

BELOW Bright future: the debut of biobutanol in the ALMS showcased race technology that will one day find its way onto the highways



TOMORROW'S TECHNOLOGY PASSES ITS FIRST TEST

Alan Lis investigates a biofuel experiment that consolidated the lead the American Le Mans Series holds in the race towards cleaner fuel

WITH the announcement of a Green Challenge competition within its sportscar racing championship, the organisers of the American Le Mans Series moved to place their series in the forefront of environmentally friendly and sustainable motorsport in the USA. As a part of this process the use of E10 – 10% ethanol – fuel was mandated for all competitors and the use of other alternative fuels and green technologies was encouraged.

The most recent fruit borne of this initiative occurred at the 2009 Petit Le Mans when the Dyson Racing team became the first to use a fuel with a biobutanol element in an international race event. This was the result of work carried out by BP, Mazda Motorsport and its UK-based engine development partner AER.

In the 10-hour race at Road Atlanta a Dyson Racing Lola finished seventh in the overall classification and would have won the LMP2 category had it been eligible to score points in that class. Dyson also ran a car with the new fuel in the series finale at Laguna Seca, where it placed 14th.

BP has been working on the production and development of biobutanol for the past five years and proposed its use in a race fuel one year before it made its competition debut. The first manifestation of the project was the use of biobutanol fuel in the Mazda 6 pace cars used at the 2008 Petit Le Mans race.

EXISTING HARDWARE

"We proposed a fuel that we felt would be better than the existing race fuels and would also work with the existing hardware," says BP vice-president Tim Hayes. "We weren't looking to make a radical step, rather to provide a relevant fuel that would perform better given the ALMS requirements of power and endurance."

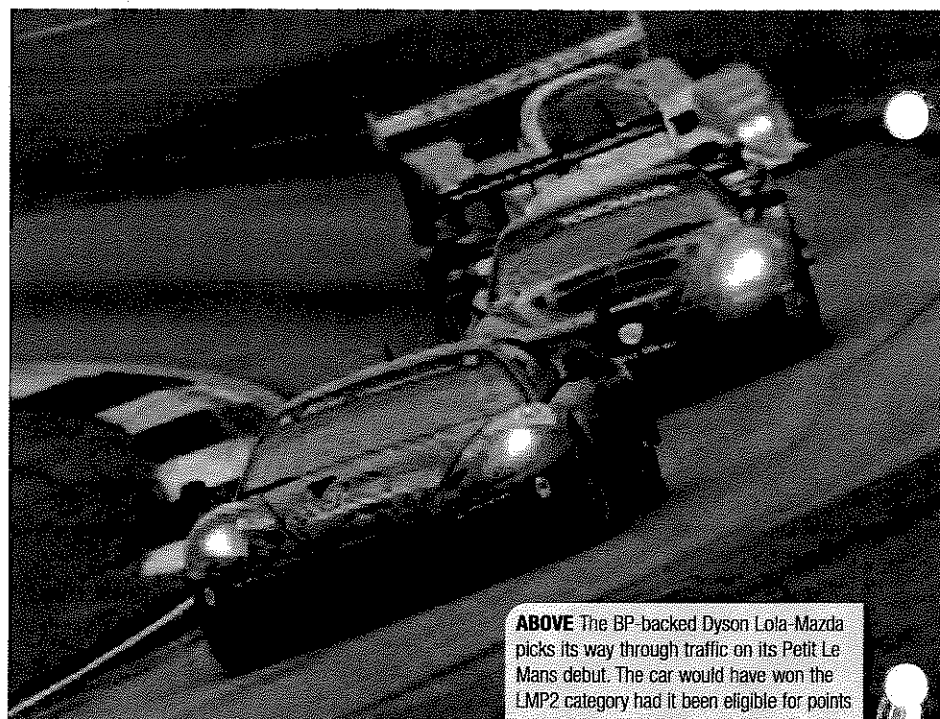
In the past a major drawback of alcohol fuels such as ethanol was their lower energy density relative to gasoline. In practical terms this meant lower fuel mileage and, in competition, the need to carry more fuel and/or make more refuelling stops. In the case of biobutanol, its energy density is 85-90% of gasoline – ethanol by comparison has 63% of the energy content of gasoline. Butanol also has a further advantage in that while alcohol fuels such as ethanol and methanol readily attract water and when mixed in that way become highly corrosive, butanol is not prone to

attracting water. This makes it much more compatible with elastomers and metals, thus avoiding the need for changes to engine and fuel system hardware.

The recent upsurge in production of alcohol fuels, due to spiking fossil fuel prices, has run into opposition from the green lobby over the use of food crops for their manufacture. Biobutanol is made in a similar fashion to ethanol and can be sourced from raw materials such as corn grain and sugar cane but its 'greenness' can be enhanced by sustainable raw materials used for its manufacture and the

and energy grass. When we use those materials to produce biobutanol it actually creates a smaller carbon footprint than you would get from the gasoline or standard ethanol production processes," says Hayes.

"BP has a policy that our biofuels come from sustainable sources that don't endanger either virgin forests or displace food crops. We have also invested heavily in sugarcane production in Brazil, which is highly sustainable. Butanol can be made from any source material that you can make ethanol from. We have made a conscious effort to pursue the use of non-



ABOVE The BP-backed Dyson Lola-Mazda picks its way through traffic on its Petit Le Mans debut. The car would have won the LMP2 category had it been eligible for points

“The feedback was that the engine felt smoother across the entire power band”

method of production. "In the future we expect biobutanol to be a much cleaner fuel to produce than gasoline or grain ethanol," says Hayes.

To this end BP has invested heavily in planting crops to make the lignocellulosic materials used to produce ethanol and ultimately biobutanol. According to BP these crops actually have a negative carbon footprint because they take carbon from the air and sequester it back into the ground. "The lignocellulosic sources are either crop waste or purposely grown woody material plants such as switchgrass

food feedstocks with our biofuel programmes for commercial use."

Determining the percentage of alcohol in a blend is an important consideration in the development of new eco-friendly fuels for use both on the road and the racetrack. "Our experience is that in hot and cold climates you need a range of boiling point molecular weights in the fuel: some light ends that help with starting on a cold morning and heavy ends that will avoid vapour lock on a hot day," says Hayes.

BP's expectation is that biobutanol would probably always be mixed with gasoline ►

rather than used as a pure component. At the present time the range of blend percentages at which it could operate in a car is still open for investigation and discussion. Ethanol can be run in concentrations anywhere from E10 to E85, where the 15% gasoline element allows starting on a cold day. A lot of that is driven

biobutanol, ethanol and gasoline," says Hayes. "We were looking for a fuel that would work well with a small displacement turbocharged engine because we believe that – based on feedback from a number of OEMs – the global marketplace for gasoline engines is moving in that direction. Roughly speaking, the fuel used in the

biobutanol we can blend more of it into our fuels for road cars. We have tested blends of up to 20% with good results." So what advantages does biobutanol offer in a motorsport application?

ADVANTAGES

"The ALMS being an endurance racing series places importance on fuel economy as well as power," says Hayes. "As biobutanol has a much higher energy content than ethanol it's possible to go much further on a gallon of biobutanol than a gallon of ethanol. It also has a relatively high octane rating which helps with power production in a small displacement engine, such as the Mazda MZRR."

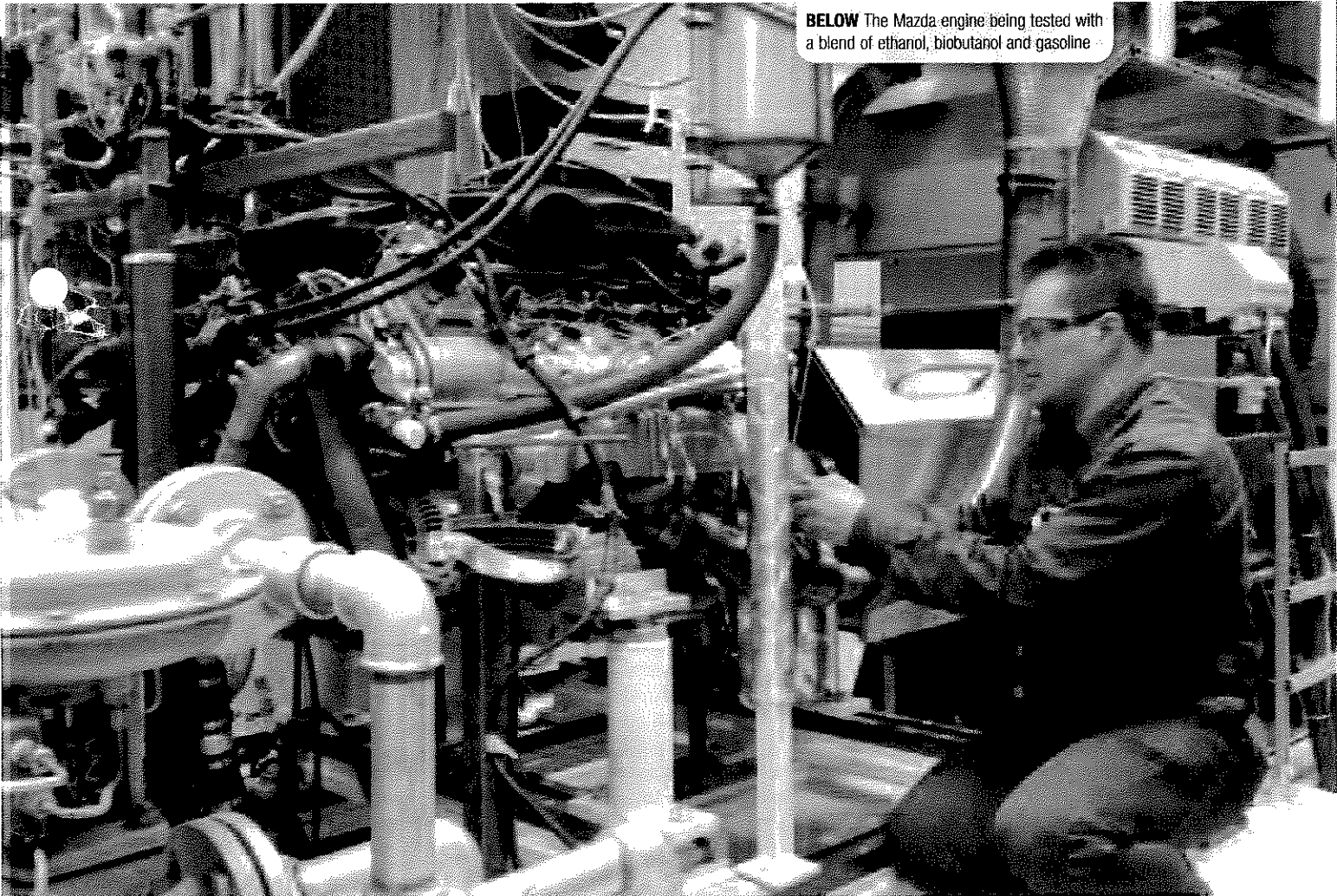
"The advantages we found with the fuel were almost immediate," says Mazda Motorsport's John Doonan. "At the very first test of a fuel with a biobutanol element the drivers were commenting very favourably on the driveability, in particular coming out of corners. There were ▶

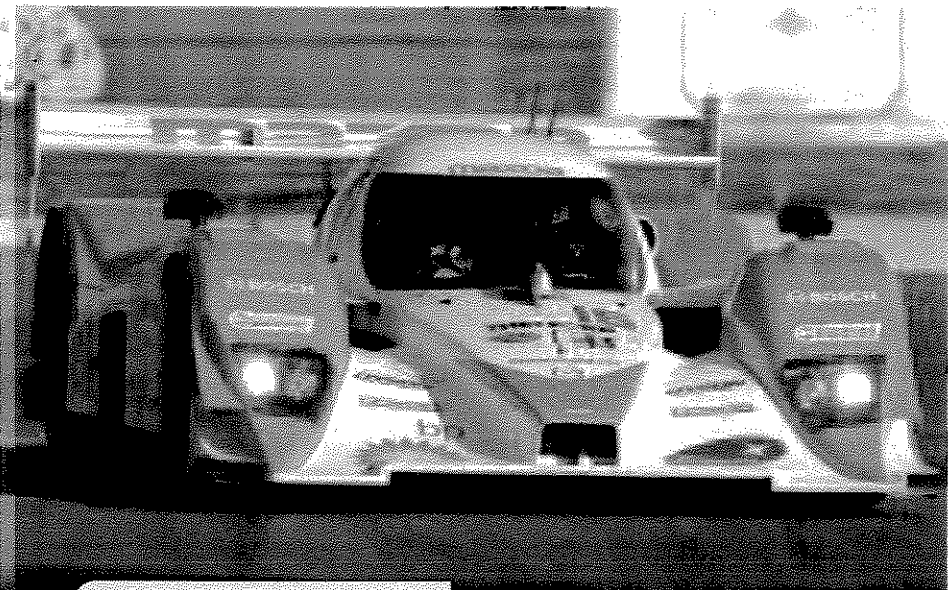
“ We expect biobutanol to be a much cleaner fuel to produce than gasoline or grain ethanol ”

by the calibration on the engine and the materials compatibility of the fuel tank and engine components as well as the materials compatibility of the fuelling infrastructure such as the ground tanks and dispensers. As the project is still very much a work in progress, BP is not willing to go into specifics on the blend percentage of biobutanol used in the ALMS races. "The fuel we used in those races was a blend of

ALMS races contained about 20% oxygenates (biobutanol/ethanol)." That's the same blend percentage of biobutanol that BP is currently looking at for broader transportation fuels. BP's Tom Mueller explains: "Today we blend about 10% ethanol with gasoline but there are challenges. There is a blend 'wall' with ethanol because of the corrosivity issue. Because there isn't that problem with

BELOW The Mazda engine being tested with a blend of ethanol, biobutanol and gasoline





ABOVE No official classification but the exercise did collect valuable data that will be used to determine the future of the project

noticeable and smooth power increases across the entire power band and looking down the borescope after testing the engines looked cleaner than we had experienced previously. We also achieved good mileage figures.

"Of course a lot of optimisation work still needs to be done so what you saw at Petit Le Mans and Laguna Seca was really just further testing, albeit under race

conditions. The initial feedback was that the engine felt much smoother across the power band. Ideally you want to optimise your ignition across the full engine map; this fuel gave us some hints that we are going to be able to do that.

"Working with BP and the ALMS we have been able to dip our toe in the water of a new opportunity of sustainability and add that to our Zoom Zoom philosophy."

Biobutanol is not currently approved for use in the ALMS, which is why the car which raced at the Petit Le Mans and Laguna Seca was not eligible to score points in the LMP2 class. BP and Mazda Motorsport have still to decide on the future of the biobutanol project. "The ALMS has given us the criteria and the steps we need to take to get it approved," says Doonan. "We are still in discussion with BP about what we would like to do. We are comfortable with how the tests went but it's something we need to continue to discuss."

SHOWCASE

"Having run the two races we have a significant amount of data which we are now poring over as part of that process of deciding where we go from here," says Hayes. "We have been very pleased with the working relationships we have enjoyed with Mazda and the Dyson Racing team and with the opportunity we have had to showcase biobutanol in the ALMS.

"We are planning to continue the project into 2010 but at this moment in time we haven't yet committed to doing that. If we think we can make a difference and be very productive with biobutanol, it's something we would certainly like to do." **RT**

BUTANOL'S RENAISSANCE

BUTANOL is a primary alcohol in which each molecule contains four carbon atoms – twice as many as in ethanol. This results in a 25% increase in harvestable energy relative to ethanol, making it attractive as a potential automotive fuel. This is further enhanced by the fact that when burnt in an internal combustion engine butanol generates only carbon dioxide and no SOX, NOX or carbon monoxide emissions.

Butanol naturally occurs in the production of alcoholic drinks such as beer, brandy, whisky and wine. Like ethanol and other alcohols, butanol can be produced by fermentation from a variety of source materials, including corn, grass, agricultural waste and other types of biomass. Produced by this method it is possible to manufacture butanol with effectively a negative carbon footprint.

The industrial production of butanol dates back to World War One when it was generated as a by-product in the fermentation process used to manufacture acetone, which was used in the production of

cordite for the munitions industry. The process generated twice as much butanol as acetone and in the 1920s this excess found a use as a constituent in paint for the automotive industry among other applications. By the 1950s the production of fermented butanol and acetone had ceased as production using petrochemicals had proved more economically viable.

Butanol is used in the manufacture of perfumes, antibiotics, hormones and vitamins. Other applications include the manufacture of natural and synthetic resins, dyes, degreasing agents, brake fluid and wood treatments.

In recent years fermented butanol has undergone a renaissance as a potential automotive fuel. In June 2006 BP and DuPont formed a partnership to develop new biobutanol production technology using lignocellulosic feedstocks and in July 2009 the partnership took over the US company Biobutanol LLC.

"BP has invested \$500 million over a 10-year period in an energy biosciences institute

in the USA to understand future technology," says Tim Hayes.

"We made a statement at that time that ethanol probably wasn't the sole biofuel solution for gasoline-powered engines. BP has invested heavily in sugar cane production in Brazil, in lignocellulosic ethanol production in Louisiana, and energy grass production in Florida. It's clear that BP views biofuels as a viable component of personal mobility in the future.

"Like hydrocarbons and everything that came before them, there will be better technology solutions and we need to continue to invest in this to find appropriate choices and solutions. Butanol has been around for quite a while but I think biobutanol is very new in terms of its production from renewable materials. There is no commercial biobutanol production facility in the world at this moment in time but BP is working with DuPont on developing commercial scale technology to be able to roll out that capability around the world. It's cutting edge stuff right now." **RT**