



LOTUS
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Q&A with Jaguar Land Rover's Bob Joyce

Extending the reach of bioethanol through "invisible" blends of methanol, ethanol, and gasoline

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There is always plenty of interesting activity in the Lotus Engineering research and development groups but at the moment it seems to be a particularly important time.

Our Omnivore engine has been testing for a few months and the early results are highly encouraging, showing again that the typically Lotus approach of tackling a problem from a different direction is again paying dividends. Not only is Omnivore achieving CO₂ and emission results significantly better than the best gasoline engines in the marketplace, it is operating in HCCI over a wide operating range. This is something that the industry has been chasing for a while – Omnivore is achieving it, even starting the engine from cold!

This issue, we look in detail at two further aspects of our R&D. Firstly, our extensive study into alcohol fuels is continuing to break new ground. Jamie Turner explains how methanol can be blended

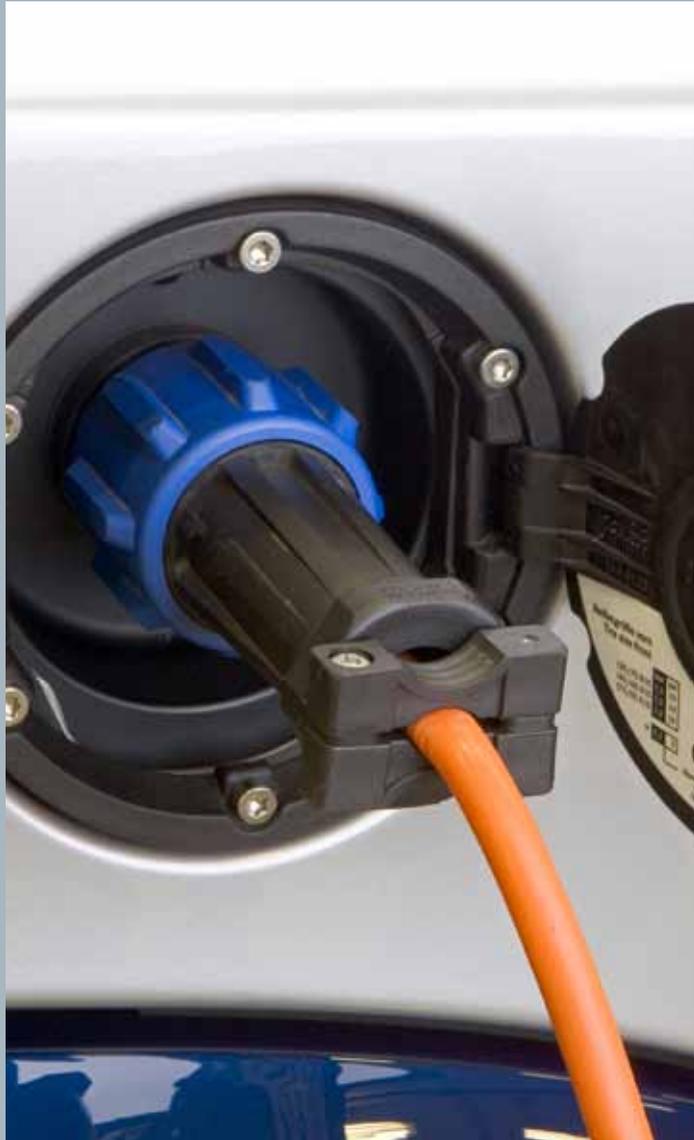
with ethanol and gasoline to create new fuel blends cheaper than E85 that not only reduce CO₂ emissions, but are compatible with the current 6 million flex-fuel vehicles already in the market place. Some major fuel producers are already taking note.

Secondly, power management is a key challenge on many of the hybrid and electric vehicles we undertake. Leon Rosario takes an in-depth look at one approach being applied, the use of ultracapacitors to augment the battery pack.

So some quite complex subjects this issue, but the technical detail behind new technologies and new ideas is where Lotus Engineering excels, so no apologies for that. I hope you find it interesting.

Peter Morgan

Marketing Manager – Lotus Engineering



UK: Electric cars get tax breaks

As expected, the UK government has announced significant tax breaks for electric cars as part of the Chancellor's annual pre-Budget report. The measures are designed to encourage company fleets to opt for more EVs.

From the start of the next fiscal year, in April 2010, electric cars and vans are to receive a five-year holiday from benefit-in-kind personal taxation – which is currently levied at 9% of the value of the vehicle in the case of electric cars.

In the UK, employees pay income tax on cars, based on the cost of company cars and their CO₂ emissions. The range varies from 9% for electric cars to between 10% and 35% for fossil fuel consuming cars.

“To help boost the number of electric cars on our streets, I have decided to exempt them from company car tax for five years,” said the Chancellor, Alistair Darling.

“And I can also announce a 100% first-year capital allowance for electric vans.”

The measures have been generally welcomed by the auto industry.

The SMMT said that it is “pleased that chancellor Alistair Darling has announced investment and support for low-carbon technologies, with particular assistance to boost demand for electric vehicles”.

SMMT chief executive, Paul Everitt said: “2010 is set to be another extremely difficult year for the UK

motor industry as increased VAT and first-year VED rates directly impact on consumer demand. The opportunity is to take advantage of the transition to low-carbon vehicles, with new incentives for company car drivers and van buyers, as well as extra resources for collaborative research and development.”

John Lewis, chief executive of the British Vehicle Rental and Leasing Association, said: “These new measures will help speed up the mass-market adoption of sustainable road transport in Britain.”

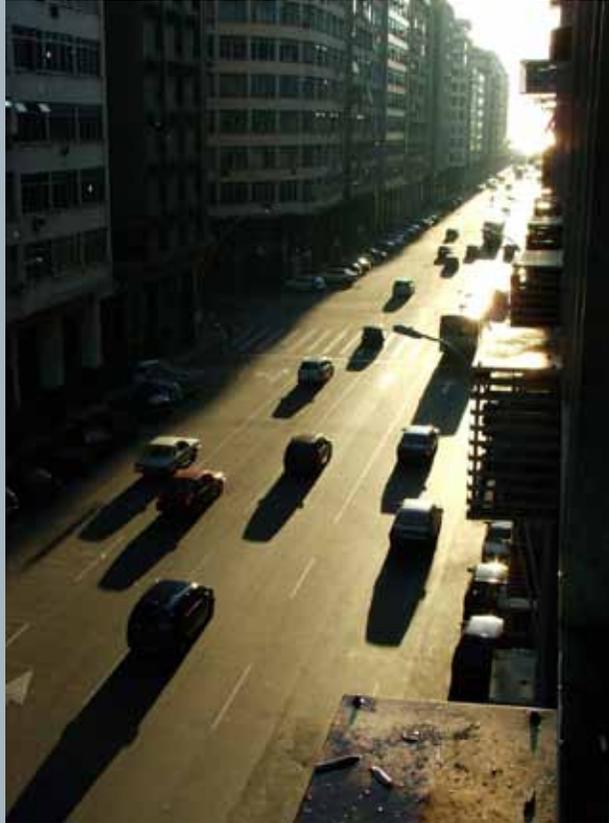
The Retail Motor Industry Federation (RMI) welcomed the move but noted that that “demand needs to be stimulated as this is a very small sector of the new car market”.

The incentive is designed to get more companies to put electric vehicles on to their fleets.

Earlier this year, the UK government also announced a financial incentive of up to GBP5,000 off the list price of a new electric car from 2011/12.

“These kinds of tax incentives are very important to nurture green innovation within the industry and develop a market for the cleanest forms of transport,” said Faye Sunderland of online green car guide, TheGreenCarWebsite.co.uk.

“Electric cars are not perfect, they have source CO₂ emissions. But with the support provided for renewable fuels and small-scale electricity production, electric cars will become cleaner over time,” she said.



It is estimated that over two-thirds of FFVs in Brazil run almost permanently on locally produced ethanol

BRAZIL: Tax changes prod importers towards FFVs

Brazil's federal government decided, late in November, to extend to 31 March, 2010 a cut in the excise tax on industrial products (IPI for short in Portuguese) which has boosted new vehicle sales this year. But there's one important change.

Now only flex-fuel (ethanol-petrol) vehicles will benefit from the current 3% tax rate on those with engines up to one-litre and 7.5% for one- to two-litre models.

Petrol-only cars will attract an 11% tax this month, rising to 13% in January (one to two-litre) and the tax will be 25% for cars with larger engines from January.

Finance minister Guido Mantega admitted the move was an environment-oriented bribe to boost flexible-fuel vehicle (FFV) sales.

It's hardly necessary. FFVs now account for almost 90% of the Brazilian market and it is estimated that over two-thirds of these run almost permanently on locally produced ethanol.

In the last three months, biofuel consumption may have fallen due to a seasonal price hike of over

30% triggered largely by the international sugar price.

CO₂ emissions by a FFV running on sugar cane is only about 30g/km (a quarter of the petrol average and the current European target).

Studies have shown that about 85% of primary CO₂ emissions are absorbed by cane plants' photosynthesis process, included the greenhouse gases emitted when planting, processing and freighting.

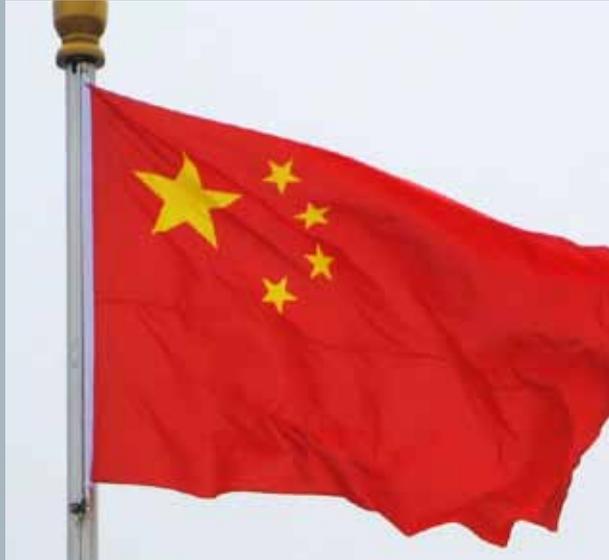
Consequently, the Government's latest tax decision is also seen here as an indirect way of reducing assembled car imports, especially from Europe, South Korea, Japan and China. All these are petrol-only.

However, there have been hints import-only brands have FFVs in the works. After all, none would be willing to stay out of a market that might absorb 4m units annually in four or five years from now.

Source: just-auto.com editorial team



Sugar cane earmarked for ethanol production grows in Brazilian sunshine



CHINA: Vehicle sales 50% ahead this year

Passenger vehicle sales in China almost doubled year-on-year in November, up 98.2% to 1.04m vehicles, according to the China Association of Automobile Manufacturers.

The result puts China on course to realise 50% growth in its car market this year, fuelled by government incentives. The November 2009 tally compared with 522,800 units in November 2008 and 946,400 units sold last October.

China's new vehicle market overtook the United States as the world's largest earlier this year and, in the first 11 months, 9.23m passenger cars were sold in the country, up 49.7% from a year earlier, exceeding the 6.76m sold in calendar 2008.

Overall vehicle sales, including trucks and buses, jumped 96.4% year-on-year in November to 1.34m units, the association said, after gaining 72.5% in October.

Analysts expect the market to slow next year if the government opts not to renew sales incentives and tax cuts which expire at the end of this month.

But there are signs that Beijing may continue its efforts to boost domestic consumption, including automobiles.

According to a recent report by the *Shanghai Securities News*, the Government will continue to support its auto industry next year with more aggressive measures including sales tax cuts that will apply to all passenger cars, not just to cars with a 1.6 litre or smaller engine. Smaller cars or those with lower fuel emission levels will enjoy deeper tax cuts, it said.

Among individual producers, General Motors more than doubled its China sales to 177,339 vehicles in November, continuing its string of monthly sales records since the beginning of the year.

Shanghai Automotive Industries Corp, China's top vehicle producer, sold 252,190 vehicles, up 91% year-on-year.

Source: just-auto.com editorial team

US: GM spends US\$336m to build Chevy Volt

General Motors said it would invest US\$336m in its Detroit-Hamtramck assembly plant to begin production of the Chevrolet Volt electric car, with extended-range capabilities, in 2010. Initially, the plant will also build Opel/Vauxhall Ampera variants for Europe although production of those is expected eventually to shift across the Atlantic.

Possibly to the Vauxhall plant in Ellesmere Port, northwest England, though a final decision has not been made.

This brings GM's combined Volt-related investments in Michigan to US\$700m, over eight facilities. Detroit-Hamtramck will be the final assembly location for the Volt, using tooling from



Grand Blanc, lithium-ion batteries from GM's Brownstown Township battery pack manufacturing facility, camshafts and connecting rods from Bay City, and stampings and, eventually, the Volt's 1.4-litre engine-generator from Flint (initial supplies will be imported).

"We expect the Detroit-Hamtramck plant will be the first facility in the US owned by a major automaker to produce an electric car. It is the hub for the wheel that we began rolling in 2007 when the Volt debuted at the [Detroit motor show]," said GM vice president of global product planning Jon Lauckner.

"Since then, the field of challengers and partners has grown significantly. This competition will expedite the development of electric vehicle technology and infrastructure."

After the Volt's debut in January 2007, other automakers announced six plug-in hybrid or electric vehicles later that year, followed by 19 introductions in 2008 and five more this year.

In addition to GM's US\$700m in Volt-related facility investments, there are the many suppliers, utility companies and organisations investing in Michigan and the US to support Volt production and electric vehicle development. In August, the US Department of Energy selected 45 companies,

universities and organisations in 28 states for more than US\$2bn in awards for electric drive and battery manufacturing and transportation electrification.

To reduce cost and maximise flexible manufacturing techniques, some equipment for Volt production is being reused from other GM facilities and installed in the Detroit-Hamtramck plant's body shop. The car will be built on the existing assembly line at Detroit-Hamtramck. Assembly of prototype vehicles will begin in the spring, with the start of regular production scheduled for late 2010.

Detroit-Hamtramck opened in 1985, and currently employs about 1,200 workers, including 1,100 hourly workers represented by United Auto Workers (UAW) Local 22.

The Volt is an electric vehicle with extended-range capability. It is designed to drive up to 40 miles (60km) on electricity without using petrol or producing tailpipe emissions. When the lithium-ion battery runs out, an engine/generator seamlessly operates to extend the total driving range to about 300 miles (500km) before refuelling or stopping to recharge the battery. Pricing has not been announced.

Source: just-auto.com editorial team



Two Amperas, with the test mule on the right



Corsini smiles for the camera

UK: Opel Ampera “on track” for late 2011 SOP

GM’s director for its European electric vehicle implementation has told *just-auto* that the development schedule for its Opel/Vauxhall Ampera extended-range electric vehicle (E-REV - the same technology as that being employed for the Chevrolet Volt) is on track.

“Everything has gone according to plan,” said Gherardo Corsini.

Production of the Opel Ampera for Left-Hand Drive (LHD) European markets is slated to start in late 2011. Right-Hand Drive (RHD) Vauxhall-badged versions for the UK market are due to start production at the beginning of 2012.

“We are on course for the final testing and validation of prototypes to take place in 2010,” Corsini said.

Opel engineers have installed the Ampera’s “Voltec” electric propulsion system - including the battery, motor, engine and electric-generator - inside the body of an existing production car (a Chevrolet Cruze - the same size as the Astra). They call this kind of development car a “mule” because, like its namesake animals, the mules are a mixture of two species. Mule cars helps engineers test technology at an early stage of vehicle development.

Specifically, engineers in Russelsheim are testing the Voltec system’s performance and the overall driving impression. In addition, engineers in Mainz-Kastel have developed and are further testing the lithium-ion battery.

The Ampera is being developed in three distinct phases. The first stage involves the engineering development vehicles, which are used to analyse the behaviour of specific subsystems and get them to work together. These are not complete vehicle tests but work to prove individual subsystems.

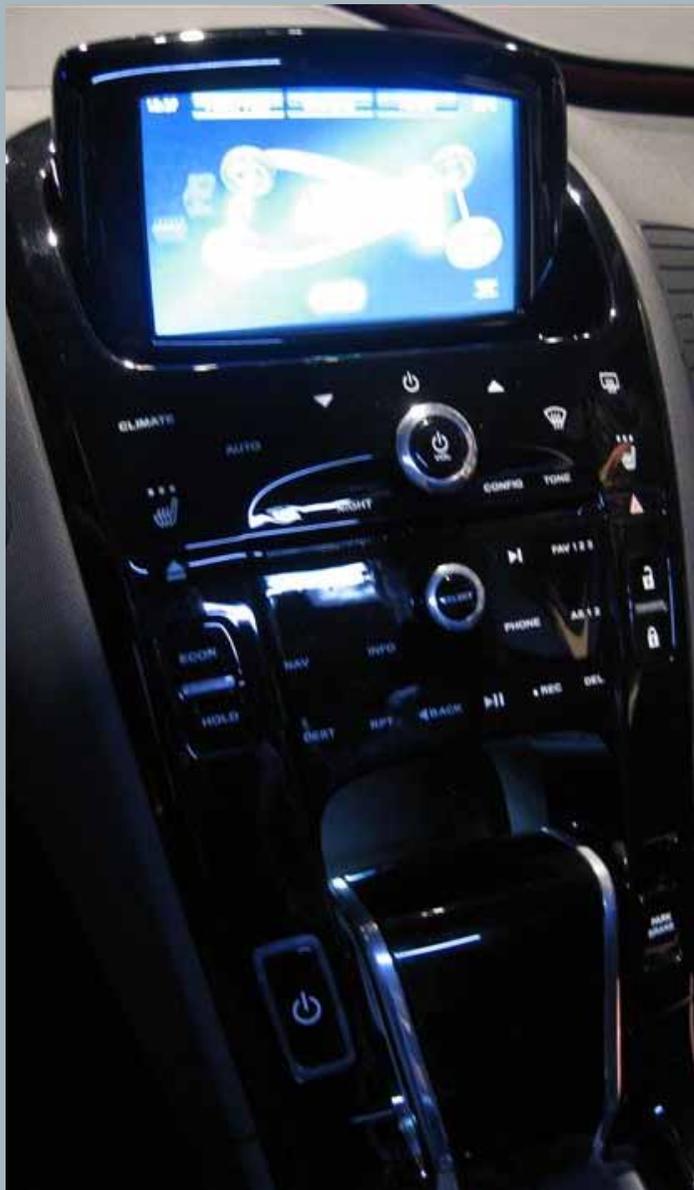
In the next phase, integration cars are built with all of the systems coming together. They contain a lot of hand-built parts, but are “design intent”. In the final development stage cars look and operate for all intents and purposes nearly exactly the same as the production cars. This phase brings everything together. All the final aero- and wind tunnel work can be done with them. They are the last phase before production.

Corsini is upbeat about the impact the car will have in the market.

“This is an exciting and innovative solution in providing mobility for the future,” he says.

“And we are taking electric vehicle mobility beyond the niche to offer it in a full-size four-door sedan rather than simply a city car - we can achieve that in our package because the extended range offered in the package we have developed provides an attractive mobility solution at lower cost [per distance travelled] and better performance than a pure electric vehicle can.”

Corsini emphasises the significance of the Ampera being able to appeal to households as the “main” car.



Ampera centre console will be close to this, with touch buttons that don't depress

“The Ampera is a practical, electric four-seater, with cargo space and the capability to be the first automobile in the household,” Corsini says.

Unlike a conventional battery-electric vehicle, the Ampera eliminates “range anxiety” (the range is 60km/40 miles “unassisted” on a full battery charge) because the battery can be charged via an on-board engine - a 1.4-litre unit. The engine acts as a generator and does not drive the wheels - unlike, say, the set-up in a Toyota Prius “parallel” hybrid that has two powertrains; range-extenders in which the electric motor always drives the wheels are also known as “series hybrids”.

When the battery’s energy is low, electricity from the engine-generator extends the Ampera’s range to more than 500km/340 miles. A gasoline/E85-fuelled engine-generator seamlessly provides electricity to power the electric drive unit while simultaneously sustaining the charge of the battery.

This mode of operation extends the range to 500km until the battery can be charged by plugging the vehicle’s on-board charge system into a standard household 230V/13A outlet.

Here’s a big question. How long does it take to fully charge the battery? GM says just three hours. Yes folks, three hours on a regular 13A socket at 230V; no need for a fancy booster to get a “fast charge”. Forty miles on a three-hour charge time sounds remarkably good.

Opel estimates that an electrically driven kilometre in the Ampera will cost about one-fifth compared to a conventional gasoline vehicle at current

fuel prices. Corsini told UK journalists that a full charge from “empty” will cost about GBP0.80 in electricity used.

The Ampera will initially be made in the US alongside the Volt at a dedicated facility where GM is concentrating production for its high-tech range-extenders. The cheap dollar and the high cost of the new technology may well mean that GM is in no hurry to migrate Ampera production to Europe. But much could depend on how governments approach incentives. Indeed, the UK government has made little secret of the fact that it would like to see Ampera production eventually taking place at Vauxhall’s Ellesmere Port plant that currently makes the Astra.

Another big question is how much will this car cost the customer to buy? Again, the potential role of government incentives to kick-start the market makes things fluid. But the high cost of this technology means that there will be a premium to pay and it will be bigger at the start. Volumes will be low to begin with. There are many demand- and supply-side factors and variables that will come into play in determining how quickly Ampera volume can rise and unit cost come down. Maybe bulk sales to fleets or leased batteries offer a way to progress more quickly to critical volume mass, but there is obviously a lot of uncertainty, still, about price-points (Carl-Peter Forster once told journalists EUR40,000) and how this car plays out in the market.

There is also the question of the rate at which battery charging infrastructure will develop for plug-ins more generally, calibrated to patterns



of use (workplace charging, for example) and numbers of plug-in vehicles actually on the road and projected to be.

Like the parallel hybrids that Toyota and others have developed, the “range-extender” (or series hybrid) addresses electric battery technology performance limitations that are proving stubborn to alleviate. We seem to be in the realm of slow incremental improvements to lithium-ion battery performance without a major technical breakthrough visible on the horizon.

Plug-in hybrid (or range-extender) charging takes the vehicle a step-closer to being “electric” because the car can be charged via the national grid without the need for hydrocarbons on short journeys. The fact that Toyota has now developed a plug-in Prius hybrid perhaps shows which way the wind is blowing (And let’s please leave the

ultimately thorny CO₂ issue of the juice that comes from the power station for another day...).

The engineers will no doubt argue over the technical merits of the different solutions to overcome range anxiety while delivering acceptably lower CO₂ and higher efficiency per mile. Toyota has put a lot of investment into its hybrids and has had a measure of success in delivering a low CO₂ solution that is both proven and practical.

However, one potentially highly significant data metric is this. The Ampera/Volt will get you 40 miles (about 65km) on pure electric drive after a full battery charge, but Toyota’s new plug-in Prius will manage just 13 miles (21km). GM could be onto something.

Source: just-auto.com editorial team



Lotus appoints Director of Motorsport

Group Lotus is pleased to announce the appointment of Claudio Berro to the new role of Director of Motorsport for Lotus, reporting directly to Dany Bahar, Group Lotus CEO.

Prior to joining Lotus, Claudio Berro held the position of Operations Racing Director for the Speedcar Middle-East International Race Series. Before that, he spent 14 years at Ferrari, Maserati and Fiat where he held such positions as Formula One Team Manager, Director responsible for all sport activities for Ferrari and Maserati (excluding F1), General Manager Maserati Corse and Director of Fiat Group's Motorsport Activities, before becoming Racing Operations Director for Abarth.

Dany Bahar, Group Lotus CEO, welcomes Claudio Berro to Lotus, "I am delighted that Claudio is joining us as Director of Motorsport. He has a proven track record of not only setting up and managing the motorsports divisions within sportscar brands but also winning championships in GT racing and rallying. His skills will be very valuable as we look to return Lotus to high-level motorsport around the world."

Berro is excited about his new role and challenges, saying: "Lotus has a peerless motorsport heritage, not just in Formula One, but we have also won in sportscar racing, saloon car racing, world rally championships, Le Mans and the Indy 500. There is no other car company in the world which can lay claim to so many accolades and championships in such a wide variety of motorsport fields, and I am looking forward to re-introducing Lotus to high-level motorsport to not only compete and win but also to demonstrate the shared technology between Lotus sportscars and future racing cars."

This isn't the first time that Berro has been associated with Lotus, as early in his motorsport career, he was rally co-driver for Peugeot Talbot Italia in a Talbot Sunbeam Lotus, twice becoming Italian Group 2 Rally Champion in 1981 and 1982.

Claudio Berro joined Lotus on the 2 November 2009.

Source: Group Lotus



Lotus HQ and test track is now on Google Street View



The iconic British sports car manufacturer opens its doors for an exclusive behind-the-scenes tour of the site and a virtual-drive around the famous Lotus Test Track.

Lotus invited Google to record a testing session of selected Lotus cars and to give fans of the legendary British sports car brand a chance to look around normally hidden areas of the Lotus Headquarters in Hethel, Norfolk. On the Lotus test track, sharp eyed Street View users will spot the Lotus 2-Eleven being driven quickly and enthusiastically (just as it is intended to be!), a research and development Lotus Exige 265E which is fuelled by sustainable, environmentally friendly ethanol, and a number of prototypes of the new Lotus Evora.

Lotus has given Street View users an opportunity to look around part of the Lotus HQ and to virtually drive the Hethel Test Track. Only a select number of drivers have driven the Lotus circuit over the years, but now anyone can get a closer look at

where some of the most iconic British sports and racing cars have been tested and developed. To see some dynamic track driving of the Lotus 2-Eleven just check out the North Hairpin!

This is the first ever circuit in the UK to be photographed for Street View and car fans are going to love taking a virtual tour and locating their favourite Lotus cars in action on the track

The Street View of the Lotus Headquarters can be viewed here:

<http://3.ly/LotusCarFactoryGoogleStreetView>

Users can access street-level imagery of the Lotus site by zooming into the lowest level on Google Maps, or by dragging the orange "Pegman" icon on the left-hand side of the map onto a blue highlighted road such as the Lotus test track.

Source: Group Lotus



The Lotus force has a dark side revealed - the exclusive “Exige Scura”

Lotus Cars unveiled its latest special edition – the Exige Scura, so called due to its dramatic matt black and carbon fibre theme – at the Tokyo International Motorshow in October.

Translated as “dark” from Italian, the name “Scura” reflects the stealth character of this already fierce-looking Lotus and its stunning soft-feel matt black paint finish. Limited to just 35 cars globally, this Exige evokes a desire to “indulge your dark side”. This is a serious-looking car and enhancements to performance and a reduction in weight from the production-level Exige S means that the Exige Scura demands to be driven by a serious driver.

Contrasting high gloss “Phantom Black” triple stripes run the length of the car and a carbon fibre front splitter, oil cooler inlet vanes, side air scoops and rear spoiler enhance the stunning distinction between the different textures and exaggerate the tactile quality of the velvety touch to the matt black paint finish.

Continuing the dark “Scura” appearance into the interior, carbon fibre is used extensively to compliment the exterior theme and reduce weight. The seats and centre console are crafted from carbon fibre, and the handbrake and gear knob have a special anodised treatment which leaves the metal with an anthracite colour finish. All carbon fibre components have been beautifully finished in high-gloss clear lacquer allowing the weave to remain exposed which gives the cabin a raw and racy ambiance.

Whilst there is no doubt that this is a visually stunning car, the Exige Scura is not just about its looks – it begs to be taken on track, and its racing character encompasses poise, power and technology to make it a serious contender. Equipped with the most powerful engine in the Exige range and generating 260PS, the Exige Scura achieves a top speed of around 245kmh and reaches 0-100kmh in just 4.1 seconds.

Other equipment fitted as standard to boost the Exige Scura’s track credentials include:

- Launch control to ensure optimum performance from a standing start;
- Variable slip traction control, enabling the driver to tune the car to track surface conditions and their own driving style;
- Ohlins 2-way adjustable dampers for personalised ride and handling characteristics.

Source: Lotus Cars





Jacques Villeneuve visits Lotus

Jacques Villeneuve visited Lotus to drive the “it” car of the year and was treated to a snapshot of Lotus’ legendary story.

During a recent trip to catch up with old friends, Villeneuve spent a day at Group Lotus’ UK head quarters where the 1997 Formula 1 World Champion was presented with a chronicle of Lotus’ rich history, from its founding years with a tour of Colin Chapman’s first workshops, to a session in the firm’s latest offering, the award winning Evora, on Lotus’ own test track.

It was a rare chance for Clive Chapman (son of Lotus’ founder Colin Chapman) to share with Villeneuve some of his father’s much-loved projects and the two exchanged stories of the days they respectively shared with their fathers when they were competing in Formula 1.

It was a great moment for the Lotus workforce to see Villeneuve passing through the manufacturing facility, often stopping to take in the detail of the process and to pose for photos and autographs. Recently-appointed CEO of Group Lotus Dany Bahar was keen to stress the importance of this exciting visit saying: “Jacques’ visit is an honour

for Lotus and Lotus is a team. Our people are a blend of talent and expertise combined with passion for our brand. Our highlights are theirs, so this is a special day for us all.”

Villeneuve was delighted to have spent the day at the home of one of Britain’s most revered motorsport marques and commented: “It has been a great day for me to catch-up with my friend Gino Rosato in his new role at Lotus and to see where the magic of Lotus comes from. My first toy car as a child was a replica model of Emerson Fittipaldi’s Lotus 72, I could say his name before I could say my dad’s! I really enjoyed watching them racing when I was a boy. It has been a really fun trip for me, to see the people working to build the Evora was particularly nice.”

Following Villeneuve’s drive of the Evora he passed comment to the engineering team responsible for developing the car. Villeneuve, impressed with the performance of the car, concluded: “It’s a really nice car, fun and comfortable to drive.”

Source: Lotus Cars





Lotus Omnivore engine – 10% better fuel economy than current leading gasoline engines

The initial phase of Omnivore development has achieved a 10% improvement in fuel consumption compared to stratified direct injection engines, also with ultra low emissions. The research signals a potential paradigm shift with engine ‘upsizing’ for increased fuel economy.

The first testing phase of Lotus Engineering’s Omnivore variable compression ratio, flex-fuel direct injection two-stroke engine has been successfully completed on gasoline. In addition to exceptional fuel consumption results, the engine has successfully demonstrated homogenous charge compression ignition (HCCI) - where the engine operates without the need for the spark plug to ignite the fuel and air mixture in the cylinder - down to extremely light loads. Traditionally, this has been challenging but this combustion process results in ultra low emissions and has been achieved over a wide range of engine operating conditions, even from a cold start.

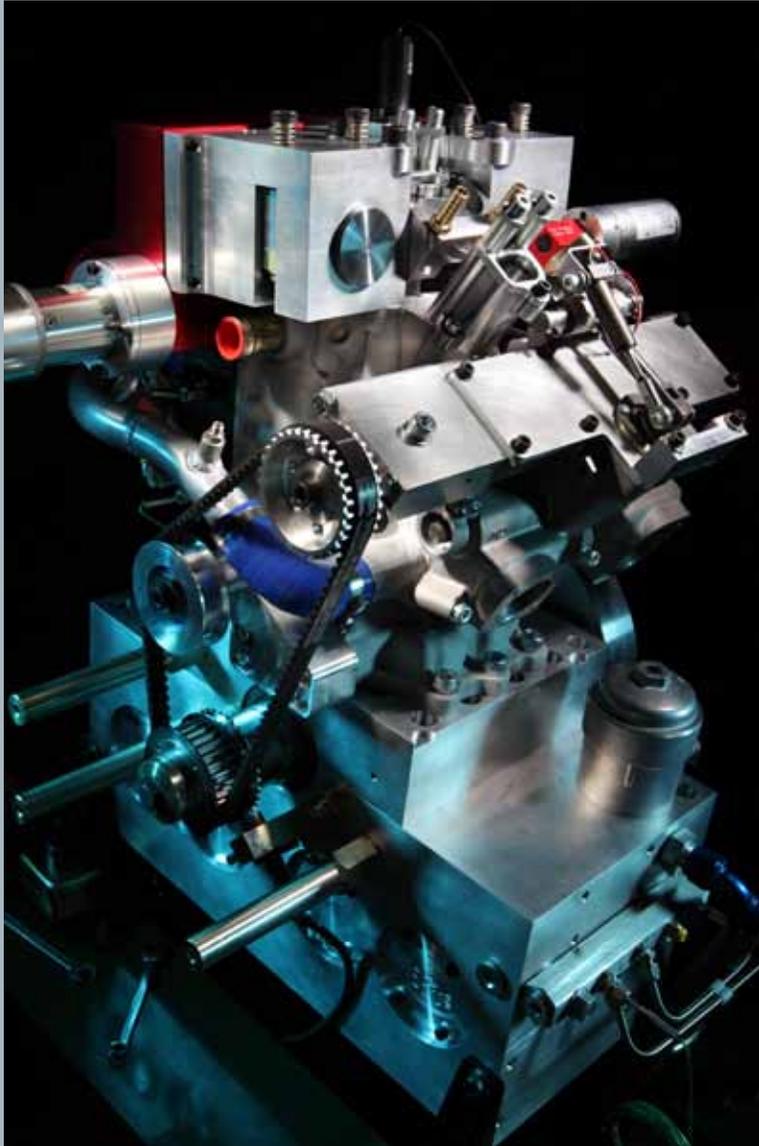
The detailed research has so far focused on lower speed and load conditions that represent a major proportion of an engine’s operation in a real world environment. At 2000rpm and up to approximately 2.7bar IMEP (indicated mean effective pressure), the ISFC (indicated specific fuel consumption) achieved is approximately 10% better than current spray-guided direct injection, spark ignition engines. Emissions results are an impressive 20ppm NO_x at less than 2.3bar load

and has four-stroke-equivalent hydrocarbons and carbon monoxide emissions.

The results represent an important step-forward in Lotus Engineering’s strategy of developing an array of more efficient multi-fuel combustion systems. Omnivore lays the foundations for a novel and pragmatic vision of a variable compression ratio engine concept suitable for production. A multi-cylinder version is practical for a wide variety of vehicles and offers the greatest benefit to C and D class passenger cars which can take advantage of the low cost architecture and significantly improved fuel economy and emissions. Lotus is continuing our discussions with other manufacturers and eagerly anticipate the development of multi-cylinder demonstrations of this revolutionary engine configuration.

The Omnivore engine concept achieves wide-range HCCI combustion and low CO₂ emissions through the application of a simple wide-range variable compression ratio mechanism, itself facilitated by the adoption of the two-stroke operating cycle. Technologies combined in this package are all synergistic and provide a route to the efficient use of alternative fuels, accelerating the displacement of fossil fuels.

Jamie Turner, Chief Engineer of Powertrain Research at Lotus Engineering, said: “The automotive industry, including Lotus Engineering, has quite rightly advocated engine downsizing for





Omnivore summary

The Omnivore engine concept features an innovative variable compression ratio system and uses a two-stroke operating cycle with direct fuel injection. It is ideally suited to flex-fuel operation with a higher degree of optimisation than is possible with existing four-stroke engines.

The engine concept features a monoblock construction that blends the cylinder head and block together eliminating the need for a cylinder head gasket, improving durability and reducing weight. In this case, the application of a monoblock is facilitated by the absence of the requirement for poppet valves.

A novel charge trapping valve in the exhaust port allows asymmetric timing of exhaust flow and continuous variation of the exhaust opening timing.

The Omnivore engine uses the Orbital FlexDI fuel injection system which produces fine in-cylinder fuel preparation irrespective of fuel type and, together with air pre-mixing, allows efficient two-stroke combustion and low-temperature starting, whilst offering a singular opportunity for advanced HCCI control.

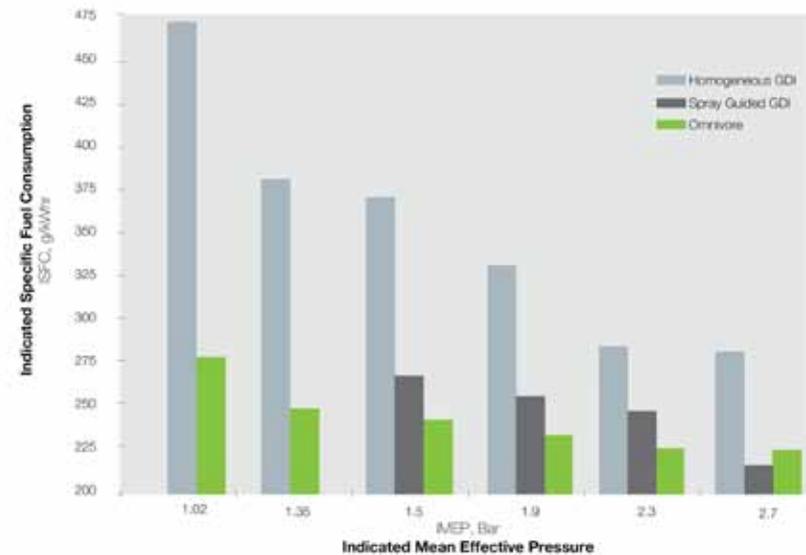
The variable compression ratio is achieved by the use of a puck at the top of the combustion chamber. This simple, yet effective system moves up and down effecting the change in geometric compression depending on the load demands on the engine.

four-stroke engines. This is as a result of the dominance of the four-stroke cycle in the automotive world and its generation of throttling losses at part-load, where vehicles run most of the time. The two-stroke cycle, conversely, does not suffer from significant throttling losses and in many ways is a more natural fit for automotive use. With the thermodynamic disadvantages of throttling losses removed, the two-stroke engine is free to be sized according to its improved part-load fuel consumption. Downsizing therefore isn't vital and, due to the improved light-load efficiency and emissions performance we see with Omnivore, this technology approach and "upsizing" could permit a more efficient engine."

The initial Omnivore programme has been in collaboration with Queen's University Belfast and Orbital Corporation Limited Australia, with sponsorship from DEFRA/DECC and DOE NI through the Renewables Materials LINK programme. Future work by Lotus Engineering will concentrate on further investigating the operation on gasoline and alternative renewable fuels such as ethanol and methanol, with more in-depth analysis of specific test points.

Source: Lotus Engineering

Lotus Omnivore Engine
Comparison Graph - 2000rpm



Hybrid energy storage systems for electric vehicles – augmenting batteries with ultracapacitors

Recent progress in electric and hybrid electric vehicles (EV and HEV) has contributed to a new era in automobile technology. It is expected in the next five to ten years, pure electric vehicles will start to penetrate the market as they deliver similar functionality of fossil fuel vehicles but at a higher energy economy and lower emissions footprint. As transportation systems continue to be a vital link in the economic chain of modern societies, private automobile appears to be the system of choice. Now, after more than a century since their first introduction, and decades since they were forced into near oblivion, electric vehicles have regained a strong global presence. Industry efforts, coupled with paradigm shifts in transportation perspectives, provide substantial grounds for development efforts in this arena.

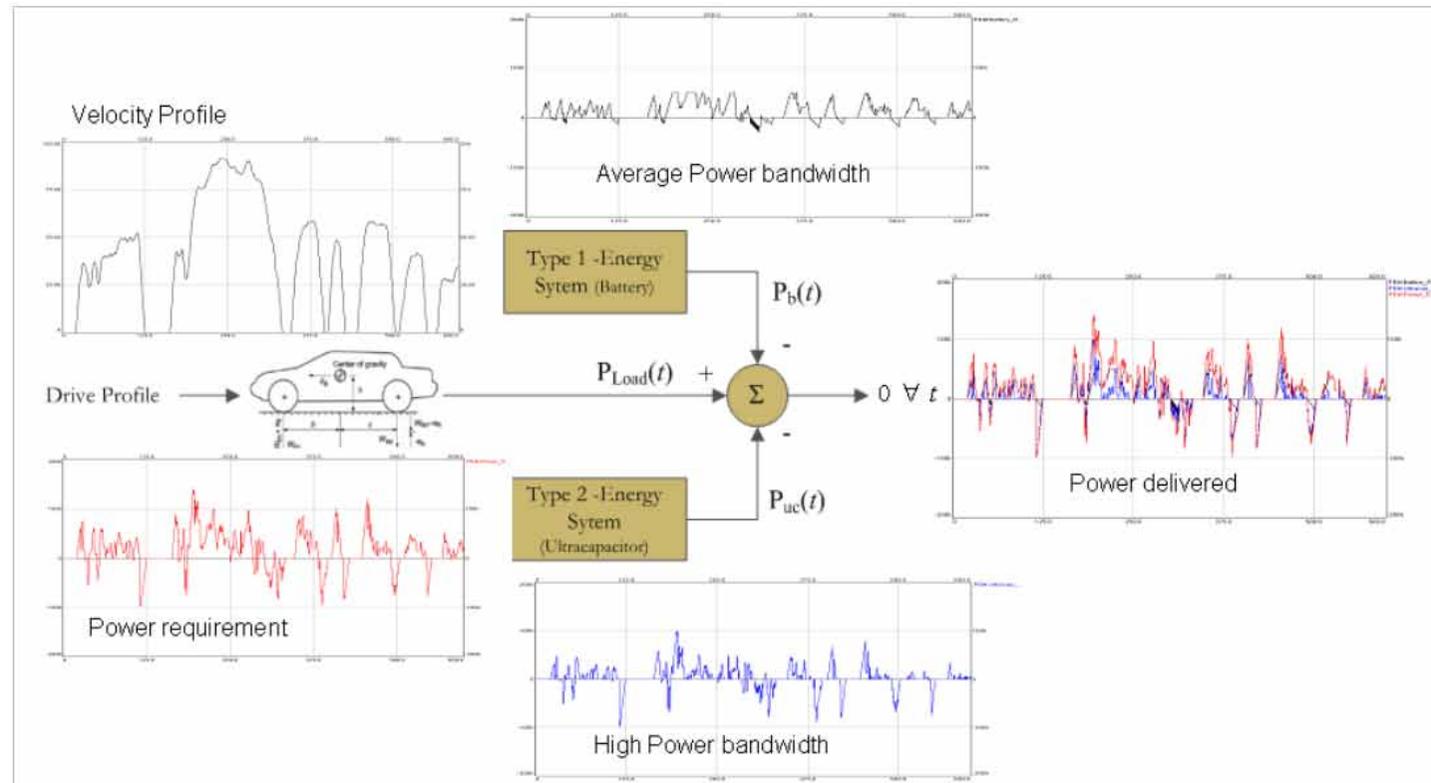
Electrical loads for both traction and ancillary loads are expected to increase as the automotive power system architecture shifts towards a more silicon-rich environment. The complex demand profiles anticipated by these dynamic loads require accurate and optimised control of power flow and energy storage subsystems within the vehicle. This presents a technical challenge and an opportunity for vehicular power and energy management research.

Onboard energy storage systems in pure EVs are relatively limited in capacity. However, from a user perspective, it is essential that the power requests from all electric loads within the vehicle power systems are met on demand. Conversely, with the present limitation of electro-chemical energy storage systems, it is impractical and cost-prohibitive to size a single energy storage unit to offer continuous power capacity many times higher than the average power

demand just to meet momentary peaks in power needs. For this reason, employing multiple onboard energy systems that are specialised or power-banded for the various segments within a vehicular power demand bandwidth becomes a viable proposition.

In the illustration below, an electric vehicle with a battery as the primary energy storage system is augmented with an ultracapacitor peak power buffer. The average power demands are serviced by the battery whereas positive and negative transients are serviced by the ultracapacitor.

A key feature of electric vehicles is the ability to recuperate energy during regenerative braking. This fundamentally differentiates the power management requirement of an EV to other mobile battery-powered equipment. Harnessing regenerative energy and transferring the energy back into the onboard storage systems is a demanding task. High power transients during rapid decelerations call for the energy storage system to be receptive to the charging currents. Conversely, during accelerations, high power is demanded from the energy source.

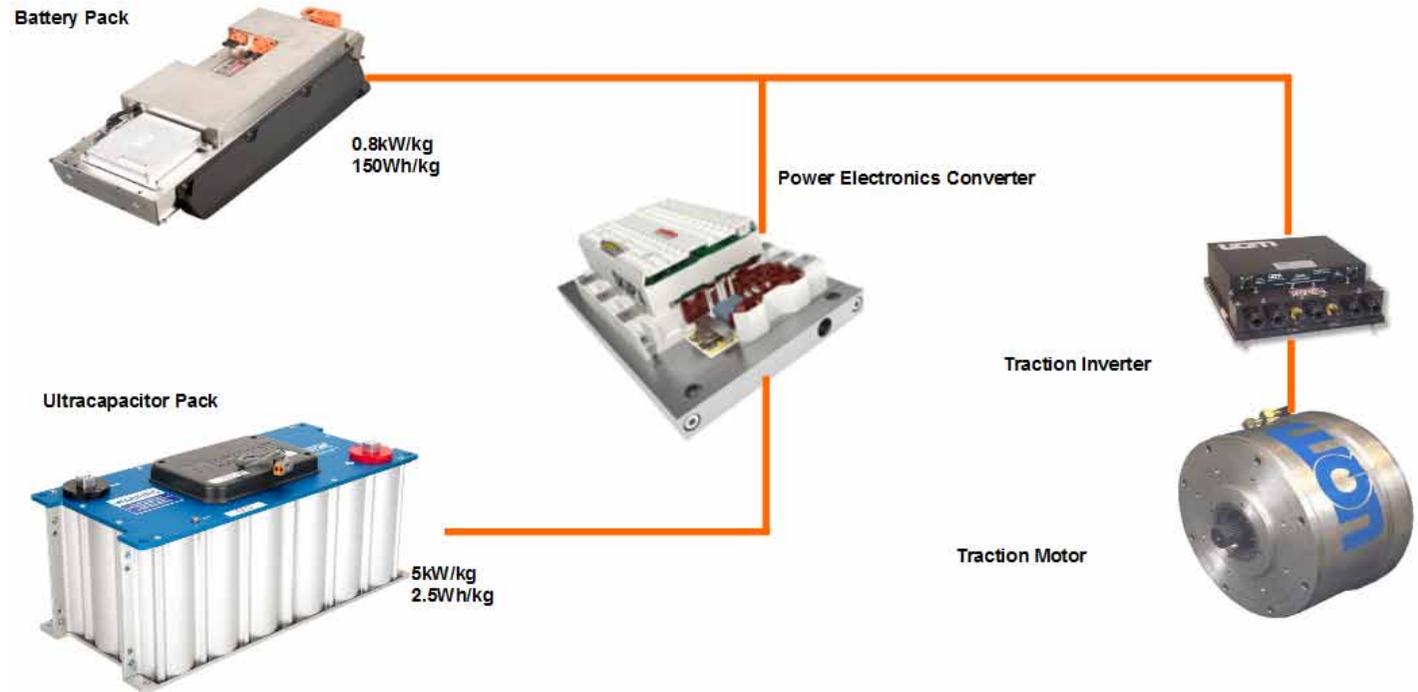


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However, the chemical properties of batteries do not permit rapid charging or discharging without severe thermal rise, which eventually leads to premature cell degradation. A peak power buffer to mitigate battery high power stresses is a way forward. With today's technology, the electrochemical double layer capacitor or "ultracapacitor" is a contending device. The ability of an ultracapacitor to rapidly cycle its energy content up to a million times before showing any sign of cell degradation makes it an ideal peak power buffer. Batteries on the other hand will start to reduce in capacity and performance after about 3,000 deep discharge cycles. Combining the two energy storage devices in an EV driveline has a net benefit but presents a few technical challenges that must first be addressed.

The combination of high specific energy batteries with high specific power ultracapacitors creates a hybrid energy storage system (HESS) that can emulate a 'non-existent super-device'. The concept of combining power dense double layer capacitors with high energy density batteries is not new by any means. In fact, the proposition to do so was first claimed by Michio Okamura in Japan back in 1992. However, vehicular applications have only started to appear in recent years. As with any new driveline concepts, the major challenge lies in the implementation.

Augmenting the battery pack in an EV with an ultracapacitor in a synergistic arrangement permits key attributes of the individual systems to be exploited. However, to obtain high utilisation efficiencies, these energy storage systems require an intervention of their natural power sharing. As such, a power and energy management system coupled with a suitable



power electronics architecture is required to strategise and arbitrate power sharing between the HESS and the electric load. The task of a power and energy management system then is to suitably coordinate the dynamics of the HESS without compromising the vehicle's target performance.

There are numerous intelligent energy management strategies but only few are implementable in a real-time control environment. Designing a HESS requires the development of a causal high-level control scheme that determines the proportional amount of power to be generated, or split between the two sources. Predominately, how these sources

are configured electrically within the vehicle power system and how the HESS is coordinated is a power electronics intensive problem requiring a systems level supervisory control scheme.

The concept of the HESS assumes the battery pack provides the average or steady state power and the ultracapacitor provides the peak or transient power. As such, a time constant and absolute levels have to be defined to discriminate between average and peak power loads. The boundary between these states contributes to the dimensioning requirements of the battery and ultracapacitor modules themselves. In general, vehicles that will significantly benefit from

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a HESS are those with high peak to average power ratios. For example, a vehicle requiring 100kW for 10 seconds followed by an continuous average power of 10kW will benefit more from having a HESS compared to a vehicle needing 100kW for 10 seconds followed by an average power of 60kW. The duty cycles of the transients are also important to consider. Transient may occur too frequently and hence reduce the opportunity charging time window for the ultracapacitors before the next peak power occurrence. In such a case, the duty cycle indicates that the HESS would need to be sized for multiple transients. Clearly this presents itself as a multi-objective optimisation problem to determine the right HESS configuration for a particular application.

Several techniques to determine the optimum HESS power-to-energy ratio may be utilised. Wavelet transforms or other offline filtering methods may be applied to the load profile to compute the power split requirement within the HESS. Several design iterations using some form of constrained cost – function minimisation technique would then yield the optimum HESS configuration for a given set of drive cycles.

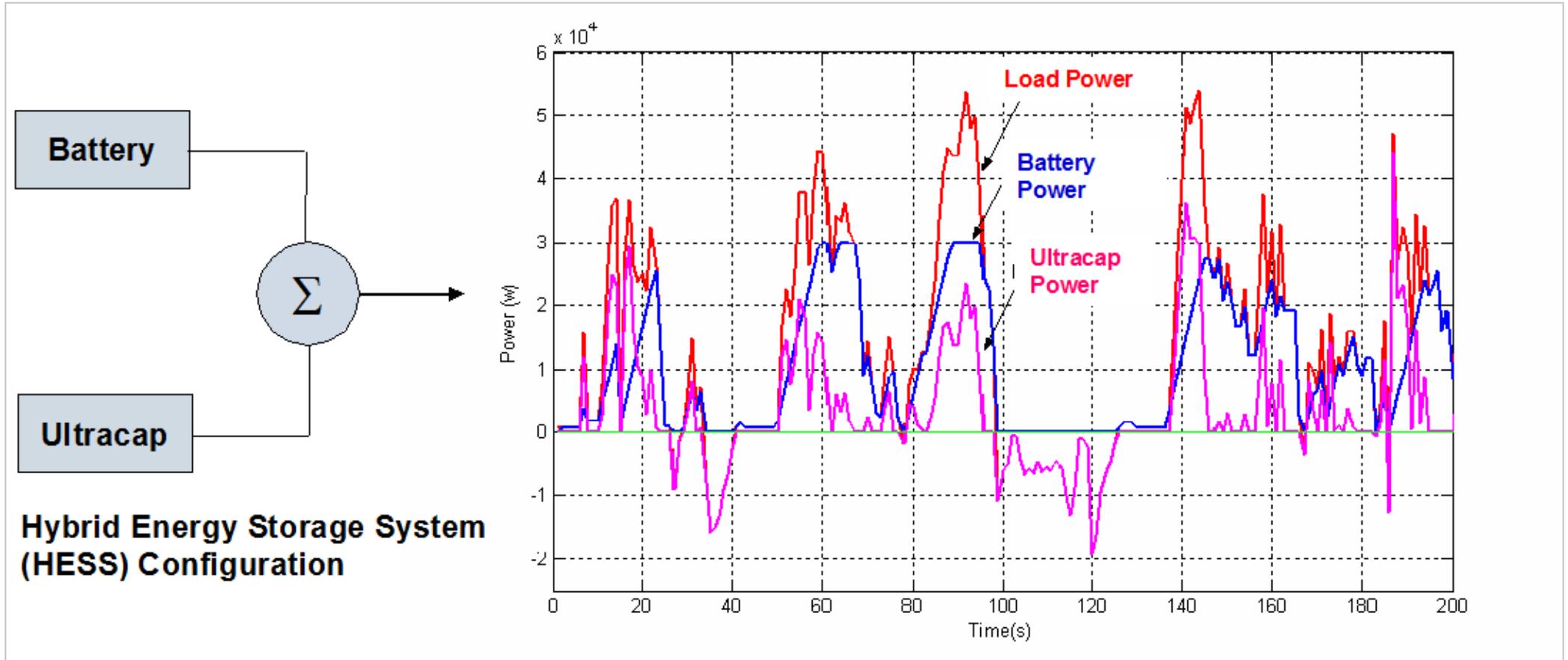
To complete the HESS, a power electronic converter to facilitate active power sharing is required. Essentially, the converter provides the infrastructure to arbitrate the power split between the battery and ultracapacitor. Because power flows to and from the energy storage systems via the converter, efficiency optimisation is

paramount. High levels of current circulating within the HESS can contribute to significant joule heating and switching losses if not designed correctly. To accentuate the problem, high voltage swings typical of ultracapacitors limit the number of standard power converter topologies that can be utilised. This is one of the reasons why HESS is still limited in EV applications. As a technology enabler, it is essential that power converters for this particular application achieve efficiency figures close to 97% across the entire power bandwidth.

Several published reports tend to support the suitability of ultracapacitors as electric vehicle peak power mitigation devices. Depending on the application, a simple analysis will show that the combination of



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batteries and ultracapacitors far outweighs either system acting on its own. However, many reports stipulate that the technology is unfavourable due to the cost of individual ultracapacitor cells. Arguably, even if the cost of the cells is driven extremely low, there is still a large overhead in terms of the silicon, copper and other passive components within the associated power electronic circuitry. To support

a complete cost analysis of ultracapacitors in a HESS application, figures should include the power electronics overhead that is fundamentally required to exploit their use in EVs. Along with the cost per Kilowatt for the power electronics devices, the unit mass per kilowatt is also a factor to consider. A recent projection of power electronics metrics indicates that at present, production volume figures are circa 5kW/

kg at GBP12/kW, with figures of 14kW/kg at GBP1.8/kW expected by the year 2020. To achieve this while maintaining target efficiencies above 97% is extremely challenging. With this in mind, much remains to form a favourable value proposition at this point in time but advances in the power electronics arena are showing a very promising future for the HESS.

Source: Leon Rosario, Lotus Engineering

Q&A with Jaguar Land Rover's Bob Joyce



Bob Joyce heads up engineering at Jaguar Land Rover (JLR). *just-auto's* editor Dave Leggett recently caught up with him on behalf of proActive

DL: What are you busy with at the moment?

BJ: We're spending a lot of time on our future product portfolio. We've been busy with launches in the 2010 model year and then we have a whole new portfolio of powertrain, hybrid and vehicle technologies for the next five years. Next product launch though is the new XJ which we are very excited about.

DL: So how does your time break down generally?

BJ: It is generally spent doing technical product reviews as well as selecting and developing key technologies that are critical for Jaguar Land Rover's product portfolio.

DL: How big is the department and how is it structured?

BJ: I'm head of Group Engineering for JLR which is circa 2,400 people. It's organised as a single engineering function in the component system areas. We matrix into our product programmes which are led by chief programme engineers and are separate for Jaguar, Land Rover and Range Rover. We then have vehicle line directors for Jaguar and Land Rover to make sure we develop the brand DNA and exploit the brands' business potential. We also have separate design directors for Jaguar and Land Rover.

Behind the scenes we are trying to drive – where appropriate for the brand and the customer – technologies that can go across both brands.



DL: Things like shared powertrain technologies?

BJ: Yes, the most obvious examples would be powertrain and infotainment technologies. For the 2010 model year we've actually got the same family of V8 petrol and V6 diesel engines and gearboxes across all of our north-south Jaguar Land Rovers. It's important that both brands can share the critical mass of technology development where appropriate. But we ensure they are developed to meet the very different needs of our brands.

DL: Have you seen changes to the engineering department that reflect changes of company ownership?

BJ: Ownership doesn't really impact the way engineering operates. Most engineering operations have to work to a certain formula to deliver the required efficiencies and effectiveness. We do work with Tata Motors where there are areas of synergy on component systems.

DL: Is there much working with Tata Motors?

BJ: It's clearly limited because our existing product portfolios are very different, but who knows where future areas of synergy may be? We will obviously work closely with Tata Motors wherever we see opportunities to exploit synergies.

Q&A with Jaguar Land Rover's Bob Joyce



DL: What do you see as the main engineering challenges ahead for JLR and indeed the industry generally in the premium segments where JLR operates?

BJ: I think the single biggest challenge facing the premium car segment is its response to the environmental pressures. There will clearly be a move towards greater hybridisation and electrification, but also a strong drive towards more fuel-efficient vehicles without a need for the expense of electrification.

All of that clearly has to be done within a business model that works and maintaining the delivery of products to the customers that are still desirable and meet their needs.

So there's a challenge to keep the DNA – beautiful, fast cars for Jaguar, the finest all terrain vehicles for Land Rover – and still meet the requirements for the future to make the products relevant and affordable.

But I think the environmental pressures and the changes to powertrain technology that will inevitably come in the next ten years probably amount to the single biggest change that I'll experience in my life in the automotive business.

DL: When might we see the first JLR hybrids?

BJ: We're on a timescale that is consistent with that of our major competitors. In the not too distant future, that technology will roll out. We have already recently

produced a technology demonstrator range extended hybrid XJ called Limo Green.

DL: Do you see any other big strategic issues on the product side?

BJ: The growth of consumer electronics in the vehicle is phenomenal. We've launched XJ with a state-of-the-art integrated audio module with all of the key technologies in one unit. The processing power is phenomenal. Infotainment requirements are being consumer led.

Electronics requirements in terms of safety, chassis, powertrain and electrification – that's about the relentless drive for higher capacity, faster response and more reliable electronics systems. That will continue to be a major thrust for us.

DL: What about vehicle weight and keeping that down?

BJ: Weight is always a key priority. If you look at the new XJ it's the lightest car in its segment. We have already made the commitment to use new lightweight technologies in our next-generation SUVs. Achieving body structure weight targets is critical, but there is a lot of integration opportunity, too. If you can break five or six separate modules currently doing audio, navigation, Bluetooth, phone, digital radio and so on and put them into one unit you've got downsized capacity and lower cost.

So there is a need to maintain the features that people want, but at a weight that is manageable and affordable. There are ways through that.



Q&A with Jaguar Land Rover's Bob Joyce



DL: And on the materials side, do you see a bigger role for aluminium, for example?

BJ: We have been committed to aluminium on Jaguar saloons and sports cars and we have made commitments that we will see that technology rolled out onto Land Rover in the foreseeable future. We have high competence with aluminium and we can see the benefits.

Often the light weight means we can avoid the cost of more complicated technologies, particularly chassis technologies which may be required to compensate for the heavier mass of the vehicle.

DL: Can you describe how the new XJ was designed and engineered?

BJ: It was a team of about 300 or so engineers and designers over roughly a three-year period. We have benchmarked Japanese competition and believe that's a pretty competitive timescale.

For much of that period we were, of course, still owned by Ford, so were operating to their product development process. All the engineering work was done in a synchronised and compatible way 18 months before job 1, which used a lot of virtual engineering up front and we only had to use prototypes in critical areas where CAE cannot yet fully optimise the car – final dynamics tuning and wind noise, for example.

DL: Was that product development process on the XJ new for JLR?

BJ: No. We piloted the process on the XF saloon, two years earlier. We learned from that. Our 2010 model year programmes launching new petrol and diesel engines into Jaguar and Land Rover vehicles



Q&A with Jaguar Land Rover's Bob Joyce



were done in the same way. So this is our first full application of the system that catches the learning from these previous projects.

DL: And you'll use the same system in the future and try and drive the development time down further?

BJ: Yes, it's in place for future products and we'll look to continue to make progress on driving improvement, but robustness of delivery is key. The development of virtual tools and deciding the structure and content of programmes is also a key enabler.

DL: What about virtual tools? How important are they compared with more traditional engineering methods?

BJ: Virtual tools are absolutely fundamental to where we are. There are some areas where they can't go because the science isn't there yet. But for every vehicle attribute, there should be an engineering target that can be laid down for it and virtual tools, once proven and demonstrable, are by far a more accurate way of developing a car. We've seen that in crash analysis. People said we'd always have to crash cars. There are still legal requirements for physical crash tests which we of course comply with, but we

have more confidence in the virtual tools because of the stochastic nature of the physical crashing versus using virtual data. It's the same with dampener tuning and ride handling. It can all be increasingly done with proper engineering techniques in the virtual world.

DL: So you see a growing role for virtual engineering?

BJ: It is absolutely fundamental to our future success and speed to market.

DL: Changing the subject, what are the main developments coming in all-wheel drive transmission technology on Land Rovers?

BJ: In terms of the drive technology we will be looking to reduce parasitic losses and give more flexibility on the move. There's also an awful lot of traction and other off-road technologies that mean our cars become more capable and the customer has to do a lot less configuration in tackling difficult terrain and handling it in a very robust and compliant way.

DL: More two-wheel drive?

BJ: I think we will see a movement in some parts of the market towards more two-wheel drive for SUVs.

Source: just-auto.com editorial team

Bob Joyce - Group Engineering Director of Jaguar Land Rover

Bob has been in the automotive business for 20 years and has over 27 years of engineering experience. After graduating in engineering from Leicester University, he began his career at Ricardo Consulting Engineers working on fundamental research into automotive diesel engines. He progressed to lead a programme on combustion chamber development for large bore natural gas engines before moving to America for Dresser Industries USA. In this role, he led the development of a new family of diesel/lean-burn petrol engines, with six to 16 cylinder configurations.



On moving back to the UK in 1986 he was placed at Rover, undertaking a range of Senior Engineer positions, including Chief Engineer of Rover's K-Series engine family, Director Gaydon Technology Centre, Director Rover Body & Pressings and Body Engineering Director of the Rover Group. In 1997, working for BMW, he became Senior Vice President for FWD platforms, including MG Rover and the new Mini, taking the latter programme from initial approval to engineering sign-off.

Bob was appointed Group Engineering Director for Jaguar and Land Rover in 2003 and has since then overseen the creation and delivery of a range of new vehicles, including Range Rover, Discovery 3, Range Rover Sport, Freelander, Jaguar XK, Jaguar X F and the recently announced Jaguar XJ.



Extending the reach of bioethanol through “invisible” blends of methanol, ethanol, and gasoline

While ethanol is an excellent fuel for spark-ignition engines, it is widely known that there is a limit to how much of it can be made sustainably from the biomass feedstocks available today. This is termed the “biomass limit”, and it varies from country to country. Some nations with low population densities and favourable climates (such as Brazil) might be able to make a significant portion of their fuel energy requirement from ethanol; others may have a desire

to use it as a mitigator for climate change or to reduce their dependency on imported energy but might not be able to deploy as much as they would like. Globally, the sustainable biomass limit stands at between 20% and 30% of the transport fuel energy requirement, and the fact that this is a minority proportion of what is required has been used by some analysts effectively to rule out ethanol as a major transport fuel. This has led governments and commercial organisations instead

to promote significantly more costly fuel/technology systems (such as mass electrification or the hydrogen economy with or without fuel cells), with a belief that there will be several major technology breakthroughs – or “miracles”, to quote US Energy Secretary Steven Chu – to permit their application without their being prohibitively costly. As a consequence in the short term there is little promise of a move away from hydrocarbon fuels for the mass mobility market.

While it cannot provide a full solution, it must be remembered that ethanol is one of two successful alternative liquid energy carriers which are being sold now for use in vehicles which people can actually afford to buy (the other is methanol which is a significant transport fuel in China and its penetration there is likely to increase over time, possibly to a dominant level). Furthermore the CAFE regulations in the United States have ensured that there are many more cars in use which could operate on ethanol than there is fuel which could be supplied to them economically: GM alone has produced four-million flex-fuel vehicles from the total of six-million on the road there. However, many purchasers of these vehicles choose not to use the E85 blend because a combination of the volume price and the mileage per gallon of the fuel makes it more expensive to use than gasoline. The unfortunate irony is that those vehicles have been engineered and sold to the end-user precisely because the use of ethanol is an easily-deployable and affordable technology which works within the current economic framework. This is a significant advantage over battery electric and fuel cell vehicles.

The challenge is to change the price per mile of using a blend fuel in favour of encouraging the end-user to



The Lotus Exige 270E Tri-fuel runs on any mixture of gasoline, bioethanol and methanol.

Extending the reach of bioethanol through “invisible” blends of methanol, ethanol, and gasoline

move to full-time vehicle operation on a sustainable fuel blend? Lotus Engineering believes that this is possible, if methanol is used as a blend component in ethanol-gasoline mixtures, because gasoline, ethanol and methanol are all miscible together in any proportion. If a suitable “invisible” gasoline, ethanol and methanol fuel blend could be supplied there are many vehicles available to accept it already in the field, which effectively removes the vehicle-side obstacles to investigating the potential. Methanol is cheaper than ethanol on both a volumetric and energy equivalence basis, which also offers a possibility that a blend incorporating it could be significantly cheaper than E85. The immediate concern is to establish whether such an invisible fuel blend is possible and what blend rates of the three components should be targeted.

In fact, this target is fairly easy to establish. Flex-fuel E85/gasoline vehicles can operate on any mixture of gasoline and E85, and so the limits of operation in terms of air-fuel ratio (AFR) for them are already set – anywhere between 14.7 and 9.7, i.e. the chemically-correct (or stoichiometric) AFR for gasoline and E85 respectively. It is fortunate that methanol, at 6.4:1, has a lower chemically-correct AFR than either gasoline or ethanol, because this lends the possibility of removing some ethanol from the E85 and replacing it with an “equivalent” methanol-gasoline blend of the same stoichiometric AFR. This equivalent-to-ethanol blend is 32.7% gasoline and 67.3% methanol by volume, or “G32.7 M67.3” (see sidebar). Blending it into E85 by replacing some of the ethanol component would then produce a ternary blend which we have termed GEM9.7 (meaning a ternary blend with a stoichiometric AFR of 9.7, i.e. that of E85). The volume

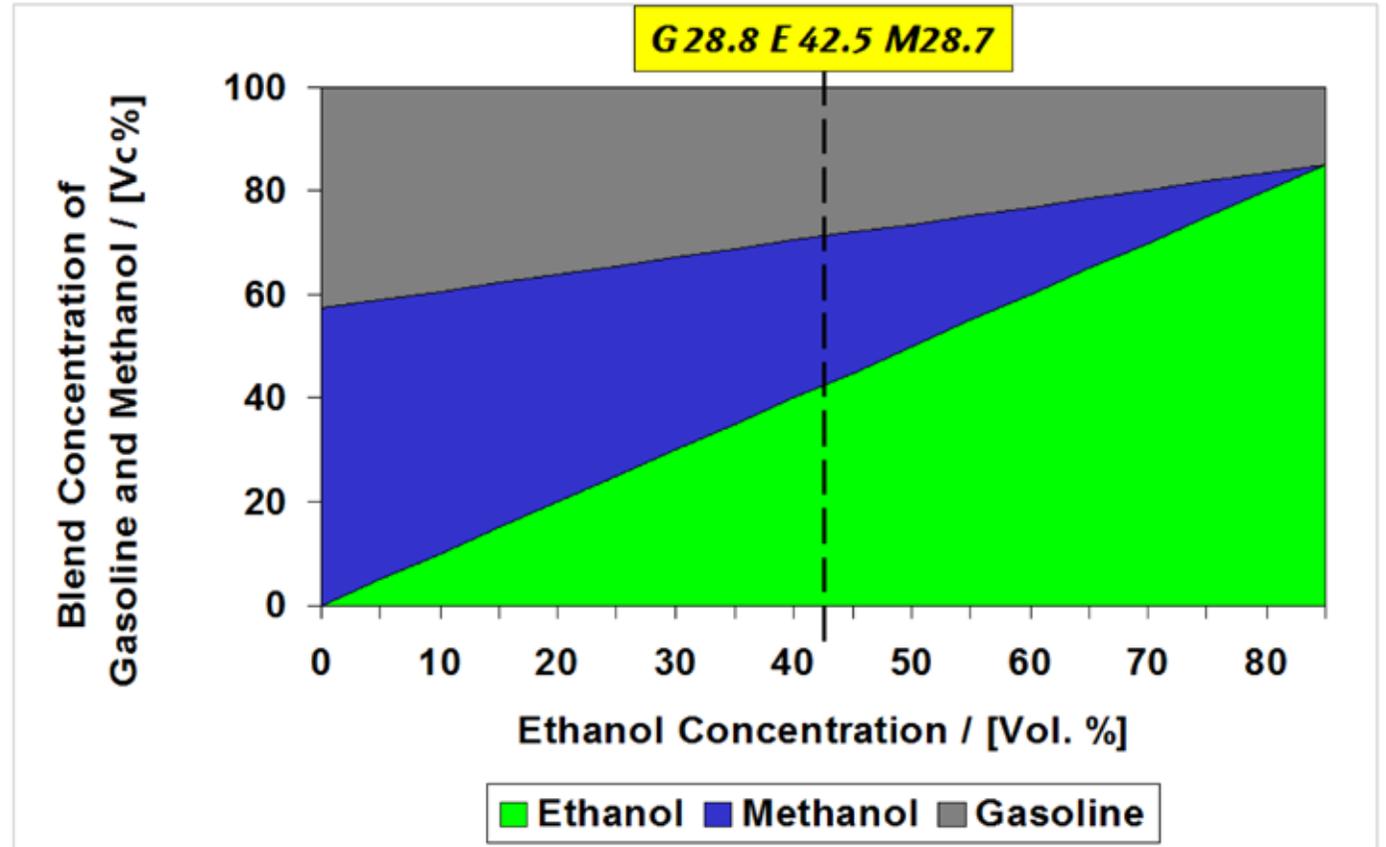


Figure 1: Concentrations of ternary blends of gasoline, ethanol and methanol corresponding to a stoichiometric AFR of 9.7 – so-called GEM9.7 (i.e. that of current E85). A blend of 28.8% gasoline, 42.5% ethanol and 28.7% methanol is shown; this splits the supply-limited ethanol component across twice the amount of fuel

proportions of the three fuels as units of ethanol are removed from E85 and replaced with “equivalent” methanol-gasoline blend units of G32.7 M67.3 are shown in Figure 1. Note that the relationships are linear.

Gasoline is displaced because the same amount of ethanol is spread across twice as much fuel; in the case of the G28.8 E42.5 M28.7 blend shown, in

which the same amount of ethanol as is in one unit of E85 is spread across two energy units of fuel, the use of methanol displaces 53% more gasoline. The mechanism for this is represented in Figure 2, where equal amounts of energy are shown on either side of the dotted line.

There are some other characteristics of the blend which have to be very similar to E85 for the new

Extending the reach of bioethanol through “invisible” blends of methanol, ethanol, and gasoline

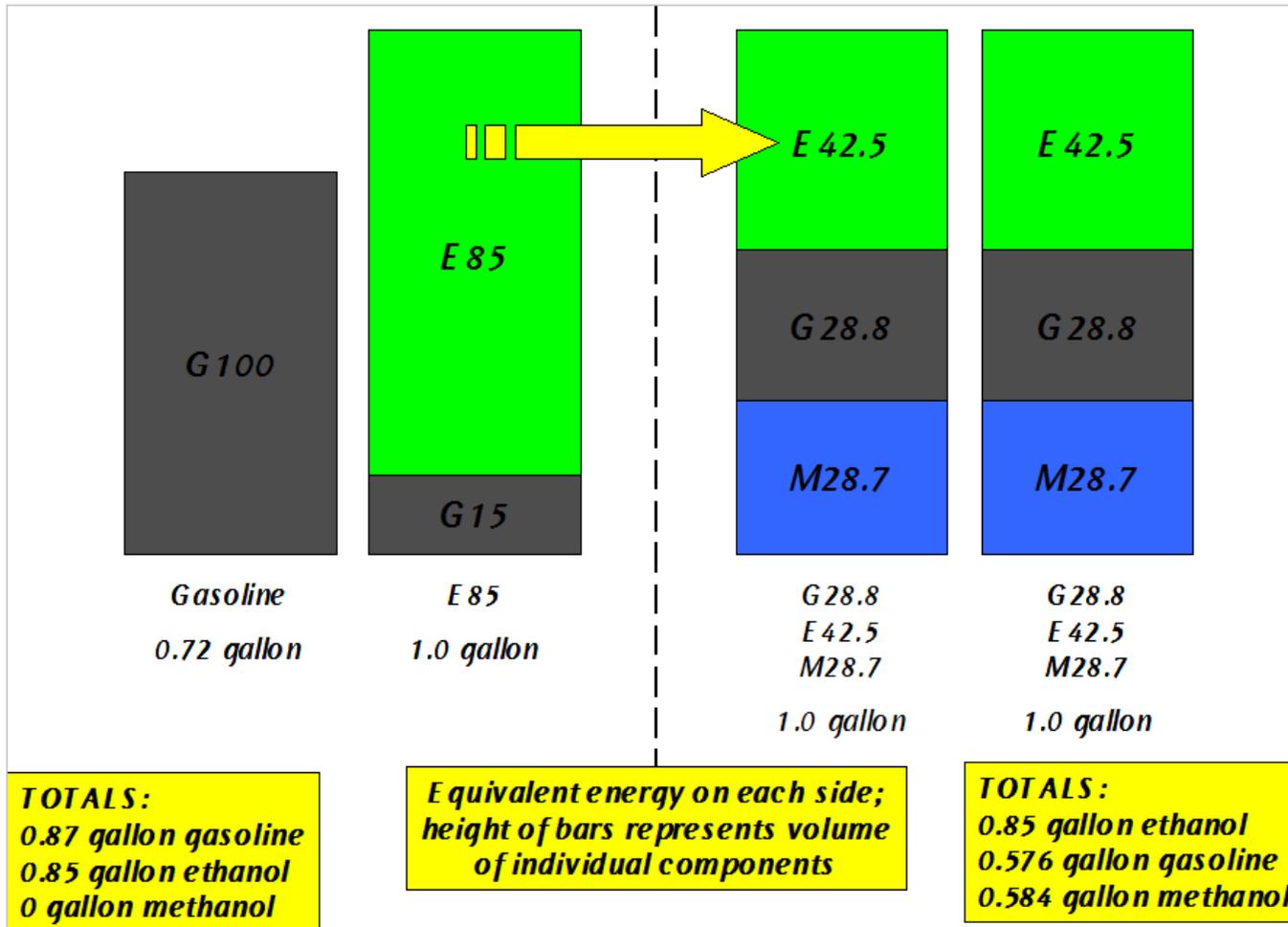


Figure 2: Representation of how a GEM9.7 blend of G28.8 E42.5 M28.7 splits the available ethanol across twice as much fuel volume and introduces gasoline and methanol to compensate. There is the same total energy on each side. Methanol can be manufactured with regard to increased energy security and reduced CO₂

blend to be a “drop-in” solution. The most important is the volumetric energy content. Performing further calculations on G32.7 M67.3 (see sidebar) reveals that it has just under 99% of the volumetric energy content

as the ethanol it would replace. This means that the on-board diagnostics (OBD) of a vehicle it is used in would essentially be unaware of a change in fuel composition from E85. Also, the heat of vaporisation

of the mixture is within 4% of ethanol, ensuring that the charge-cooling effect that this characteristic of the fuel brings is not degraded to a significant degree. The dielectric signature should be within 7% - again, close enough to ensure that the vehicle OBD will not be impacted due to a significantly-changed signal from the alcohol sensor (but note that not all flex-fuel vehicles use such sensors anyway).

Hence, it would theoretically be possible to introduce such GEM9.7 ternary blends into the E85 fuel pool and not impact the performance of vehicles already sold and in the field. Importantly, the near-identical volumetric energy content means that there should be no taxation issues for this blend in the field either. While some materials compatibility assessment and testing would need to be conducted, it is unlikely that this will be an issue since ethanol is itself almost as corrosive as methanol, and some of the ethanol is being removed and replaced with gasoline.

Encouraged by the above, Lotus Engineering is forming a partnership to conduct more in-depth testing on GEM9.7 blends in a production vehicle to demonstrate that no engine fault codes are activated due to operation on the ternary blends. It is hoped that a fuel company will join this more-extensive investigation so that complete fuel blend characteristics can be obtained as well.

It is important to stress that, being a liquid, any such GEM9.7 blend would be easily transportable within the existing E85 infrastructure and hence there will be no requirement to completely redesign the transport energy supply system (as is the case with hydrogen and, to a lesser extent, electricity).

Extending the reach of bioethanol through “invisible” blends of methanol, ethanol, and gasoline



In the main document we have used the prefixes G, E and M to represent the volume percentage of gasoline, ethanol and methanol in a “tri-fuel” mixture respectively if they are present. Hence what is normally termed simply “E85” is G15 E85.

The Lotus Fuel Mixture Database program was used to perform the calculations referred to and the fuel characteristics used are found in the table below. From these it can be calculated that the stoichiometric AFR of E85 is 9.7, and that an “equivalent gasoline-methanol blend” of G32.7 M67.3 has the same stoichiometric AFR as ethanol.

Fuel Component	Stoichiometric AFR (:1)	Gravimetric LHV (MJ/kg)	Density (kg/l)	Molecular
Gasoline	14.5298	42.7	0.7359	114.56
Ethanol	8.5982	26.8	0.7892	46
Methanol	6.4375	19.9	0.7913	32

Table 1: Fuel properties used in ternary blend calculations

Currently methanol is significantly cheaper than gasoline on an energy basis – this is what will provide the opportunity to target blends of GEM9.7 with equivalent or lower costs per mile than gasoline, hence providing a stimulus for the customer to move to a blend containing renewable components which are less sensitive to security of supply issues. When made from natural gas (currently the most widely used feedstock, and now in abundant supply in the US due to the recent finds there), methanol reduces fossil CO₂ emissions on a unit energy basis by 5%. The current spot price for methanol on a volumetric basis is about 50% that of gasoline. Assuming the volume price of ethanol to be slightly lower than that of gasoline means that a GEM9.7 blend of G28.8 E42.5 M28.7

starts to become attractive, because its cost per unit energy is the same as gasoline, and increased vehicle efficiency due to fuel characteristics can then make it cheaper for the customer to use the fuel on a cost-per-mile basis.

As well as the opportunity to extend the ethanol currently blended in E85, other blend proportions can be investigated. The US is moving towards E10, and the GEM13.9 blend spreading the same amount of ethanol across twice as much volume of fuel is G91.5 E5 M3.5. Similar calculations can be performed to find GEM13.4 blends analogous to E20, which is a long-term US aim. The huge reserves of natural gas that have just been found in the US would permit the ready development there of methanol as a fuel, thus meaning that together with ethanol two of the three blend components would have improved energy security credentials versus gasoline. It is also important to note that methanol can be made from any feedstocks containing hydrogen and carbon; because these can ultimately be obtained from the oceans and atmosphere respectively, there is effectively no long-term limit to how much methanol can be made, given the availability of sufficient renewable or nuclear energy.

As a consequence there exists a means to encourage consumers to use ethanol-blend fuels to the benefit of renewability and energy security. These blends can compete on a price basis and be chosen by the consumer within the current economic framework. Their use will then encourage the development of sustainable methods of production, aiming to improve on the 5% reduction currently achieved by Methanex, the largest methanol supplier, using natural gas as a feedstock – another plant, operated by BioMCN in



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Holland, produces methanol with an EU-validated 70% reduction in fossil CO₂ already. Hence this approach could provide a paradigm shift in the promotion of low-CO₂ transport, which would ultimately result in an economic and taxation framework for transport very similar to that which we have now. The transition is possible because the three fuel components blend together, while having different stoichiometric AFRs and the vehicle technology necessary to use these blends which are already in widespread use precisely because it is cheap to implement for manufacturer and customer alike.

Figure 1 shows the blend relationship as units of ethanol are removed from G15 E85 and replaced with G32.7

M67.3 – the equivalent blend with a stoichiometric AFR of 9. Knowing the volume percentage of the three components and their individual densities, lower heating values, heats of vaporisation, dielectric sensor responses, etc allows these properties to be calculated for any mixture. The volume percentages of the individual components also provides a basis for calculating blend price. Because the calculations show that the volumetric energy content of the blends at any given “target” stoichiometric AFR is effectively constant, the energy purchased by a customer is the same, and since this is the property actually of use to them then for any volume-based taxation system the rational tax per unit volume is the same.

A final observation is that the typical “winter E85” has a gasoline content of 30%. Taking for example the GEM9.7 blend of G28.8 E42.5 M28.7 (in which the limited amount of ethanol is made to go twice as far), the increased gasoline content and the presence of methanol both imply a fuel which would be as easily started as “winter E85” (this observation is made because methanol is easier to cold start than ethanol). Thus the approach can be made available all the year round, to the benefit of yet more potential gasoline displacement from the fuel pool.

Source: Jamie Turner and Richard Pearson, Lotus Engineering



Part of the methanol plant operated by BioMCN



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