Last year's car there wasn't enough ballast to just take it out of the car, we had to look at everything - the engine, the gearbox, the structured parts, the monocoque, everywhere.'

There was a rumour that the car tested at Sebring without the MGU-H working, and both Reinke and Laudenbach were coy about it. 'It is the right way to go, but it is a tough way to go and we still have some months to go before Le Mans,' said Laudenbach, while Reinke added: 'In the last two years we've fully simulated the complete heat resources of the car, and we can be pretty exact. So far the testing hasn't been hampered by that. We have different variations of the car running at different tracks.'

Extra cooling has not been a major issue for the chassis designers, and Audi would not be drawn on how the system would be used. 'If you have an MGU in the exhaust system, you will always be in the situation to use it as energy recovery as a boost, but it costs you energy,' says Laudenbach. 'You can use it for an anti-lag if you have a problem

with it, because it is not the most efficient way of using it. As a first step, you would be happy if you don't need it.'

Final calibrations won't take place until the 36-hour tests planned for early next year before the final specification of the car is set.

'Normally you do one or two 36-hour tests, and everyone looks

at the hardware, but you have to do the same as the software,' says Laudenbach. 'We still have some time before Le Mans, and I want to have the software calibration at the last endurance runs.'

'The rules have changed. Last year we had an MGU with two electric motors on it, which would mean two systems. You can do it, but then you cannot do anything else. For the FIA they need a clear definition. This is one motor, one control unit.'

'The flywheel now exactly fulfils the demands which we have to comply with the new rules. Anything else would be stupid. It is the same principle - some components we took over. A hybrid system is a system, and if you have an MGU with a max power of 170kW, and a storage system capable of 100, you need to work out how much storage you need. You don't take more, because it is weight.'

So, Audi has presented its car, but has kept the final details under wraps.

Its first race, at Silverstone, will be the first indication as to what to expect for the year, but the development of this new technology is going to be fascinating.

LASER LIGHTS

Audi has had another stab at improving its light system on the new generation R18 and has introduced a laser light system in addition to the LEDs that have come to be an iconic feature of the car.

A blue laser beam backlights a yellow phosphorous crystal lens through which the light beam is then emitted. This new light source then provides even more homogenous lighting of the road.

The last time Audi introduced its super-bright lighting system, it blinded the GTE drivers and could have been a contributory factor in Mike Rockenfeller's accident in 2011.

'By using this new lighting technology, Audi is setting yet another milestone at Le Mans,' said Dr Ulrich Hackenberg, member of the management Board for technical development of Audi AG. 'Laser light will also open up completely new possibilities for our production models in the future.'

'The new laser light is just one of numerous technical innovations featured by our new R18,' said head of Audi Motorsport Dr Wolfgang Ullrich. 'We're not going to reveal any more than that at this early stage, as in 2014 we're facing an extremely tough competition and a year full of challenges for Audi Sport.'