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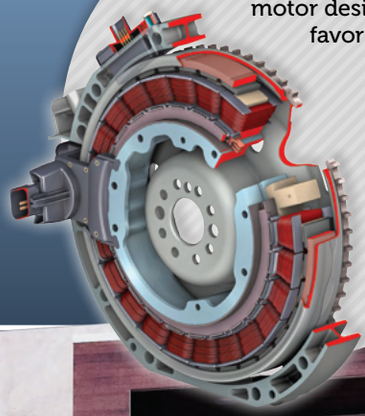

MOTOR ON

What type of electric motor designs will win favor with OEMs?

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Expert advice on overcoming the shortage of skilled electric powertrain engineers

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LEAP OF FAITH

Is Volkswagen taking the plunge into diesel-hybrid powertrain development?

July 2012

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JULY 2012

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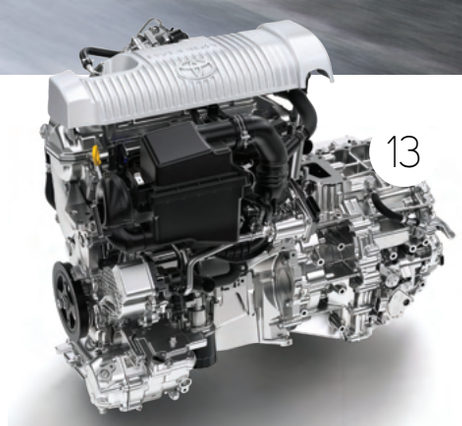

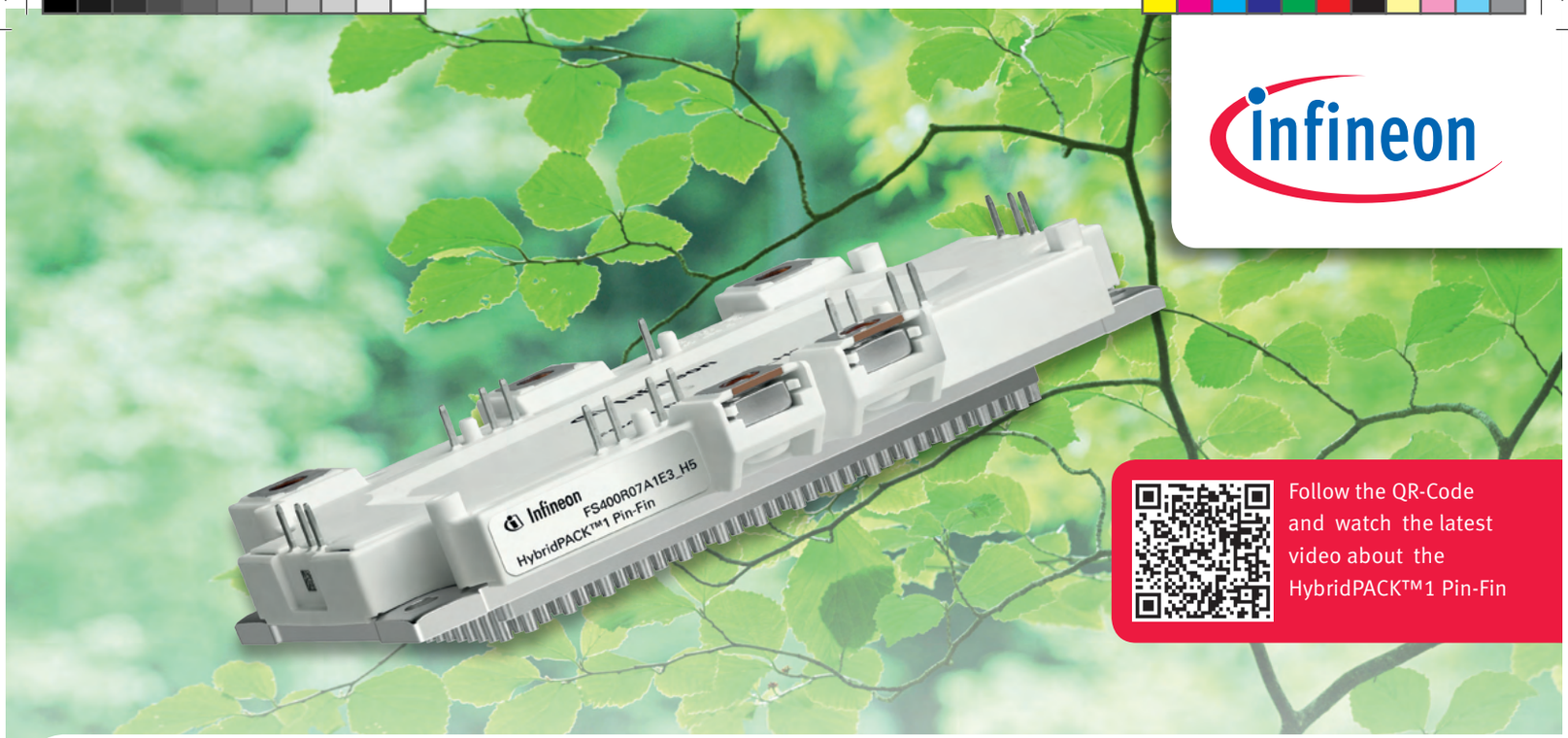

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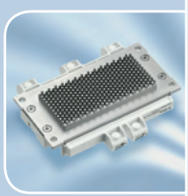
HybridPACK™ 1 Pin-Fin



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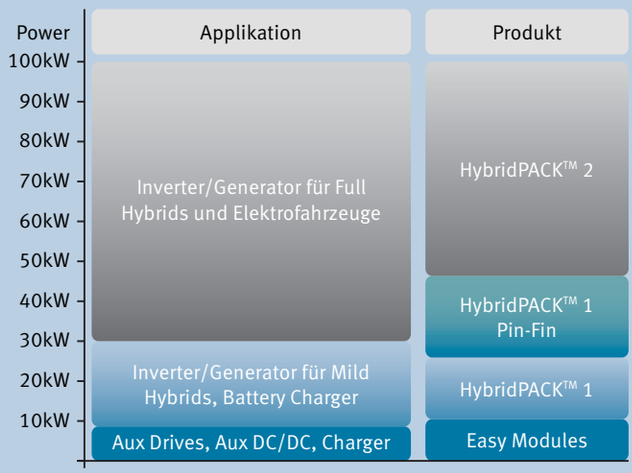

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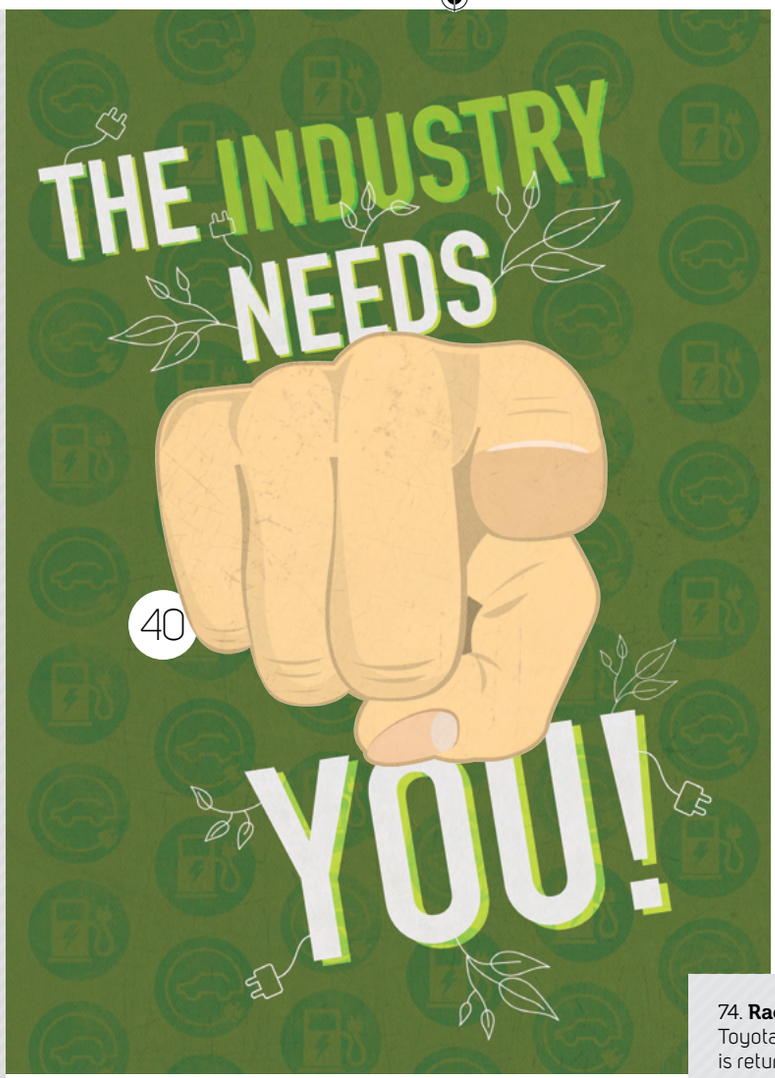
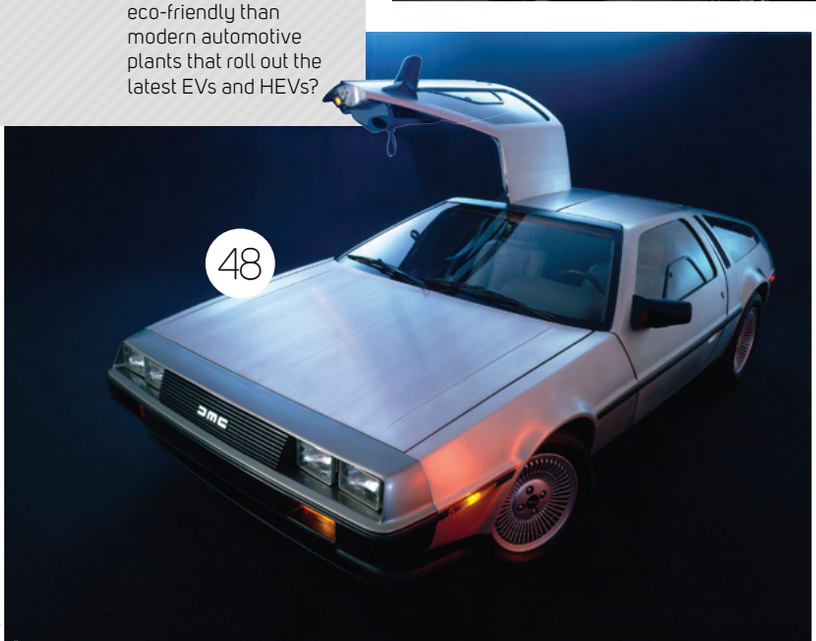


FEATURES



CONTENTS

181

156

178

PRODUCTS & SERVICES

INTERVIEWS

EDITOR'S NOTE

We here at *E&H* have been championing the diesel hybrid vision for many, many years. And while this technology has – until recently – remained firmly within the R&D labs of OEMs and suppliers, most engineers agree that this powertrain setup is the optimum engine solution to today's automotive needs. In fact, I have always said, if done correctly, the diesel hybrid can tick all the boxes: power, performance, emissions, fuel economy, range, and much, much more.

So, having spent the last seven years or so talking up diesel hybrids in various degrees of concept and prototype forms, the industry is ready to welcome not one but three production diesel hybrid products – and as this issue of *E&H* shows, it seems there are a few more on the way, with Volkswagen now seemingly being really serious about commercializing the technology, and at least one Chinese OEM also rumored to be in the latter stages of development.

As a supporter, this news delights me, because no matter which engineer I speak with in any part of the world, all agree that diesel hybrids from an engineering perspective make a lot of sense, if not from a global standpoint, then definitely for Europe.

Putting Volvo and Mercedes-Benz to one side – two of the three car makers that have confirmed production plans for their own, in-house-developed diesel hybrid systems, it's PSA Peugeot Citroën that's first to market with this technology, which for them goes under the marketing banner of HYbrid4. Not only did we recently sample the powertrain in Peugeot's 3008 model, but I also recently got the chance to speak with the French car maker's head of R&D, Guillaume Faury.

The culmination of over US$650 million of investment and some 300 filed patents means that HYbrid4 is a technology that Faury and the rest of his PSA colleagues truly believe in – and with those figures, I suppose they have to.

Here's the deal: on the road, HYbrid4 is far from perfect, but it did assure me that my long-standing support for this technology has been justified: four-wheel-drive capability with 200bhp, fewer than 100g/km of CO_2, and impressive average fuel economy. There's very little to argue about here.

So, now that I have properly lived with a diesel hybrid vehicle for a week, will I cite HYbrid4 as my number one when asked what's my favorite engine? Probably not, no, but in terms of endeavor and achievement, PSA deserves a pat on the back for daring to lead the way, all during a time when most other OEMs have jumped on the EV bandwagon. I truly hope they reap rewards from this massive investment because as history has shown time and time again, sometimes the best technical solutions don't always win.

Dean Slavnich

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Committed to

Volkswagen has flirted with diesel hybrid development a few times. Now, having unveiled the Cross Coupé concept, is Europe's largest car maker about to give the production nod to a technology that many see as being the optimum package for today's automotive world?

WORDS: **DEAN SLAVNICH**


the cause?
SESSANTA

Volkswagen has taken a big step forward in its bid to launch a mainstream diesel hybrid passenger car, having unveiled the Cross Coupé concept, but the OEM's powertrain head, Dr Heinz-Jakob Neusser, has told *E&H* that the future for this technology all depends on what legislators decide to do in the next year or two.

"Technically, the technology is easy to do. However, the advantages of a plug-in hybrid with a diesel engine all depend on aspects of the legislative side of things," says Neusser.

"If, for example, a situation is realized where you have to drive emission-free in city centers, then you need a plug-in hybrid, otherwise you can't get in and out of the city without starting the conventional diesel engine. For that to happen, such a vehicle needs to have an electric driving range of at least 50km (31 miles). For a customer that needs to drive further than this, then a plug-in hybrid with a diesel engine is an attractive option."

"Technically, the technology is easy to do. However, the advantages of a plug-in hybrid with a diesel engine all depend on aspects of the legislative side of things"

Neusser says that the engineering challenges to creating a diesel hybrid powertrain have been overcome

Modular matrix

The Wolfsburg-based OEM has been closely monitoring the viability of diesel hybrids for many years (see *Diesel Hybrid Form* box), but the Cross Coupé TDI plug-in hybrid concept – which looks production-ready – is the heaviest hint yet that it plans to launch such a technology soon. Already on the market are diesel hybrid products from both PSA Peugeot Citroën and Mercedes-Benz, but the application most like the concept that VW has unveiled is Volvo's V60 plug-in model, which comes to market in 2013 and has already created a lot of excitement – both in terms of media coverage and pre-launch consumer bookings.

So, what's so special about the VW example? Firstly, the compact SUV rolls off the company's new Modular Transverse Matrix (MQB; see page 28) that it has promoted so heavily in recent weeks.

Within this very important architecture, which will be applied to most members of the VW Group, there are certain design parameters that are standardized across model series and brands, including the mounting position of engines. MQB elements that grace the Cross Coupé that will be applied to a future generation of SUVs include the 187bhp EA288 TDI engine and the six-speed DSG, but specifically for the development of this concept, electrical components such as a lithium-ion battery placed inside a center tunnel housing, a front electric motor with 40kW, and a rear electric motor offering 85kW, were also all created in-house by VW engineers.

Such a powertrain package means that the Cross Coupé has it all: economy in so much that the 1,858kg SUV offers 1.8 l/100km (156mpg) on the NEDC; green credentials due to an equivalent CO_2 emissions rating of just 46g/km; and performance in having the ability to sprint

Despite weighing 1,858kg, the Cross Coupé boasts a CO_2 emissions rating of just 49g/km thanks to its diesel hybrid setup

VITAL STATISTICS

Powertrain: All new turbo-diesel (187bhp); front electric motor (53bhp); rear electric motor (114bhp)

Transmission: New six-speed DSG

Battery: Eight lithium-ion modules; energy capacity of 9.8kWh, 85kW

Drivetrain type: Front-wheel drive via TDI and electric motor in the front; all-wheel drive via TSI and electric motors; rear-wheel drive via rear electric motor

to 100km/h in just 6.5 seconds before hitting a top speed of 220km/h (135mph). This latter point comes down to the EA288 engine offering 400Nm of torque from 1,750rpm, while the two electric motors chip in with a further 180Nm at the front and 270Nm at the rear.

In electric mode, where the TDI is decoupled from the drivetrain by disengaging the clutch while the clutch on the gearbox side remains closed and the six-speed DSG is engaged, the Cross Coupé offers a top speed of 120km/h (75mph), and the vehicle is able to cover a distance of 45km. The SUV has been configured to offer two different forms of driving while in electric mode: City, where only the e-motor on the rear axle powers the car, maximizing the range; and Sport, where the electric drive system powers both front and rear wheels, offering more power and a dynamically enhanced style of driving.

The two electric motors get their energy from a lithium-ion battery that consists of eight modules. The battery has a capacity of 9.8kWh and has been placed in the center tunnel of the Cross Coupé. Power electronics operating at 370V, which are integrated in the front engine compartment, manage the flow of high-voltage energy to and from the battery and the electric motors. The 12V electric system receives its power via a DC/DC converter.

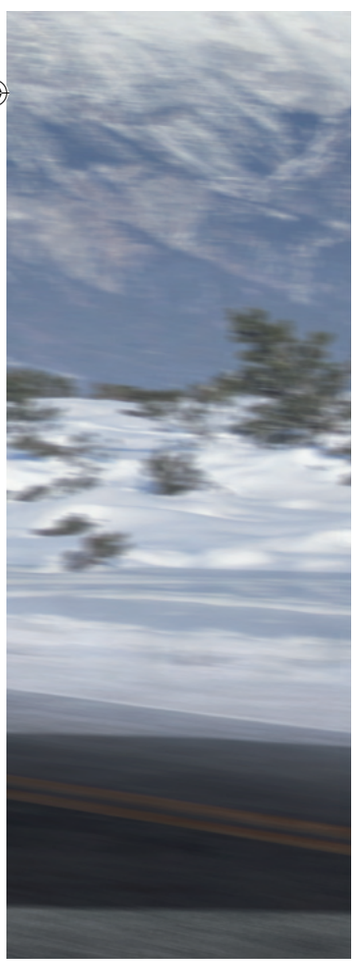
In order to charge the battery via the EA288 diesel, the driver can switch to charge mode by simply pressing a button next to the gearshift. Along with the electric mode driving options – City, Sport, and Charge – Cross Coupé also offers a secondary city mode that ensures minimal fuel consumption of the TDI, Sport mode, where VW says high dynamic performance is realized, and Offroad, which activates continuous all-wheel drive.

The TDI engines in the MQB will be available with a 1.6-liter and 2-liter displacement, and will span power outputs of 89-187bhp, the latter being the power offered in the Cross Coupé. The 2.0 TDI base in the concept features two balancer shafts that eliminate the system-induced free inertial forces that naturally occur in a reciprocating engine.

Most engineers agree that a diesel hybrid solution meets most of the needs of the automotive industry, but does that mean VW will push the powertrain in the Cross Coupé into production? "If you look to electrification, there are many variants that can be attractive to the customer," says Neusser. "Until now, it's not been easy to choose a single way to market with vehicle electrification. So, we look to hybrids, like the Jetta Hybrid in North America, we are looking into plug-in hybrids, and we are working on EVs.

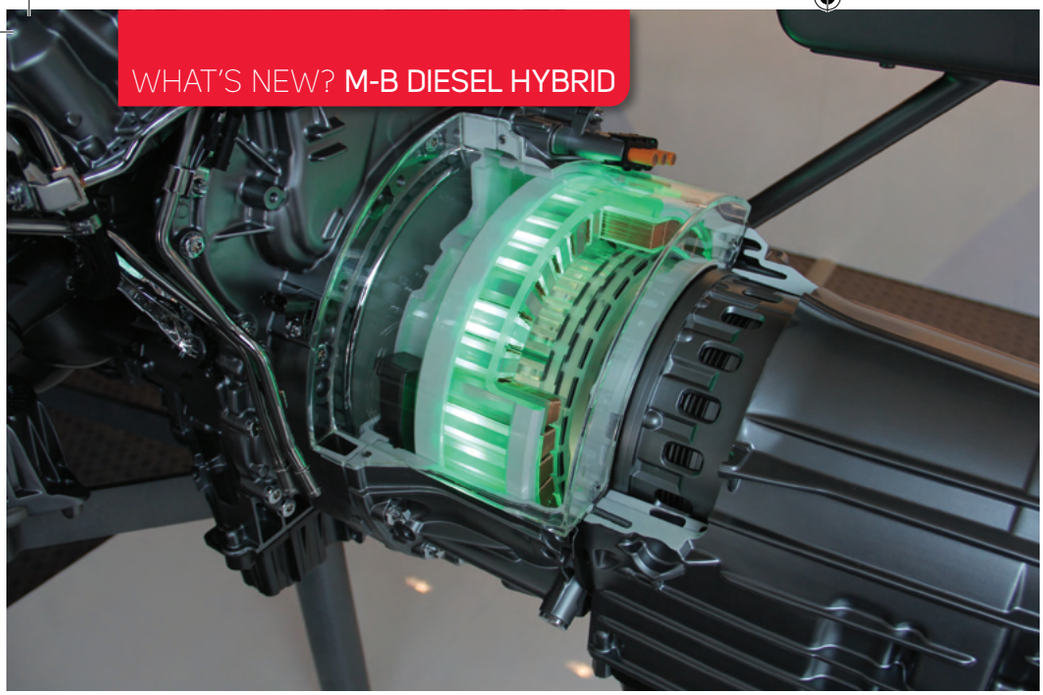
"The Cross Coupé implements a diesel engine as part of its powertrain. In the past, it has not been clear whether this [diesel hybrid] is a possible way forward, but we need to get a feeling about what the customer wants and what the trends are in terms of legislation as we go forward."

VW's Cross Coupé concept features key engineering innovations that are part of the company's new Modular Transverse Matrix, such as the EA288 TDI engine placed at the front and the six-speed DSG

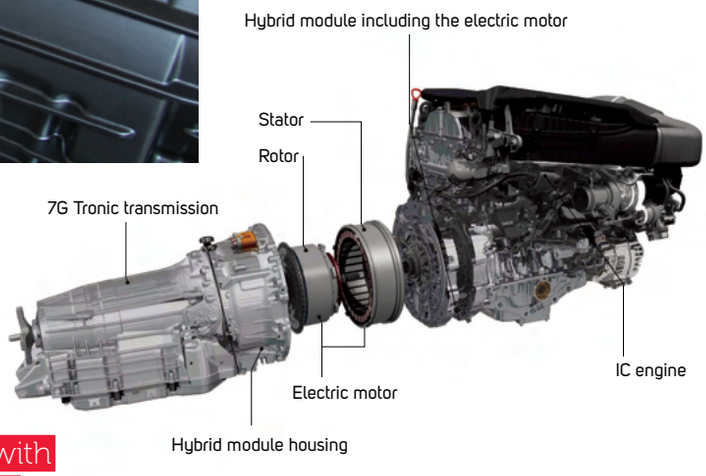


DIESEL HYBRID FORM

Volkswagen has history with diesel hybrids. In the late 1980s, the German car maker conducted trials involving 40 naturally aspirated diesel hybrid Golf vehicles, only for it to be decided that the cost of developing such a vehicle for production was too high. Then, five years ago, sister magazine *Engine Technology International* led with an exclusive tech fest into another Golf TDI hybrid concept that essentially combined a diesel engine, an electric motor, and a seven-speed DSG. The key differences between the 2008 Golf concept and the Cross Coupé are that the former relied mainly on power from a three-cylinder diesel, there was only one electric motor, and the use of heavy Ni-Mh batteries, which were lumped into the trunk of the vehicle. The result was total torque of 180Nm being delivered at 2,200rpm and an additional 94bhp from both the diesel and the electric motor. Fuel consumption came in at 3.4 l/100 km (83mpg) and emissions were rated at 89g/km of CO_2.



The E 300 BlueTEC Hybrid features a 20kW motor that is placed between the IC engine and the 7G tronic transmission



Euro star

Have the clever engineers at Daimler just come up with a winning hybrid powertrain combination for the EU?

As most premium hybrid propulsion setups go these days, there is very little that is really refreshingly new to get excited about. Volumes on hybrids in established markets, such as the USA, are holding steady, but not really growing by much. Nowadays, whereas gas-aided hybrid systems are finding welcome new favor in old faithful China, the hybrid scene in Europe remains difficult going because, in the minds of EU buyers, the latest-generation diesels gobble up the niche where a typical hybrid might be proposed. Europe needs something special to make hybrids valid.

So, what could be better than taking all that is good about new diesel powertrains and teaming it with the very latest hybrid-electric scheme? PSA Peugeot-Citroën has pioneered this for the mass market to a certain degree. But while all of that development has been happening in France, Mercedes-Benz has been quietly formulating a suitable diesel hybrid architecture for the larger premium segments.

Introducing, then, the Mercedes-Benz E 300 BlueTEC Hybrid. At the heart of the show is the well-programmed Mercedes modular hybrid system that, bearing in mind where we'll be seeing it beyond this E-Class, is reminiscent of the huge successes of the modular Toyota-Lexus system. In all engineering senses, this is a true breakthrough investment by mothership Daimler while BMW awaits the launch of its ambitious 'i' models and Audi of its e-tron cars.

OM651 goes electric

Having already proved its worth in big Mercedes applications, the 2.2-liter four-cylinder CDI of the E and S 250 CDI models is employed in the E 300 BlueTEC Hybrid to work in parallel with the electric portion of the drivetrain.

Called OM651 and with a 2,143cc capacity, the in-line four unit creates 204bhp and 500Nm of torque between 1,600 and 1,800rpm. Meanwhile, the parallel part of this 'P2' classified system is a compact 35-cell, 0.8kWh lithium-ion battery pack from wholly owned Deutsche Accumotive, cross-developed with BMW, and a 20kW 'donut' electric motor good for 249Nm of torque that is integrated in the housing for the 7G-tronic transmission and takes up just 65mm in the lengthwise cross-section view.

The label 'P2' shows that the electric motor is fully parallel but technically separated from the diesel IC engine by its own clutch. All this adds just 99kg to the overall weight of the hybrid car versus a standard E 250 CDI model, which is not bad going by any means.

Having the compressor for the climate control run electrically directly from the lithium-ion battery pack makes for a much simpler timing belt scheme at the front of the engine and eliminates the need to start the IC engine while at a standstill (necessary on a standard design to support the energy needs of the climate control). Ultimately, Daimler talks of an average fuel consumption of around 5l/100km (56mpg), with total CO_2 emissions on average standing at 109g/km. In the market of western Europe, the powertrain is classified as Euro 5 without any additional aftertreatment of exhaust emissions, and all this 'greenness' comes with the fact that the E Class wagon hits 100km/h (62mph) in just 7.8 seconds.

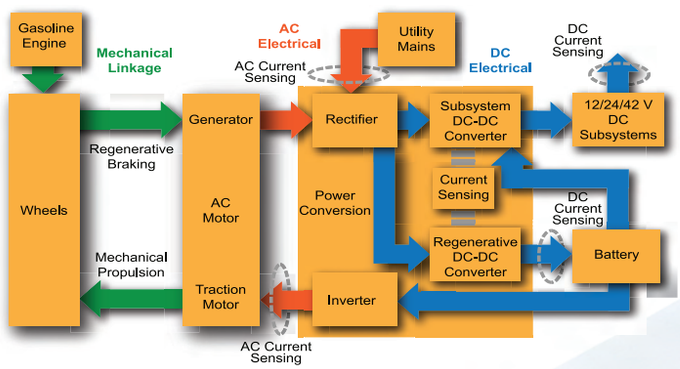
Despite the additional weight that the hybrid-electric modular bits and enhanced EPU add to the vehicle, the E 300 BlueTEC Hybrid tips the scales at just under 1,850kg, which is an impressive feat of engineering from Mercedes. Because all this compactness still needs to deliver the premium feel of a Mercedes and satisfy those on board, extensive work was done with Bosch to master the refinement of the IC engine EPU interface.

Innovative Integrated Current Sensor IC Products

Hybrid Vehicle Current Sensing

Consumers are embracing environmentally friendly "green cars" as a result of the rising cost of fossil fuels and a growing concern for the health of the environment. Hybrid electric vehicles (HEV), quickly becoming the most popular green car, employ complex power electronic circuitry to control the flow of electric energy through the vehicle. In a single electric motor HEV, the motor acts as a drive motor in parallel with the internal combustion engine in the drivetrain, or as a generator to charge the battery during regenerative braking.

A typical HEV also contains various sub-systems that require electrical current sensors for maximally efficient operation; including AC motor and DC–DC converter applications. Read the entire article explaining recent advances in Hall-effect current sensor technology and the use of unique, high bandwidth, enhanced resolution current sensors in HEV applications by visiting **www.allegromicro.com/promo1075.**



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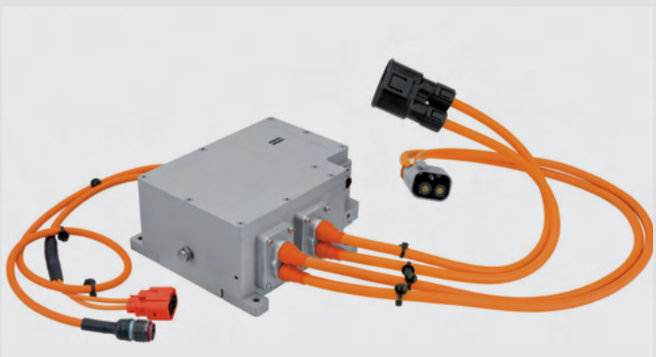

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Shrink to fit

Toyota has re-engineered its hybrid powertrain to a supermini-size without compromising performance

The Yaris Hybrid program spanned six-years and has been co-developed with the Aqua (Japan) and Prius C (USA) models

Though the latest-generation Toyota Yaris, launched around a year ago, is 100mm longer than its predecessor, it's still a small car in which to package a hybrid powertrain. So rather than the 1.8-liter petrol engine as used in the current Prius and Auris Hybrid models, Toyota's small city hatch is fitted with a re-engineered version of the 1.5-liter unit from the Mk2 Prius, and as such, downsizing and extensive redesigning have both been a key theme of the development program.

Reductions all round

The 16V, 1,497cc engine now develops 73bhp at 4,800rpm and a maximum torque of 111Nm between 3,600 and 4,400rpm; its thermal efficiency has been improved (by a claimed 6%) and friction reduced. New features include an electric water pump, a low-friction timing chain, a compact exhaust manifold, and exhaust gas recirculation, which, in combination with the delayed-compression and high expansion ratio Atkinson cycle, further reduces engine operating temperatures. A new radiator and intake manifold, plus a repositioned catalytic converter, further contribute to better heat management. Such has been the extensive re-working of the unit, that around 70% of the engine's components are new or redesigned. There is no clutch, no starter motor, and no alternator.

As a result, weight gain has been controlled – the hybrid tips the scales at just 20-55kg (depending on spec) more than the Yaris 1.33 VVT-i manual, and both passenger space and cargo capacity remain unchanged, with the batteries being accommodated completely under the rear seats. This TMC-developed nickel-metal hydride pack (120 cells, down from the Auris Hybrid's 168 cell design and 11kg lighter) has nonetheless had its charging efficiency improved, and its smaller and lighter power control unit promises enhanced cooling and reduced energy losses, too; the output current is lowered from 120 to 80A, and 650 to 520V.

Toyota also points to a smaller converter, improved engine lubrication, new engine dampers to reduce vibration, and the company's smallest-yet hybrid transaxle: the electric motor and generator are both housed within the transmission

TOMORROW'S HYBRID?

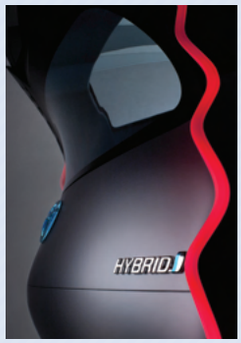
Unveiled earlier this year, the FT-Bh is a pioneering concept that drops some very obvious hints as to what Toyota is thinking in terms of future small car hybrid development.

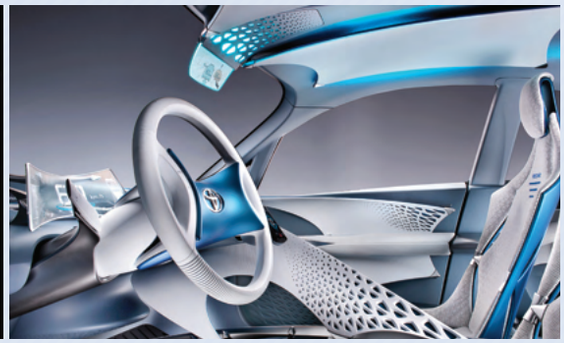
Longer than the Yaris but some 25% lighter thanks to comprehensive weight-saving measures, the FT-Bh, says Toyota, offers an average fuel consumption of 2l/100km (135.5mpg) and emissions of just 49g/km of CO_2.

Those impressive figures are partly down to FT-Bh's full hybrid drive system, which is a masterpiece in terms of powertrain downsizing. With substantial weight savings in every driveline component, it is almost 90kg lighter than the Hybrid Synergy Drive system used in today's Prius. FT-Bh's lightweight, two-cylinder, 1-liter Atkinson cycle petrol engine combines high efficiency with low thermal capacity to increase combustion efficiency and reduce friction levels. The unofficial word is that Toyota is seriously looking into producing a two-cylinder design.

Weighing a mere 786kg thanks to a construction combination of high-tensile steel, aluminum, and magnesium, means FT-Bh is not just ultra green, it's bound to be quick off the mark too, although Toyota has not published performance figures.

Further goals were improvements in the recovery of thermal energy and a 50% reduction in electricity consumption. As a result, the cabin uses thermally efficient components and the air-con focuses only on parts of the car where people are sitting.





casing, enabled by a multifunctional reduction gear within the power-split mechanism. The Denso-supplied motor, which generates 45kW and 169Nm, has flat-wound coils in place of round wire, and new magnet material; along with the smaller Aisin e-CVT, this allows for an 11kg weight saving and a 6% reduction in length over the Auris Hybrid's transaxle. The total hybrid system weighs 201kg – 20% and 42kg less than that of the Auris.

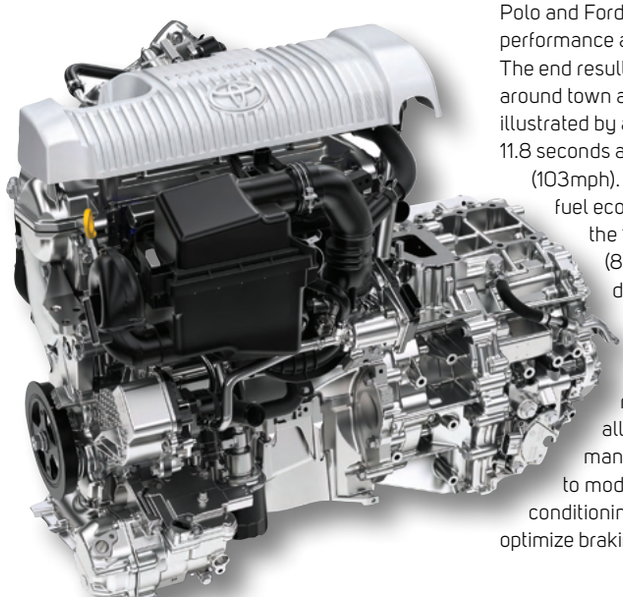
European integration

While this Japanese-developed powertrain is largely shared with the domestic-market Toyota Aqua and US-bound Prius C subcompacts, and was created in an overall six-year program, its integration into the Yaris and the calibration to suit European needs and tastes was carried out in a three-year project at Toyota's engineering center in Brussels, says chief engineer Hirofumi Yamamoto. Besides specific work to meet European emissions requirements, attention was paid to optimizing the powertrain and its control software for higher-speed use and longer-distance highway travel, as well as fine-tuning the suspension for sportier handling. Toyota has also carried out its own internal crash-testing on the hybrid and emulated the mainstream model's five-star performance in the Euro NCAP rating; not surprisingly, since this latest Yaris platform was engineered from scratch to accommodate a hybrid option.

Co-development with the Aqua and Prius C has been necessary to achieve economies of scale; after packaging, cost-effectiveness has been a particular challenge. Lithium-ion batteries were deemed too costly for a car of this type, and a plug-in system is considered too expensive to engineer into the Yaris at this point in time, explains Yamamoto. "We could have plug-in, but it is too complex for a car in this segment, so we chose a simple hybrid," he says. Further into the future, the two-cylinder engine in the hybrid FT-Bh concept car gives a few clues as to Toyota's thinking in the small-car sector (see 'Tomorrow's hybrid' sidebar).

Above: The lightweight FT-Bh might be a concept, but some of the technology underneath its skin – including an all-new hybrid system and a two-cylinder engine – could make it into production at some stage in the future

Below: An extensively reworked 1.5-liter petrol unit is used in the Yaris Hybrid. Around 70% of the engine's components are either totally new or have been modified



Toyota benchmarked the Yaris Hybrid against the Prius and Auris Hybrid, but also against IC engine competitors – economical Volkswagen Polo and Ford Fiesta models – for its driveability, performance and overall fuel economy levels. The end result is a vehicle that is lively to drive around town and capable at highway speeds, illustrated by a respectable 0-100km/h time of 11.8 seconds and a top speed of 165km/h (103mph). And while the claimed combined fuel economy of 3.5l/100km (79mpg) for the 15in wheels, or 3.3l/100km (85mpg) for the 16in, and carbon dioxide emissions of 79 or 85g/km, may not be representative of real-life returns for the heavier-footed, the benefits of the active regenerative braking system and the all-electric driving mode (which is manually selectable, as is an Eco mode to modulate throttle response and air conditioning, and a 'B' transmission mode to optimize braking energy recovery) are tangible.

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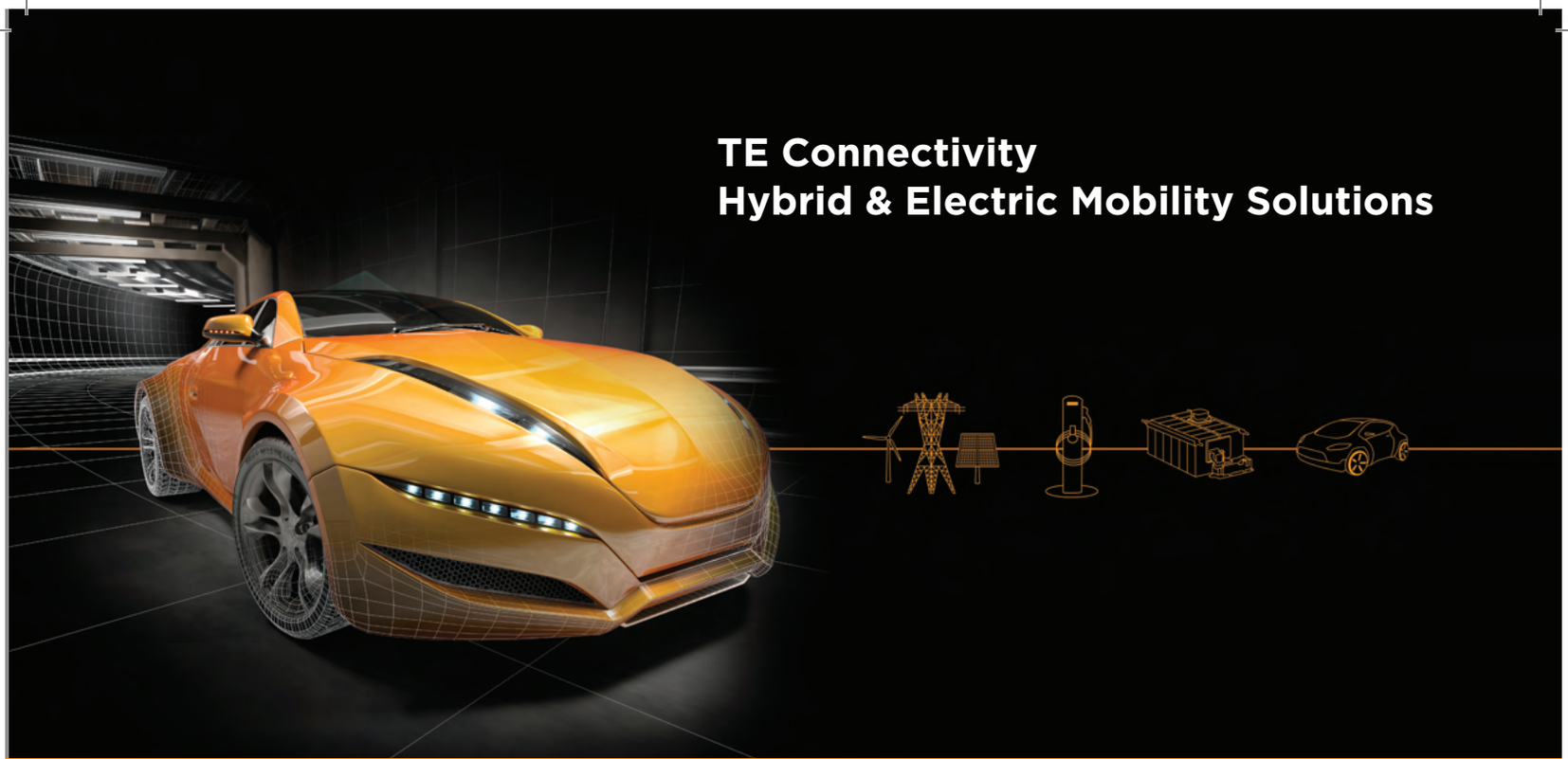

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Volt winners

Drayson Racing Technologies is building a business in alternative-powertrain development, using best practice from the OE and motorsport worlds

The Drayson B12/69EV electric racer has been developed to hit speeds of 322km/h (200mph)

Just as all-electric road cars have yet to fully break through to the mainstream (exceptions such as the Nissan Leaf aside), so the world's racetracks have yet to resonate to the silence of four-wheeled electric competition. Yes, there have been some rare cases such as drag cars, student specials and the two-wheeled TTXGP series, but mainstream racing cars remain very much IC engine-powered.

The real birth of international electric car racing should come with the FIA's new Formula E championship, which is scheduled to begin – in demonstration form at least – next year. A number of organizations, including Toyota Motorsport and Fondtech, have tendered for the contract to build the cars, with the already delayed decision by the FIA due imminently.

Another of the bidders is Drayson Racing Technologies, in partnership with fellow UK organization, Lola. Drayson has form in running alternative-fuel sports prototypes for the company's founder, Lord Paul Drayson, a former UK government minister. Now, in order to showcase what's possible and prototype much of the technology that would be used in a Formula E drivetrain, the partners have unveiled the Lola-Drayson B12/69EV, an all-electric Le Mans Prototype race car boasting a mind-bending 850bhp (640kW) of power and 0-100km/h acceleration in just over three seconds.

The car is intended to raise the profile of electric motorsport – and Drayson's expertise – by racing against the clock rather than other competitors. But it has also played a central role in readying

The Lola-Drayson's engine compartment boasts a new carbon structural element

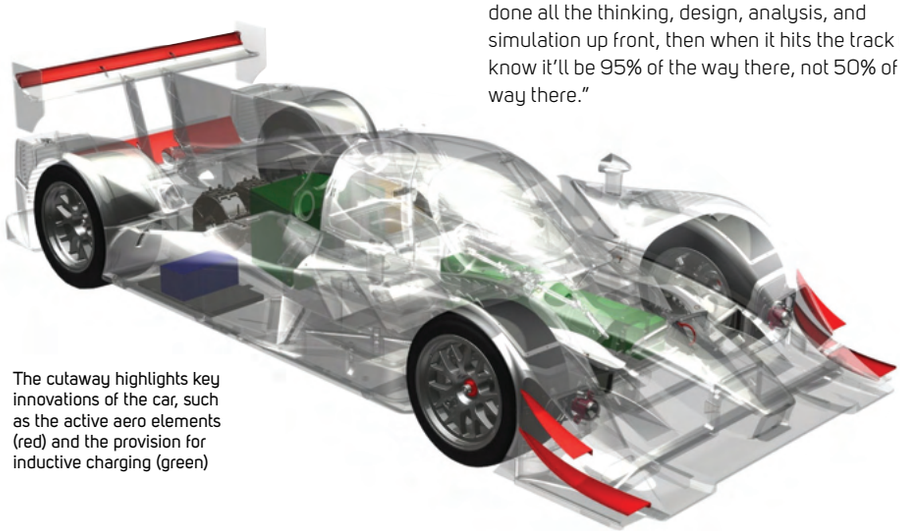
the Drayson organization for the high-end automotive and motorsport development projects that, it hopes, will be central to its future prosperity.

Virtual process

"We've taken a high-quality, automotive-like approach to designing it," explains Angus Lyon, chief engineer for electric drivetrain at Drayson Racing Technologies. "We've done an awful lot of simulation, design, analysis and requirements capture, and then followed that through a closed loop, which means all the people supplying us have a 30-plus page specification document for what we want them to provide in three or four months' time. That's proved challenging – quite a lot of people in the electric industry are quite new and are struggling to understand the OEM-type approach. What we've tried to get is a decent balance between an OEM approach in terms of safety and quality, but more of a motorsport-type approach in terms of speed and efficiency."

With extremely high voltage levels required to deliver the car's performance, safety has been top of the development agenda from day one. Drayson has been involved in the development of the safety package for Formula E, but it's not just current and future motorsport regulations that have been taken into account; road-car standards are also considered. Lyon believes that the processes put in place can only enhance Drayson's credibility to future partners.

"With the voltage and performance it has, and no differential, the car has some fairly nasty failure modes," he observes. "As a company, we have to prove that we can deliver safe, high-quality systems. If you were designing this type of thing for a road car, you'd have to be following ISO 26262. That's quite a big task and so by doing something that's quite a lot of the way there – and I have prior experience of 26262 systems – it's a challenge, but it can change your way of thinking and your design to make it both safer and more efficient. And in some ways, you can deliver it more quickly if you're intelligent about it. If we've done all the thinking, design, analysis, and simulation up front, then when it hits the track you know it'll be 95% of the way there, not 50% of the way there."



The cutaway highlights key innovations of the car, such as the active aero elements (red) and the provision for inductive charging (green)

Keeping control

Lyon adds that this is some distance from an approach that's still prevalent in the nascent EV sector, whereby off-the-shelf motors, inverters, and batteries are brought together with minimal integration. Drayson's small but expanding engineering team has developed all of its own control systems and worked with Cosworth on ECUs and the data support package.

Simulation work on the car has taken a number of forms. Lola has undertaken the lap time and aerodynamic elements, and suppliers have played a part, too – for example, YASA Motors' thermal modeling of the electric motors, which also come from YASA. The car features four inverters from Rinehart Motion, while the electrical regenerative damping technology is supplied by Multimatic.

"We decided just to complement that with the control-systems simulation, the electrical systems, and battery simulation," continues Lyon, for whom MATLAB/Simulink and Excel-based tools have been key. "There's been a lot of work on simulating the battery (current, voltage drop, thermal characteristics, battery range; and the same with the high-voltage circuitry), temperatures of the motors, inverters, down to things like fuses and cables. It's been very collaborative to bring it together efficiently and ensure there are no two identical pieces in the jigsaw."

The B12/69EV has plenty of unproven elements to master. The electric motors put out more power than any previous such units from YASA. A123 Systems' Lithium Nanophosphate cells are also previously unused. The battery modules weigh in at 300kg and are manufactured by Mavizen.

Post roll-out, the car was stripped for dyno testing of the motors and inverters at YASA, which met the team's expectations in terms of thermal behavior and performance. In parallel with that, Lyon reports that the HiL and electronic systems testing also progressed well.

This conservatively built demo car is heavier than a fully developed thoroughbred racer would need to be – at just over 1,000kg, it tips the scales with around 200kg more mass than a regular IC engine-powered Lola LMP. However, there is room for manoeuvre, as Lyon says, "There's a lot of copper on this car and you could take a lot of it out when you started looking at optimizing it for the drive cycle you're going to do."

And as well as being early days for this unique race car, these remain early days for Drayson as a business. "When you look at the car, everything's in there," says Lyon. "It's very safe and has been very well thought through. You could take this out and put it in another race car or a road car, so it gives us as a company a very good foundation. And if you get your foundations right, then it means the next project starts from this, not from scratch. It's a much more productive way to build a business."

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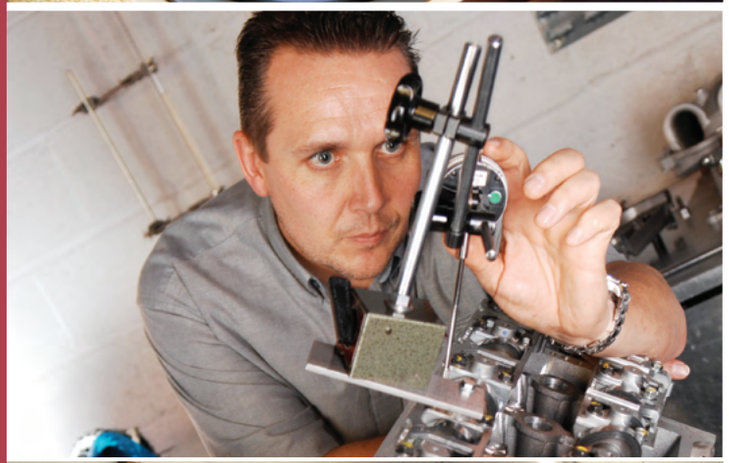

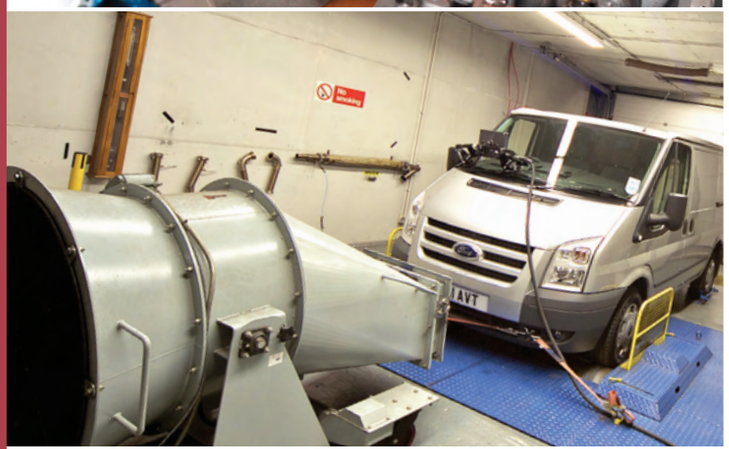

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An electric sports car with a five-speed manual transmission has been designed by Morgan with the support of British technology specialist Zytek

Fun size

Two companies are investigating the potential of an electric sports car with a manual – and the end product could reach production with very few changes to the prototype shown here

Looking almost identical to the hand-built Morgans that have been in production since the 1930s, the company's latest prototype hides a surprise. Open the long, louvered hood and you'll find a smartly finished inverter and high-voltage battery; and look a little deeper and you'll see an e-motor neatly integrated into the transmission tunnel entrance. Unveiled at the Geneva Motor Show earlier this year, this is the new Morgan Plus E – a concept that might reach production soon.

Inside the vehicle, other than a few changes to the instrumentation, the luxurious leather-trimmed cabin is completely standard, even down to the selector for a five-speed manual. The reason, says Morgan, is that this car is focused as much on fun as it is on eliminating vehicle emissions.

The Plus E is being developed with the support of Zytek, an experienced EV/HEV engineering consultancy. Clothed in the 'traditional' body from the new BMW V8-powered Plus 8, also launched at Geneva, the E is based on a tailored version of Morgan's lightweight aluminum platform chassis built by metal forming specialist Radshape.

Power is delivered by a new derivative of Zytek's 94bhp, 300Nm electric engine, which is already proven in production applications with a number of European and US vehicle manufacturers. Drive is taken to the rear wheels through a conventional five-speed manual and clutch.

"A multispeed transmission allows the motor to spend more time operating in its sweet spot, where it uses energy more efficiently, particularly at high road speeds," explains Zytek Automotive sales director Steve Tremble. "It also enables us to provide lower gearing for rapid acceleration and will make the car more engaging for enthusiast drivers. And because the motor can operate from zero speed, the car can be driven like a 'two pedal' with no gear changes, ideal for urban use, and as a conventional multispeed transmission when the traffic clears."

The fun factor

The two companies initially considered a two-speed automatic transmission (Zytek is working with Oerlikon Graziano on other projects), but decided instead to investigate the potential for a manual electric sports car. "Morgan is about fun and that means a combination of performance, style and driver interaction," explains program manager Robert Gibson. "This project will allow us to take a decision on the transmission based on customer feedback."

The first Morgan Plus E concept will be powered by a derivative of Zytek's production 70kW E-Drive, providing 300Nm of readily accessible torque

Keeping weight down to that of the standard car (around 1,250kg) meant limiting the number of batteries carried, so managing their energy efficiently was critical. The first prototype uses Valence Li-ion phosphate cylindrical cells assembled into a custom enclosure by Zytek and split between front and rear packs to provide a near-50/50 weight distribution. Zytek also supplies the power electronics and control systems.

The second prototype is likely to use batteries from a different supplier (for back-to-back testing) with water cooling, allowing considerably more power to be released from the motor. In the show car, the Zytek unit is cooled by the standard vehicle's front-mounted radiator, but a more compact, lightweight system is being designed for the second prototype.

Morgan predicts a 0-100km/h time of under seven seconds for the first car, with a range of 193km (120 miles). "With more power and optimized gearing, the second prototype should hit 100km/h in less than six seconds," claims Gibson.

Morgan believes that there are currently no rivals for the car. "This is a different market to the very focused Tesla," says Gibson. "Reaction to the Geneva show car was sensational, which has given us the confidence to move quickly toward production-specification prototypes that our customers can evaluate. Having access to Zytek's considerable experience has helped us move forward very quickly with a product that will meet worldwide homologation requirements. The current intention is to hold customer trials in 2013. If that goes well, the Plus E could be in production for the following summer."

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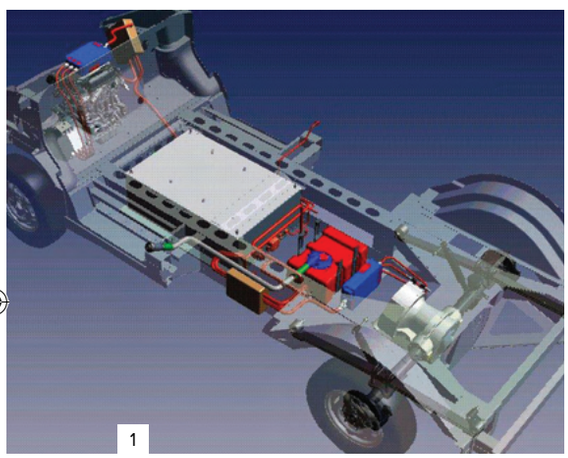
Tricks of the trade

1. The t-001 drivetrain features a 25kwh lithium-ion battery pack, which drives a 75kw electric motor at the rear axle

2. The t-001 is a series hybrid in that the road wheels are only powered by the electric motor, and the range extender engine solely runs the on board generator

3: Emerald chose EVO Electric for the axial flux motor and permanent magnet generator

A range-extended, hybrid delivery van is set to hit the market having been developed using some industry-leading systems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A hybrid delivery van – conceived, engineered, developed and tested in the UK over the past 18 months using companies identified as 'the best of the best' – will be built in the USA toward the end of 2014 and, a couple of years later, be offered as a fuel-cell-powered zero-emissions vehicle.

Andy Tempest, CEO of Emerald Automotive and the man behind the t-001 project, talked to many fleet operators – including some of the world's largest postal authorities – to conclude that the key to a successful future delivery EV was light weight. "Put a range-extended hybrid powertrain into a traditional vehicle, and you'll significantly reduce the payload because you're taking out a 2.3-liter diesel engine weighing 120kg, but putting in a battery pack, motors, inverters, generator, and a small range-extender engine all weighing 500kg. So, converting a standard van reduces the payload by almost 400kg!

"Our first step was to do an aluminum chassis and thermo-plastic body panels – all designed to meet safety requirements – so that we could take 400kg out of the structure. That way we could put in 400kg of hybrid drivetrain and still give the customer the same payload and duty cycle as a conventional van plus the ability to run in city zero-emission zones."

Duty cycle for the t-001, currently being tested at Millbrook, is 106kms (66 miles) as an EV plus 643kms (400 miles) with its Ford 1.4-liter diesel range-extender engine running. "We're in discussions with three other OEMs on engines as we look for a 75bhp small-displacement engine," says Tempest. For the USA, the range-extender will be a gasoline engine.

Best of the best

"We have chosen the best of the best to produce t-001," states the Emerald CEO. The list includes Ricardo for the drivetrain design concept; Revolve Technologies for integration and build; Multimatic for chassis and other components; Advanced Composites Group for body panels; Delta Motorsport for the cab safety cell; Kokam Li-ion cells for their charging characteristics for batteries; RDVS for the DC:DC converters; and EVO Electric for the compact high-density axial flux motor and the permanent magnet generator.

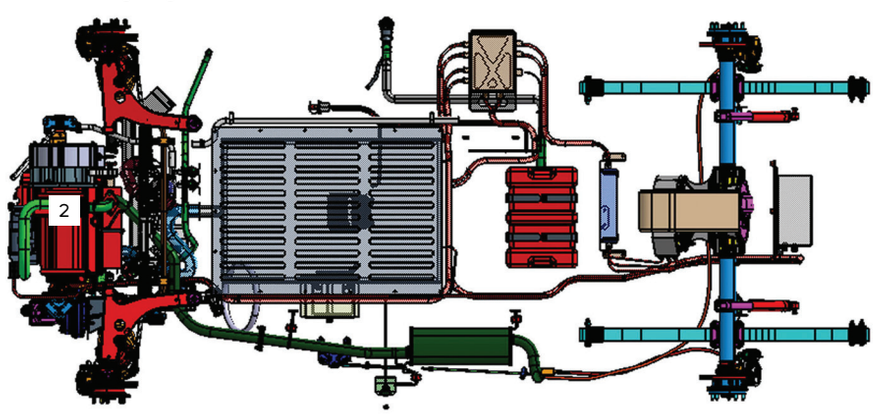
For the t-001, EVO's 50kw generator, weighing 28kg, is directly connected to the crankshaft and replaces the flywheel. It cuts in as soon as the 25kWh battery pack level falls to 25%. The 75kW EVO axial flux traction motor, weighing 40kg, was chosen because its shape perfectly suits its location – bolted to the rear differential, which comes from a Ford Transit, but is housed in a bespoke lightweight casing.

Because UK-based Intelligent Energy (for whom Tempest remains a consultant) saw t-001 as the ideal platform for its fuel cell as the range extender, it funded the initial proposal.


3

However, several organizations in the St Louis area of the USA – plus the City of Hazelwood where the vans will be built – are backing the Emerald t-001 project.

"We are all really excited by this project to give customers a cost-effective solution to the problem of achieving low CO_2 without increasing running costs," concludes Tempest.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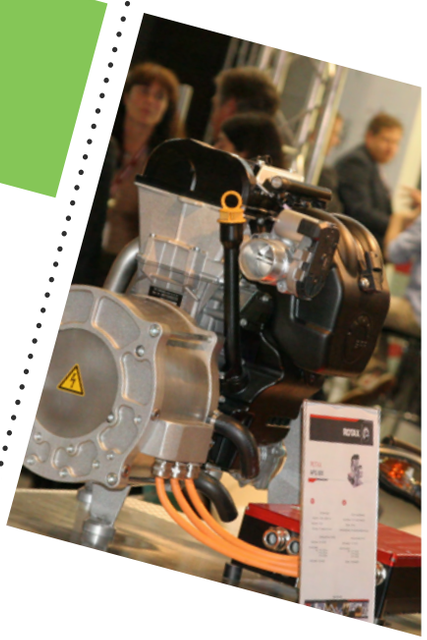

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And now for something totally new...

Opel/Vauxhall Ampera

Having come to market first in North America in the Chevrolet Volt, GM's widely praised Voltec powertrain has now been launched in Europe in the Opel/Vauxhall Ampera – and *E&H* was one of the first to drive it!

In short, this vehicle ticks all the boxes when it comes to modern, family motoring: it's fuel efficient, it eliminates the range anxiety problem associated with BEVs, and it's eco-friendly. But perhaps more importantly, in terms of day-to-day usability, the five-door Ampera is practical, comfortable, and can easily accommodate a family of four on long (or short) journeys.

Good start, then, and there's no denying that it's the range-extender technology that's behind much of what's good about the Ampera. A 16kWh lithium-ion T-shaped battery combines with a 111kW electric drive unit that's located alongside the gasoline engine to deliver 80km (50 miles) of electric operation. When the 198kg battery reaches its minimum state of charge, power is inverted to the electric drive unit from an 86bhp, 1.4-liter engine that acts as a generator, enabling more than 500km (310 miles) of driving without refueling.

The battery, which has been placed in the center tunnel of the vehicle and was developed with LG Chem, has 288 prismatic lithium-ion cells and provides 370Nm of instant torque.

Although the technology has been much talked about – GM won the Green Engine award at the 2012 International Engine of the Year – what strikes home from a consumer perspective is that the Ampera is very user friendly. Inside, there's plenty of space, and due to the intelligent packaging of the battery, luggage room in the trunk is not affected, with 310 liters of space available. There's a smooth feel most of the time when behind the wheel, and that's especially the case when on the motorway.

The only gripe is the price: at well over US$50,000, we think consumers might feel it's a lot to pay for an Opel/Vauxhall, but fundamentally, it's the state-of-the-art powertrain technology that they're buying, not the brand. Let's hope they remember that.

Propulsion system: Electric drive system with two electric motors at the front; lithium-ion T-shaped battery in a central tunnel with liquid active thermal control; 1.4-liter Ecotec gasoline engine at the front

Peugeot 3008 Hybrid4

Five years ago, PSA Peugeot Citroën announced it was going to bring to market the world's first mass-produced diesel hybrid powertrain. Half a decade later, said eco-friendly system – marketed as Hybrid4 – rocked up to *E&H* Towers in the Peugeot 3008.

The 3008 Hybrid4 combines a fuel-efficient, 2-liter, 163bhp HDi engine with a 37bhp electric motor from Bosch. Maximum torque of 500Nm is available: 300Nm at the front from the diesel, and 200Nm at the rear generated by the electric motor. With so much power, the 3008 has been designed to offer four driving modes: auto, ZEV, four-wheel drive and sport.

Unlike the Ampera, the 3008's battery is of a Ni-MH nature – which has been co-developed by Sanyo and fitted under the trunk, near the electric motor. The 1,997cc engine, which is mated to an electronically controlled six-speed manual, features stop/start to help ensure CO_2 emissions are kept to below 100g/km.

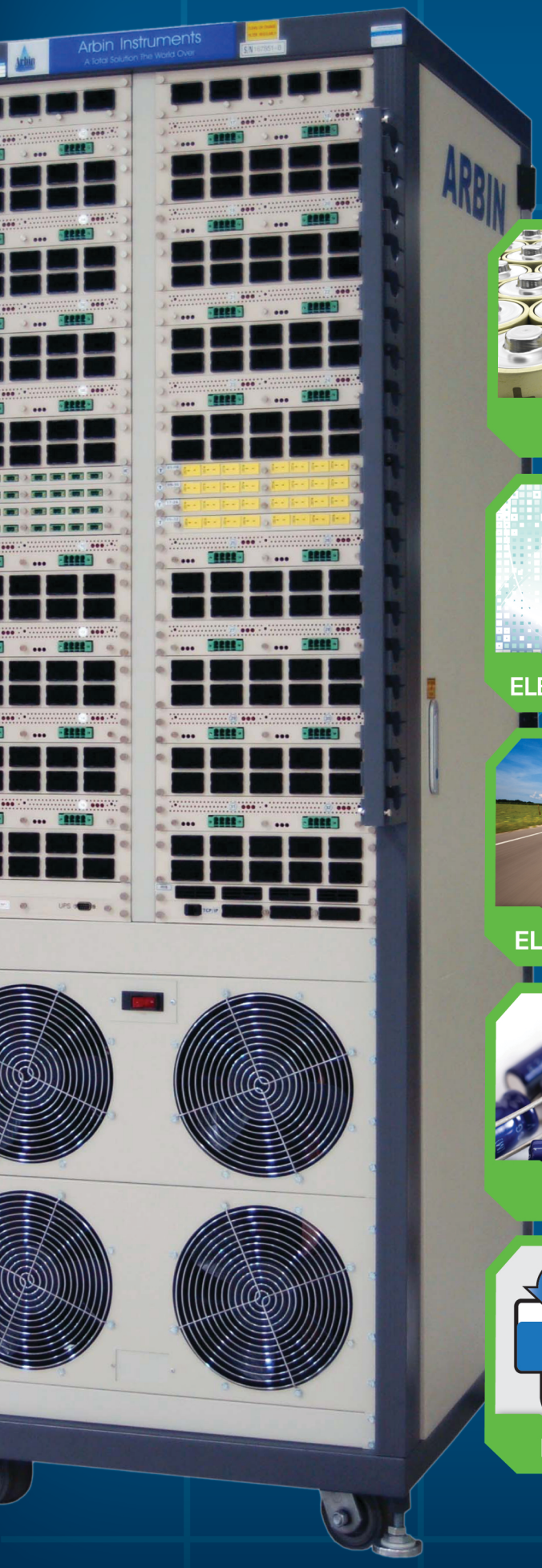
As a family vehicle, the 3008 does what it's meant to do: it's roomy, comfortable and practical. Like the Ampera, it's more at home doing high speeds on the motorway than stop-and-go low-speed commuting in town, but don't read that last statement in the wrong light: despite its frame, the 3008's powertrain makes the crossover easy to maneuver in urban areas, and when running in ZEV mode you can't help but grin as you notice smaller EVs containing driver, passenger, and shopping all crammed into a small and very confined cabin space.

There are, however, two things we need to point out: like the Ampera, the price is on the high side. Our 3008 costs the best part of US$44,500, which consumers might think is steep for a PSA vehicle. Plus, no matter how hard we tried, we just could not get near to the claimed fuel economy of 70.5mpg.

Yet Despite that, Hybrid4 is a very commendable diesel hybrid effort from PSA – and the thinking must be that as the industry moves forward, the French OEM will steal a lead on others in terms of evolutionary steps.

Propulsion system: Synchronous electric motor with permanent magnets at the rear; high-voltage Ni-Mh battery also placed at the rear; 2-liter four-cylinder HDI FAP diesel engine at the front

ARBIN
TESTING SYSTEMS



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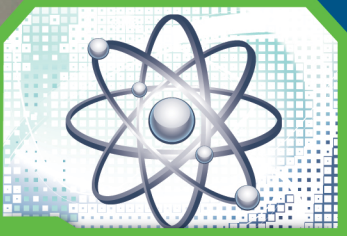

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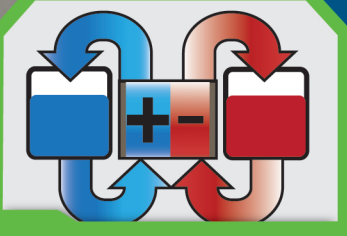
ELECTRIC VEHICLE

CAPACITOR



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PRODUCTION **NEWS**

GM AND PSA SIGN TECH SHARING DEAL

GM Motors and PSA Peugeot Citroën have announced the creation of a long-term strategic alliance that will ultimately aim to improve the profitability of both OEMs, as well as boost their overall competitiveness in Europe. The agreement will also see GM become the second largest shareholder in PSA by securing a 7% stake.

The groundbreaking alliance is structured around two main pillars: the sharing of vehicle platforms, components, and modules – and this includes powertrain development and the creation of a global purchasing joint venture for the sourcing of commodities, components and other goods and services from suppliers, with combined annual purchasing volumes of approximately US$125 billion.

Initially, the partners will focus on small and mid-size passenger cars, MPVs and crossovers. The companies will also consider developing a new common platform for low-emission vehicles, with the first vehicle on a common platform expected in 2016.

FUEL CELL JV FORMED BY INTELLIGENT ENERGY AND SUZUKI

Intelligent Energy and the Suzuki have announced the creation of a joint venture company called SMILE FC System Corporation, which aims to develop and manufacture air-cooled fuel cell systems for a range of industry sectors. The JV will also include a non-exclusive license agreement that gives Suzuki access to Intelligent Energy's advanced fuel cell technology for its next generation of fuel cell vehicles.

Under the terms of the agreement, both companies will take a 50% stake in SMILE FC System, which will be led by Osamu Honda, executive VP and representative director for Suzuki, who will become president of the JV. SMILE will be headquartered in Hamamatsu City, Shizuoka, with operations initially based in Yokohama.

"Suzuki Motor Corporation has been developing fuel cell vehicles with Intelligent Energy since 2006, and this successful relationship has led to the formation of SMILE FC System Corporation," explained Honda. "I believe that we can accelerate the commercialization of fuel cell vehicles through this joint venture with Intelligent Energy."

Commentators say the agreement represents good value for both parties, enabling Suzuki cost-effective access to Intelligent Energy's advanced fuel cell technology through partnering and licensing, thereby avoiding the higher costs associated with in-house development. Intelligent Energy will benefit from Suzuki's production expertise and the emerging Japanese supply chain to jointly develop the next generation of automotive standard air-cooled fuel cell systems.

Phil Caldwell, newly appointed board member of SMILE FC System Corporation and business development director at Intelligent Energy, commented, "This joint venture is the latest exciting development in the successful relationship between Intelligent Energy and Suzuki, which has previously resulted in the Crosscage motorcycle and the Suzuki Burgman Fuel Cell Scooter. It is a big step toward the mass production of automotive fuel cell systems."

VW GROUP REVEALS MODULAR TRANSVERSE MATRIX

VW Group has unveiled an all-new architecture that will allow the German OEM and its mainstream brands to develop a raft of new models that feature transverse-mounted engines.

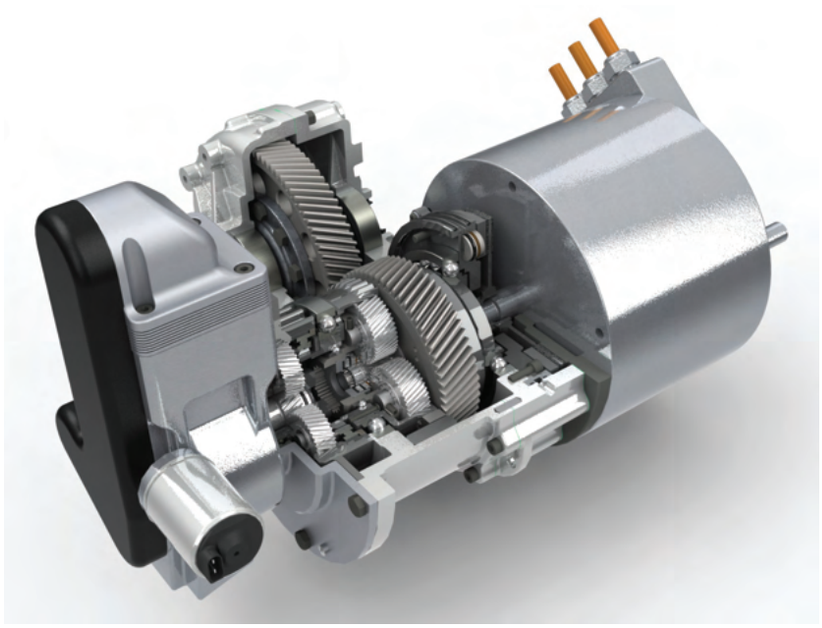
Known as the Modular Transverse Matrix, which in German translates to Modularer Querbaukasten (MQB), the architecture promises to optimize production costs and processes by allowing Volkswagen, Audi, Škoda, and SEAT to share more components, subsystems and technologies, including those relating to the powertrain.

VW says MQB represents a turning point in the design and production of future automobiles with transverse-mounted engines. It extends from the A0 segment range through to the B segment. Within the VW brand, that will currently include the likes of the Polo, Beetle, Golf, Scirocco, Jetta, Tiguan, Touran, Sharan, Passat and Passat CC. The German OEM says that in the future, all of these models could theoretically be produced on the same assembly line – despite their different wheelbases and track widths, and this will also apply to A0 and B segment vehicles from Audi, Škoda and SEAT. The first new vehicle to be produced based on MQB is the all-new Audi A3, which made its debut at the Geneva Motor Show, and the next-generation Golf, which say industry insiders, is due to be unveiled later this year.

On a powertrain front, two systems integrated in the MQB strategy that play a key role within the new architecture are the modular petrol engines with the new EA211 – and this includes the world's first four-cylinder engine with cylinder deactivation – and the modular diesel engine system with the new EA288 family. VW claims that in one swoop, the new engine series will reduce the group's engine and gearbox variants in MQB by 90% without a detrimental effect. In addition to standardizing IC engine production, MQB also enables an identical mounting position for all current alternative drive designs without limitations, so this covers natural gas and hybrid versions as well as pure electric drive.

PLUG-IN HEV POWERTRAIN

DTI
Drivetrain Innovations

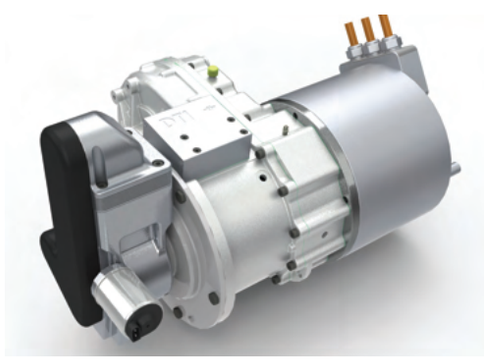


Attributes:

- pure EV mode with multiple gear ratios
- parallel and powersplit hybrid modes
- pure ICE mode with multiple gear ratios
- range extending

Components:

- single e-motor & inverter
- single dry clutch
- single planetary drive
- 2 shaft design
- 1, V2, I2 or I3 VCR engine



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PROFILE: JOACHIM HAHN

Job title: Manager, powertrain engineering
Company: Hyundai/Kia

What career did you dream of when you were growing up, and what was your first job?
There is a time in every boy's childhood when he wants to become an astronaut, a football player, a pop-star, or any other type of career that brings fame and wealth – and that was the same for me. However, once I hit my teenage years, it became obvious that I wanted to work in the car business, specifically in the field of powertrain engineering. A few years later, I became a student at the University of Aachen, studying IC engine design.

When did you first start playing around with powertrains?
This coincided with me starting my studies. I succumbed to the charm of a small British, racing-green-colored, Michelotti-styled, Triumph Roadster. Despite its character, I was forever having to tinker with the engine.

What was your career path to the position you currently hold?
Before joining Hyundai/Kia, I worked for FEV in Aachen, Germany. I had the opportunity to work on IC designs, starting from those just a few cubic centimeters in size – on chain saws, for example – right through to large engines for passenger cars, trucks, and even massive combustion engines for locomotives. I worked my way up to being head of mechanical testing at FEV, before leaving for Hyundai/Kia.

What are the best and worst elements of your job?
The best element is the wide variety in my daily work. As our European Technical Centre is of a manageable size, we can physically keep short distances between the various disciplines of vehicle development. Perhaps this variety is also the biggest burden – sometimes I would like to go into more depth.

What car do you currently drive?
My current car is a Genesis Coupe with a 3.8-liter V6. I love the sound of that engine.

Emissions legislation aside, what's your dream engine spec?
My heart beats most for high-revving engine concepts – perhaps this goes back to my

> "As an engineer, I admire the well-balanced in-line six-cylinder or even the decadence of a 12-cylinder, but I also pay tribute to those who succeed bringing two-cylinder engines to market with VVT and charging"

roots as a mechanical development engineer, and the respect that I've always had for sophisticated component design.

What would be your ideal engine specification for today's eco-friendly world?
When I look back over the past 20 years, the industry has achieved giant advances in the efficiency of drivetrains, to the point that today, we can fit a modern, three-cylinder diesel engine to a B-segment car that will consume 80mpg. With figures like these, I'd find it very difficult to opt for any other type of specification for an eco-friendly world.

In your opinion, what is the best engine that's ever been produced?
Perhaps it's not a single engine, but a group of machines that, at their time, established a new era. Maybe it's the first engines from Lenoir, Marcus, or Otto. Or perhaps it's the famous GM small block, or Porsche's four-cylinder Boxer for VW. If we use the end benefit to the customer as a benchmark, an unassuming one-cylinder, two-stroke engine needs to be mentioned, as it founded mass motorization in many countries through the humble moped and scooter.

What OEMs do you have particular respect for in terms of engine development?
I have great respect for all those that go to extraordinary lengths during their respective eras. As an engineer, I admire the well-balanced in-line six-cylinder or even the decadence of a 12-cylinder, but I also pay tribute to those who succeed bringing two-cylinder engines to market with VVT and charging, or stick to flat and Wankel designs. From personal experience, I know that powertrain development and production for cost-sensitive segments and markets is also highly challenging.

In your opinion, what will be powering a typical family sedan in the year 2030?
To answer this question, I inevitably have to mention *Back to the Future*, a film that I saw with my seven-year-old son. Since then, I have had to explain to him that you can't buy hovering skateboards, which, back in 1985, this film predicted would be on general sale around now! To that extent, I am aware that predicting the future is impossible, but if I must, then I'd consider liquid and gaseous hydrocarbons – from whatever source – as an outstanding mobile energy storage unit. However, I am convinced that the IC engine will still play a central role right through to 2030 and beyond.

Illustration courtesy of Magictorch

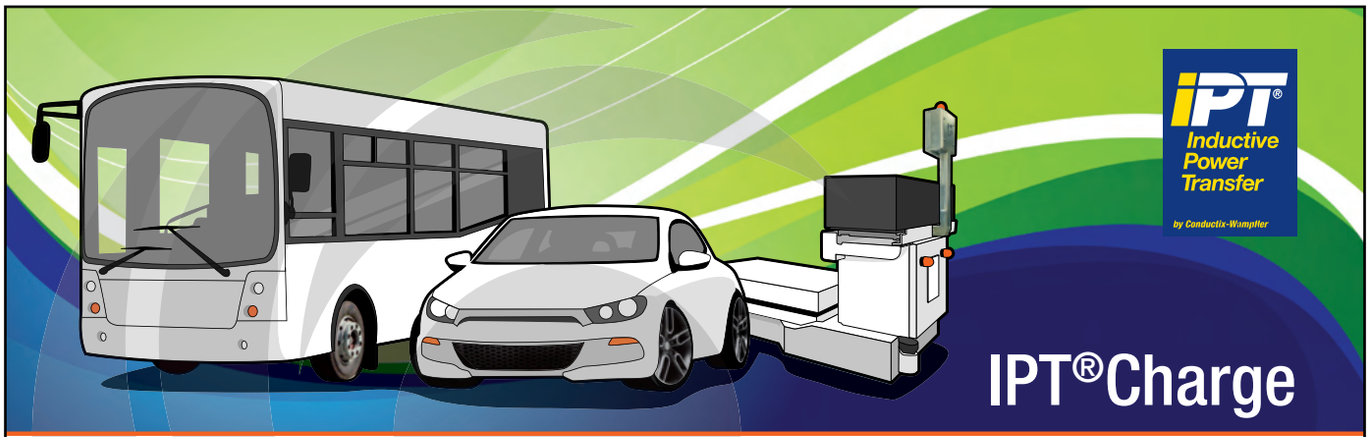
Motion picture

Could digging up existing highways in order to embed power lines for charging electric vehicles be the ultimate alternative-powered transportation solution?

WORDS: **JOHN CHALLEN**

One of the major problems car manufacturers face – and will continue to face – with the introduction of alternative-powered vehicles is the ability to keep them moving for long journeys without refueling. Fuel cell vehicles have been promised for many years, only to be repeatedly hindered by a lack of government investment in a hydrogen filling station infrastructure. Battery electric vehicles, however, are fairing much better. Having overcome the challenges of limited range and poor performance, EVs are now starting to break through, supported by an increasing number of charging stations. However, progress (and the charging process) is slow.

Static charging for EVs is not new, but recently several projects have emerged around the principle of in-motion charging. Using wireless power transfer measures, projects are being carried out to try to find a solution to the charging conundrum, and one of the most ambitious is taking place in North America. Beyond charging, the program could also have an impact on the ITS infrastructure and power delivery of the systems, as well as improving the benefits that they currently provide.



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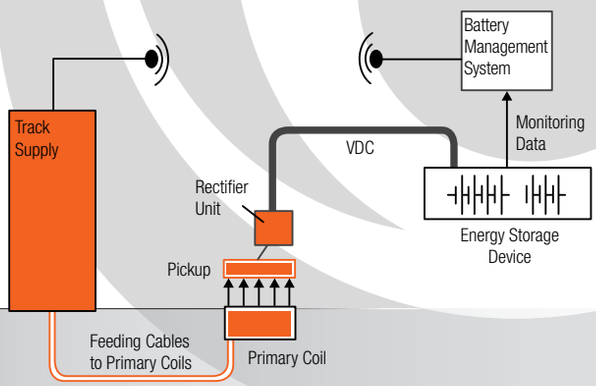

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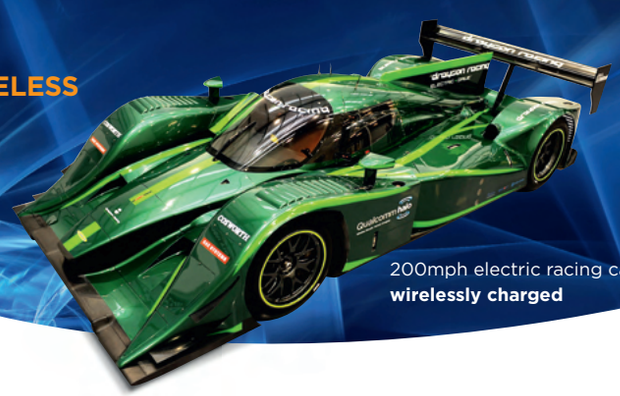

200mph electric racing car
wirelessly charged

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TECHNOLOGIES

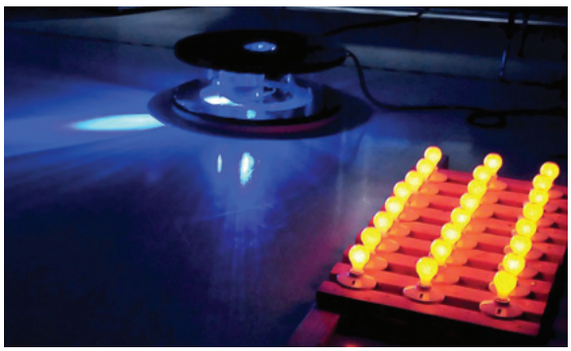
Qualcomm is a world leader in next-generation wireless technologies and since the mid 80's has developed technology and solutions for the wirelessly industry. Qualcomm believes electric vehicles will be the next major market that will go wireless.

Technology in itself is only one part of the total wireless electric vehicle charging commercialization equation. A whole industry needs to coalesce around a single standard, a new ecosystem needs to develop to deploy the technology and regulatory and standards bodies need to be engaged.

Bringing a new wireless electric vehicle charging solution to market will require a significant, multi-year investment and Qualcomm is one of the few companies that has the technical and financial strength to make the necessary long term commitment.

www.qualcommhalo.com

Qualcomm halo
Wireless Electric Vehicle Charging



"At the moment, people are solving the problem with the obvious rather than the elegant. You pull over and get charged instead of getting recharged as you drive along"

Dynamic duel

Energy Dynamics Lab (EDL) – a wholly owned subsidiary of Utah State University – started a wireless power project in June 2010 and the program has now reached an advanced stage. Having proved that the technology works in a static scenario, attention has turned to the in-motion element. "The goal of the project is to make wireless power practical for electric vehicles, starting with stationary charging applications and then moving to in-motion applications on electric roadways," explains Jeff Muhs, director of business development at EDL. "The research is focused on improving efficiency, power levels and ensuring the safety of wireless power in those applications."

In practice, an electric coil or pad is placed under the road surface, with a similar coil or pad placed on the vehicle. The magnetic field passes between one and the other in order to create energy – with the upper pad inducing a higher current. In development, EDL has used a series of plastic cylinders to replicate the distance between the road and the underside of the vehicle, and Muhs says that stationary wireless charging has indicated an output of 5-10kW over a distance of 203 to 302mm, with a transfer efficiency of 97%.

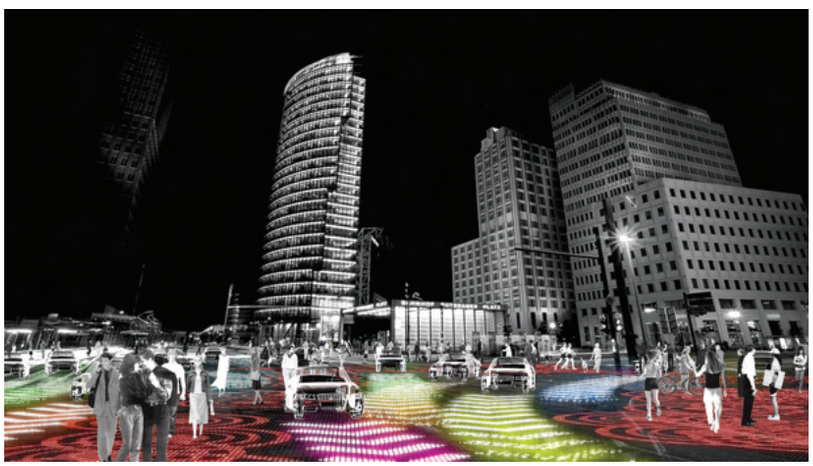
EDL believes one of the benefits of such a system would be a battery that is 80% smaller than the current offering, bringing down the total cost of the vehicle. Muhs also hopes eventually to prove the technology at speeds up to 112km/h (70mph). "Efficient in-motion charging is possible, but it will require a bit of reconfiguration of some of the hardware and software," he continues. The EDL director is, however, tight-lipped about exactly what is needed, although he does hint at modification of the power electronics and the design of the wireless power transfer mechanisms. The theory is that an EV could operate in a similar fashion to that of a slot car with the aid of the transmitting coil under the road, spaced a few feet apart. Power drawn from the road surface would then allow people to travel very long distances without needing to use the more traditional charging station. In theory, the potential is there.

Above: Future versions of the system architecture developed at EDL have the potential to be embedded under the pavement and transfer power to vehicles at speeds of 112km/h

Coming soon

Now 21 months into the project, the technology has already been proved in the lab, and a demonstration is slated for Utah in the next 12 months. "The research is now shifting toward in-motion, or at least configurations that are applicable to both stationary and

Below: In general, car makers remain cautious about the future of wireless charging, but here is a potential urban dwelling scenario from Audi



KEY MOMENTS IN WIRELESS POWER

1899: Nikola Tesla demonstrates the wireless illumination of phosphorescent lamps in Chicago before displaying a wireless power concept to a meeting of the National Electric Light Association.

1964: Electrical engineer William C. Brown demonstrates a model helicopter that is powered by a microwave beam. During 1969 and 1975, as technical director of JPL Raytheon, the American leads a project that successfully beams 30kW over one mile at 84% efficiency.

1988: The University of Auckland's Professor John Boys leads a power electronics group that develops an inverter using power electronics – and concludes that power transmission by means of electrodynamic induction should be achievable. The first contactless prototype is built.

1989: Japanese company Daifuku approaches Auckland Uniservices (holder of the patents from the University of Auckland) to develop wireless technology for car assembly plants and materials handling. The project provides challenging technical requirements on several different levels, including the multiplicity of vehicles.

1990: Boys' team develops technology that enables multiple vehicles to be run on the same inductive power loop and provide independent control of each vehicle.

in-motion applications," Muhs reveals. "Not all wireless applications will operate sufficiently with one or the other, so we are looking for something specifically related to both."

Muhs believes there are mutual benefits of what EDL is doing for the wider ITS community. "The apparatus in the road might help in lane tracking where the ITS technology could help keep the pads aligned and boost the power transfer accordingly. If the coils are not aligned properly, you get less power transfer, so the two areas can help each other. We certainly see a lot of synergies between the two."

Muhs also feels that ITS can help identify vehicles that are most in need of the power. "Some of the intermittence on the supply side could be leveled on the demand side by taking vehicles off the grid for a short amount of time, and having them rely purely on their battery," he suggests.

"There will be a certain number of local vehicles running during rush-hour that would not need electrified roadways for propulsion, so the energy could essentially be directed to avoid power transfer to those vehicles going longer distances that would need the power."

Predictably, there is a lot of excitement within the laboratories and research centers conducting these projects. In the wider ITS world, however, there is a more pragmatic response. "The breakthrough in EVs will only really take off when we have implementation of real cooperative systems," believes Richard Harris, member of the board of directors for the World Congress on ITS. "But these systems are something we have been talking about for a long time and something for which there is a lot of hope – but actually we haven't got anywhere with them.

"There have been demonstrations and trials and pushes toward operation, but nobody has really taken the plunge yet. Although I support the idea, launching it too early could prove a disadvantage in the long term."

Harris is also at odds with Muhs' view that wireless power transfer (WPT) could benefit ITS. "It may be a hindrance as it stops investment in other areas," he warns. "Do we even have the budget to repaint white lines on our roads? I don't think it's going to happen. Moreover, I don't think many governments like the 'big bang' approach – they prefer to buy one system that works properly and replicate it."

Muhs does concede that cost is clearly a hurdle – he puts a very rough per lane/mile cost at between US$1 million and US$5 million – but also knows that the process will be slow. "Research on a single vehicle will only likely occur in the next three years, and we are still five to 10 years away from having data from hundreds of vehicles," he reasons. "For commercialization, we are talking decades – not years!"

"I don't think many governments like the 'big bang' approach – they prefer to buy one system that works properly and replicate it"

Above: Richard Harris, on the board of directors for the World Congress on ITS, says commercialization of this technology might take not years but decades

Left and right: the Korea Advanced Institute of Science and Technology project is using strips of metallic materials placed at the bus terminal to assess wireless charging

2009: Nissan develops a plug-free technology that it claims will make charging electric cars easier and faster. The system is demonstrated on its zero emission vehicle and can charge in a parking bay normally reserved for plug-in vehicles.

2009: German electronics and powertrain developer IAV secures a patent on technology that allows vehicles to be charged as they drive over a road embedded with a rechargeable strip.

Researchers working for the company promise commercial availability within three years.

2010: South Korean researchers develop a system for zero-emission buses and cars to be charged wirelessly, via magnetic components that are embedded in the road surface, which interact with similar items placed in the vehicle's tires.

2011: In Japan, Toyohashi University of Technology and Toyota begin R&D investigations into the use of magnetic strips embedded under the road surface and in tires to provide constant power to electric vehicles.

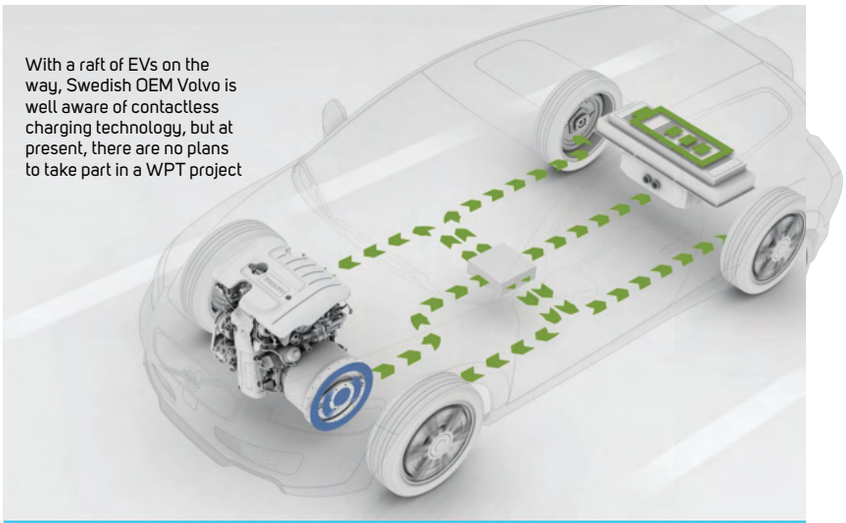
2011: An electric Volvo C30 arrives at Flanders' Drive. The company's Belgian technology partner modifies the electric prototype vehicle for inductive charging as part of a project that also involved bus manufacturer Van Hool and Bombardier, the tram builder.

Eastern promise

Shifting continents from North America to Asia, and it is understandable that Toyota – pioneer of the hybrid powertrain – has teamed up with Toyohashi University of Technology on a program that is based on the theory of electric railways. Taking the source of energy from power lines, researchers have proposed converting this energy into radio frequency (RF) by high-speed inverters that are integrated into tracks in the road. This RF voltage would be picked up by the electric vehicle via a specially fitted steel belt in the tires, generating an electrical charge to boost the vehicle's battery. The belt in the tire and the metal plate on the road is claimed to be a more cost-effective measure than the coils employed by Utah. Toyohashi also believes that leakage through the electromagnetic field is very small, further boosting the efficiency of the system. It has even been suggested by some industry experts that these communication lines could be used to the benefit of ITS from the point of view of relaying information from existing technologies, although the researchers haven't commented on these reports as yet.

Forward-thinking

Jack Opiola from D'Artagnan Consulting in the USA, however, is currently working on projects involving charging stations in Oregon, but accepts that in-motion ideas and vehicle WPT should have its place – especially with public transport. With more than 35 years' business experience specializing in project management, PPP/PFI projects, and business planning for technology projects spanning electronic road pricing and ETC to advanced parking markets, Opiola also has a keen interest in the electric vehicle movement and highlights the Korea Advanced Institute of Science and Technology (KAIST) project.



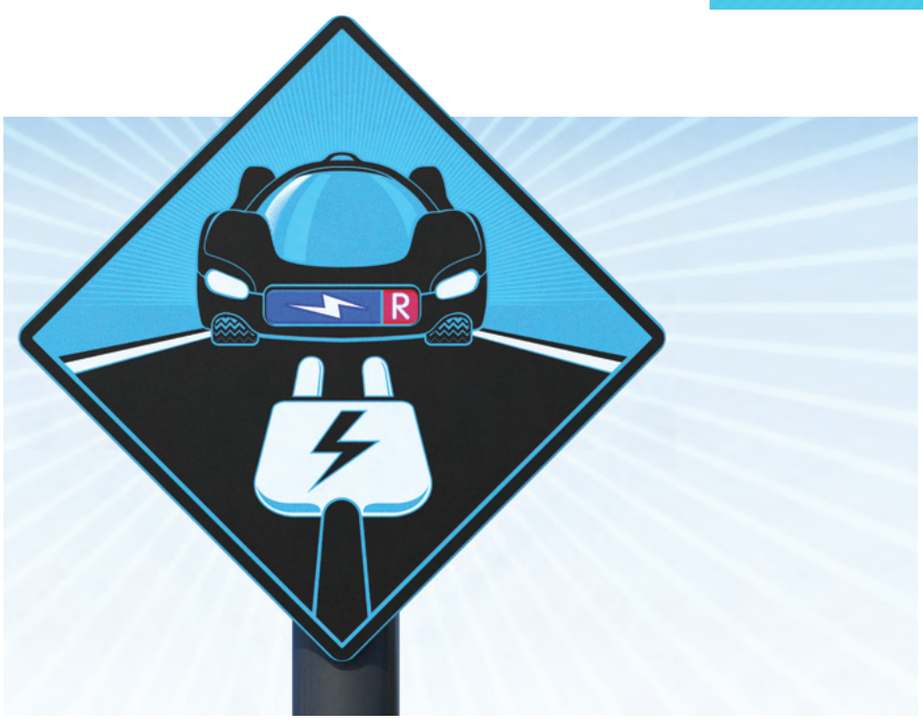
With a raft of EVs on the way, Swedish OEM Volvo is well aware of contactless charging technology, but at present, there are no plans to take part in a WPT project

THE WAITING GAME

Despite being the 'customer' for many of these proposed solutions, car makers have their reservations about the electrification of roads. Although not ruling the technology out, at the same time they don't expect to see any major breakthroughs anytime soon.

"We believe that inductive charging while moving is technically feasible," admits Larry Haddad, general manager, product strategy and planning, Nissan. "But currently it is cost-prohibitive as it would require massive amounts of expense for the metals alone that would be inlaid into the road."

Johan Konnberg, manager of Volvo's C30 electric vehicle, and head of the company's inductive charging project, is also au fait with contactless charging, but says the company is not planning to get involved in WPT projects for its cars. "We follow the development in the market, but the main drawback is the infrastructure," he says. "A system like this would require huge investments, and you have to consider the so far unexplored effects from magnetic fields. I think such a network is realistic, but within a very long timeframe – 50 years or so."



KAIST is employing a similar approach to that of Utah on four prototype buses, although it is using strips of metallic materials placed at the bus terminal.

"I think what the Koreans are doing is more like the transition; electrification of our highways is more like a glimpse of the future," Opiola states. "At the moment, people are solving the problem with the obvious rather than the elegant. Currently, you pull over, get charged, and then move on again – instead of getting recharged as you drive down a stretch of highway.

"Like many other projects in the ITS field, they've got the idea right – and it's certainly a more elegant solution for the users – but the world as we know it would have to change to adapt to this," Opiola adds. "It's the cost of the change that worries me," he concludes. "You'd have to effectively close a lane to lay the cable and put the connector in, and for roads that aren't heavily used in Utah that can be done – but for the M25, or a major road in or out of London or Los Angeles? The delay and the impact of trying to lay that would be unbearable and the cost would surely be too high. On a new road it's fine, but the costs of retrofitting it would be huge."


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Illustration courtesy of Ben White

Headhunters

Car makers and suppliers are desperate to recruit engineers who will help them accelerate their EV development programs, but the problem is that there's a lack of skilled personnel out there. ***E&H*** speaks to some leading names from OE, supplier and recruitment level, to find out just how serious the situation is and what can be done to improve it

THE INDUS NEEDS YOU!

OUR EXPERTS:

SD: Steve Doyle, director, Consilium Group
HW: Harry 'Skip' Wagner, vice president human resources, Delphi Electric/Electronic Architecture
RT: Rebecca Trengove, head of corporate affairs, Axeon
JL: Jonathan Lee, chairman, Jonathan Lee Recruitment
PR: Pascale Ruiz, HR director for Europe, Nexteer Automotive
DH: Dave Hemming, director of engineering, Prodrive Automotive Technology

Is there really a shortage of skilled engineers in the EV/HEV sector, or has this problem been blown out of context?

SD: There is a huge skills shortage of qualified and experienced engineers across the board in the automotive industry. This is particularly so in the fields of powertrain and transmission development as the manufacturers compete to produce more fuel-efficient and low-CO_2 systems, and this is exaggerated in the HEV field due to the relatively recent introduction of this technology.

HW: One respected consultancy suggested that in the USA in 2011, 50 new MBAs and 18 law-school graduates existed for every one new engineering graduate. Recruiting in the HEV area tends to be a bit more challenging as it is a new, quickly expanding specialization, where demand for related skills is growing faster than the pool of experienced candidates.

PR: There is a lot of demand at the moment for engineers with the kind of skills and experience that Nexteer looks for. Software engineers and electric drive experts are in particular demand, but we don't have a shortage. This could be because Nexteer has spent a lot of time developing the right kind of people in-house. It's not a quick solution, but if you can build a reputation for producing high-caliber people, it becomes much easier to attract the right external candidates for jobs.

DH: There is a general shortage of experienced engineers across all disciplines, but the problem is particularly acute for electrical/electronic engineering. Clearly, we speak to many different companies, as well as the specialist recruitment consultancies, and it is very much an issue across the whole automotive industry.

Just how bad is the problem?

SD: I graduated in engineering just over 20 years ago and have spent five years in engineering and 15 years in automotive recruitment. I really can't recall a time in the past 20 years when recruiting engineers has been so difficult, and this is particularly true in the areas of power electronics, motor design and battery experts.

"It is definitely an employees' market now, with the best engineers able to court a number of potential employers"

DH: It is always very difficult to quantify something like this, but I don't think we have ever quite had the difficulties we are experiencing now. It is definitely an employees' market now, with the best engineers able to court a number of potential employers.

How do you personally see the employment situation?

SD: Some employers will win and some will lose. If an employer appreciates the significance of the skills shortage and the impact that could have on their ability to design, develop, produce and therefore ultimately make profit, then there are things that can be done. The ability to recruit over the next five years will be a significant business advantage over the competition. A very close alliance with your chosen recruitment partner is essential to work together with a strategic and thought-out approach to attracting new staff. All aspects of employment must be faced, not just basic salary, which is where many employers stop thinking.

RT: Axeon is headquartered in Dundee, Scotland, and this location is not necessarily conducive to attracting automotive engineering talent. As such, it can be difficult to recruit staff in this area with relevant experience. However, we have opened an office in the West Midlands, UK, partly for its proximity to our current and prospective automotive customers, but also because of access to a wider technical and engineering talent pool.

TOP TIPS FROM A RECRUITER

With more than 10 years of HEV and EV recruitment experience, Consilium Group is established as a market leader in this sector. Steve Doyle, the company's director, outlines his top five tips for those both recruiting and those looking for jobs.

ENGINEERS LOOKING TO MOVE ON

1: Create a mission statement.

2: For the application process, take professional advice with regards to your job search. Preparation is key. Your CV must be perfect and distributed with a targeted approach from one or two agencies in your field. If you give them commitment, then they will commit to you. Do not use the splatter-gun approach, where you send your CV to every job board and agency under the sun. Duplication and ill-considered applications to inappropriate vacancies or employers is a waste of everyone's time and will ultimately do you no favors.

3: Don't just look at salary, look at the overall experience and day-to-day engineering content and challenge, plus longer-term scope and opportunity.

4: Think about the challenges facing HEV and EV recruitment over the next five years; does your potential new employer address these problems in the market?

5: What is the employer's mission statement in comparison to your personal mission statement? The two really must have synergy.

ORGANIZATIONS LOOKING TO RECRUIT

1: Define your recruitment mission statement and acknowledge the importance of the task.

2: Form a partnership with a recruitment specialist who knows your market, and work together closely.

3: Ensure your overall package and working experience is market leading. Remember – it's not just about the money!

4: Make sure the recruiting managers are on board – "too busy to read CVs" is no excuse.

5: Move quickly and intelligently. A clearly defined and efficient recruitment process is a potential employee's first impression of you; so many candidates are lost because of their poor initial perception of the employer.

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E INDUSTRY NEEDS YOU!

Is this recruitment shortage a global problem or are certain specific regions suffering?

SD: The USA and Japan have very well developed teams within these fields and they were earlier to the game. Europe has followed and is currently playing catch-up with some significant teams at various OEMs. China is developing at a tremendous rate and due to the fact that the vehicle retail market is in its relative infancy, the resistance to buy outside of pure gasoline and diesel vehicles is not so ingrained in the customer base, and so the level of HEV and EV sales are potentially huge. China is reacting fast and reaching out to the rest of the world, paying top dollar to recruit experts to develop their products for them.

What are the solutions?

SD: In the short term, flexibility by the employers, and acceptance to take an engineer with core skills and develop the more specific skills to their needs. Find a recruitment partner that knows the market, and that has the connections and knowledge to source intelligently and innovatively. In the long term, the future is all about apprentices, sponsorship of grads, graduate training programs, and generally, encouraging youngsters that engineering can be 'green' and that a career in electric vehicle development is a career in our planet's future.

HW: Among many alternatives to address the longer-term challenges, Delphi has decided to start by encouraging more young people to pursue science and engineering degrees. We are working with schools and universities and sponsoring programs that transfer the excitement of engineering into the broader community.

JL: For recruiters, there are some tips for the short term: build trust from the first meeting, live the values of your business, and show that it offers a secure future for the candidate. Don't eliminate good candidates through inappropriate filters such as particular qualifications or experience. Look for transferable skills coupled with bright, adaptable, enthusiastic talent. Have an efficient recruitment process that moves quickly, especially when a decision is made. Remember that the best candidates may receive multiple offers. And finally, retain existing good people by offering the right training and progression, coupled to good internal communications about business activities and strength.

PR: We've learned that it's not necessarily a question of specific skills being in short supply: the right mind-set can be just as important. Developing and producing

Delphi VP for human resources, Harry 'Skip' Wagner, says part of the problem in the USA is a lack of engineering graduates

"China is reacting fast and reaching out to the rest of the world, paying top dollar to recruit experts to develop their products for them"

THE GERMAN PERSPECTIVE

One car maker that has witnessed huge year-on-year growth over the past decade in Europe is South Korean organizationr Kia. With its European tech center located in Rüsslesheim, Germany, the OEM's head of powertrain engineering, Joachim Hahn, is well placed to comment about the challenges in recruiting skilled EV/HEV engineers, and interestingly, he says that while there is a growing engineering recruitment problem in Germany, the scenario there is not as bad when compared with other countries. "We have a happier situation. In the past decade, the German government made substantial investments in education – but specifically engineering education. We are now reaping the rewards of these funded universities, colleges and courses," says Hahn.

"What we do – and have done for many years – is to have close contact with universities. We established a strategy long ago to not only hire engineers with lots of experience at a senior level, which forms the core of our engineering team, but to also attract the younger people from university with fresh minds and give them a chance to progress in our company. It's a good combination."

THE INDU NEEDS YOU!

"Companies need to think long-term about their people, not just in terms of the skills they need today and tomorrow"

Engineering director at Prodrive Automotive Technology, Dave Hemming, says countries with the right engineers are leading the way

complex electromechanical systems, such as electric power steering, is much more of a team effort than some other automotive technologies. Your people have to communicate very well, work together very closely, and generally, work with a lot of urgency. You need much more frankness and a real family spirit for people to deliver effectively. Creating this kind of culture makes it easier to develop people in-house and also makes your company more attractive as a workplace. Companies need to think long-term about their people, not just in terms of the skills they need today and tomorrow.

Is the lack of engineers hampering development and progress of technology?

SD: Yes. Larger organizations are able to move people around and cover shortages, but I have seen evidence where the inability to recruit has resulted in the loss of orders and even the demise of smaller component SMEs.

HW: I don't believe so. HEV technologies are in the early stages of their product lifecycle, so the technology is relatively low volume with inevitable cost implications. To keep these vehicles as competitive as possible, we must focus on improving product features, while simultaneously reducing costs. The economics of the current and future business therefore dictate the number of engineers more than their availability.

DH: It is not so much hampering development – it is more the case that those countries with engineers with the right skills are simply leading the way.

Back to the future

A Texas company is planning on building a fleet of 300 battery-electric cars based on the legendary **DeLorean** coupe

WORDS: **JIM MCCRAW**

Following further development work on the prototypes with engineers from Epic Electric Vehicles, DeLorean plans to launch the DMC EV next year

Last October saw the launch of the newly reconstituted DeLorean Motor Company. Located in Humble, Texas, the event mostly went unnoticed by the world's media, but those plying their trade in the fast-moving world of EVs should pay attention: DeLorean, along with Epic Electric Vehicles, a Californian organization that aims to get reliable, high-performance vehicles to market, unveiled a development version of an electric powered DeLorean automobile. If ever there was a vehicle suited for the electric revolution, then this is it!

DeLorean, which has owned the rights to the name since 1995, was already in the business of buying, restoring, and selling the stainless-steel-bodied gullwing-door sports car that made its debut at the Geneva Auto Show in 1981, and such has been the success of its squirreling in recent times that it now owns the largest stock of DeLorean replacement parts in the world.

A couple of years ago, DeLorean's new owner, Stephen Wynne, originally from Liverpool, UK, started exploring the idea of replacing the original Peugeot-Renault-Volvo shared 2.8-liter V6 gasoline engine with a battery pack and electric motor supplied by Epic, and that transformation dream is now coming to fruition.

DeLorean plans to market the DMC EV in the USA in 2013, and will further develop prototypes combining the existing DeLorean automobile with the Epic electric powertrain. Together, engineers from both organizations plan to produce a number of prototypes using the Epic powertrain for evaluation this year and next.

Being cool

"Part of the problem with electric cars is that they have an identity crisis," says Wynne. "I think the Tesla is wonderful, I think the Leaf is wonderful. I think the Volt is wonderful. But they all don't have a lot of curb appeal. They're not cool cars. So, that was part of the inspiration of doing it with the DeLorean, especially to appeal to the early adopters who can afford this type of car. They'll have something special to show for their efforts and what they've spent on it." The current target price for a DeLorean EV is US$95,000.

Wynne says that all the DeLorean EVs his team builds will contain full updates to suspension, steering and chassis that his refurbished gasoline-powered cars carry. The EV version will ride on Michelin Pilot Exalto performance tires, in 17in and 18in sizes, on new DeLorean alloy wheels, far surpassing the performance of the car's original 14 and 15in tires of 30 years ago.

1

"One thing that's kind of neat for us is that we're spending our time perfecting the drivetrain. All of the regular DeLorean stuff is already perfected and we don't have to do much testing on that other than the new items we're perfecting for saving weight."

Wynne says that new parts and components around the car, including dashboards, bumper covers, electric air-conditioning and a new vacuum-formed honeycomb composite floorpan provided by partner Epic EV, should save a total of about 115kg, which brings the EV version down to about the same weight as the original car. The EV instrument panel will be redone in a digital analog format to replicate the original instruments' look, but include a battery condition/charging indicator. And aside from that, the thinking is that the interior is very close to a standard DeLorean. Eventually, Wynne says, there will be an app for owners' cell phones that can report battery condition and/or turn on the electric air conditioner or heater remotely.

What lies beneath

In terms of handling, Wynne says the original DeLoreans were balanced at 32% front and 68% rear, but the EV should come in at 45/55, with some of the lithium-ion phosphate batteries distributed around the car to help weight balance.

He also says that, because these are all 1982/83 cars, and the production run is only 300 units, they don't have to meet any of the current federal regulations that hamper companies building brand new electric cars.

Epic EV designs and manufactures a variety of electrically powered land and marine products. Epic EV founder Chris Anthony, one of the creators of the defunct Aptera three-wheeled electric car company, built his design shop in Vista, California, and the production factory is located in Vivian, Louisiana.

> "The original DeLoreans were balanced at 32% front and 68% rear, but the EV should come in at 45/55"

1: The DMC EV currently offers a driving range of 160km, but this will be improved upon as market launch nears

2: DeLorean owner Stephen Wynne says a DMC EV is exactly the type of product that the EV sector needs

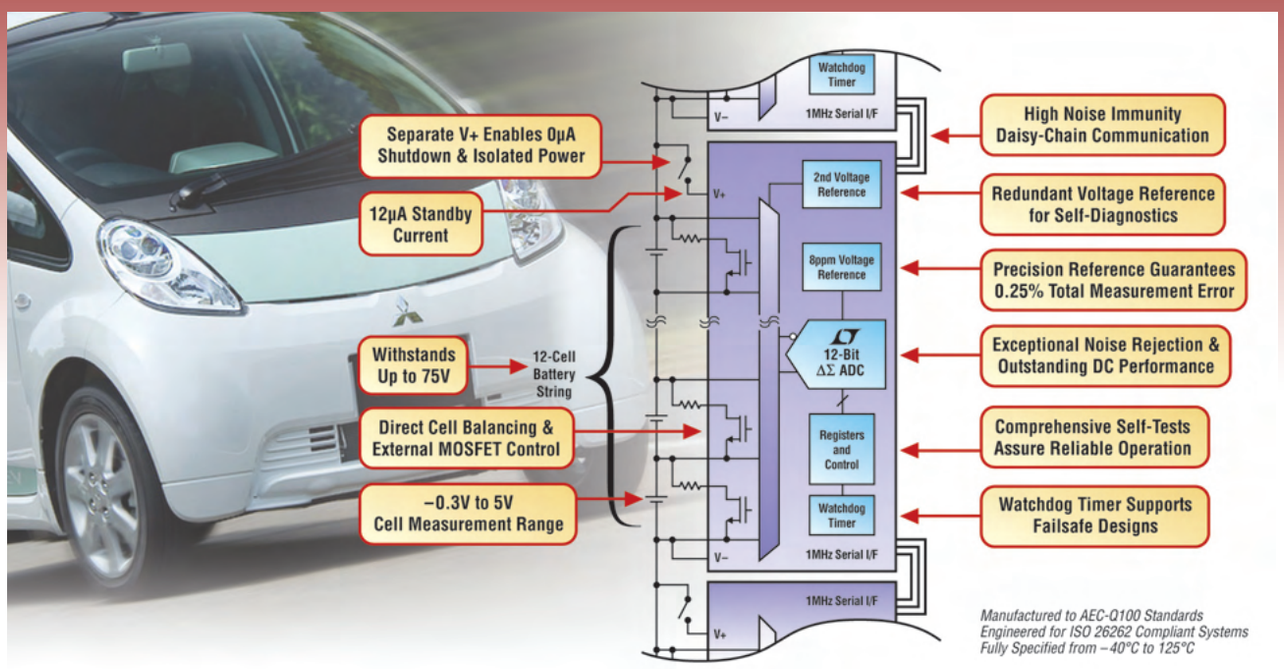
2

The prototype DeLorean uses a liquid-cooled 400V AC induction electric motor that generates 190kW at between 5,000 and 6,000rpm, and 488Nm of torque from zero to 7,200rpm, with a maximum motor speed of 14,000rpm. Like most EVs, it uses a single-speed transmission and reverses motor rotation to effect reverse gear, using a final drive ratio of 3.12:1 multiplied up to 8.28:1.

The battery package is claimed to have a quick-charge time of 3.5 hours from empty to full using a 240V charger at 70A, and the car is fitted with the standard charging plug.

The company claims the prototype has tested to a top speed of 201km/h (125mph) and a 0-100km/h time of 4.9 seconds, with a projected range of 160km (100 miles) of city driving and a projected battery life of about seven years. Wynne says the company's priority now that all the hard work has been done is the even harder job of extending the DeLorean EV's range to avoid customer anxiety by continuing weight reduction programs and adding battery capacity. The industry, DeLorean enthusiasts, and even most of the green lobby, wait with bated breath.

Road Proven Battery Stack Monitor



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LTC6803-3	2nd Generation Stack Monitor	Now
LTC6803-4	2nd Generation Stack Monitor	Now

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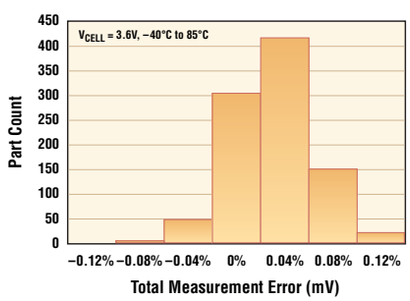

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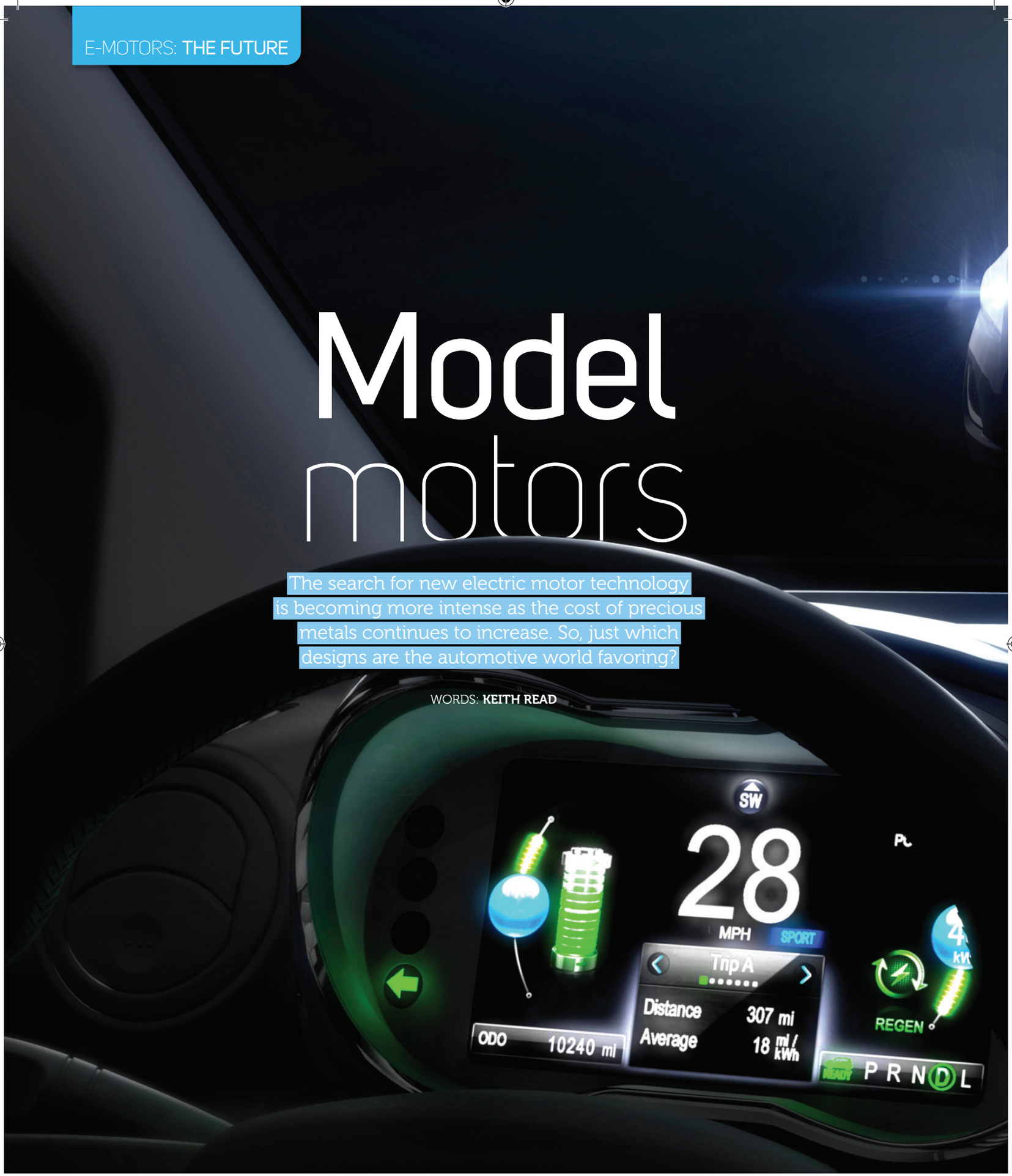
LINEAR TECHNOLOGY

Model motors

The search for new electric motor technology is becoming more intense as the cost of precious metals continues to increase. So, just which designs are the automotive world favoring?

WORDS: **KEITH READ**



GM is keeping under wraps as many details as possible about the upcoming electric Chevrolet Spark. It's thought that an electric motor with peak power of 85kW and sustained power of 56kW will be used in combination with a nanophosphate lithium-ion battery from A123 Systems

From Asia to North America, and Europe in between, international vehicle manufacturers and electric motor companies – and those producing electric power-control and drivetrain systems – are working flat-out on new designs to increase efficiency and power density for future EV applications. Even old concepts are being updated to overcome the rocketing costs of permanent magnet and rare earth materials following political moves in China, which held the monopoly.

Peter Barrass, UK-based engineering vice president for Sevcon, a pioneer in control equipment, says a key objective over the next 10 years is to perfect changes in the power electronics components so they can operate at higher temperatures. "In semiconductors, silicon devices are currently at 175°C maxima, and we expect the next generation to go up to 200°C. However, things like gallium nitride (GaN) and silicon carbide (SiC), could operate at up to 300°C."

Silicon chips

But Barrass warns that such innovations have been "just around the corner" for a long time, and issues such as wafer defect density must first be overcome. "It's massively higher in SiC than in silicon, which means you can only get a relatively small chip that hasn't got a defect," he says. "Defect density is very slowly going down, though, allowing producers to gradually increase the size of the piece of silicon that they cut out of the wafer. But it's still got a long way to go before it can get anywhere near the defect density of silicon. In power applications – the kind used in EVs – silicon chips are 1 x 1cm or bigger, so they're quite large pieces that must have zero defects."

Another consideration for power devices operating at 300°C is that the joints between the silicon wafer and its housing tend to degrade at higher temperatures.

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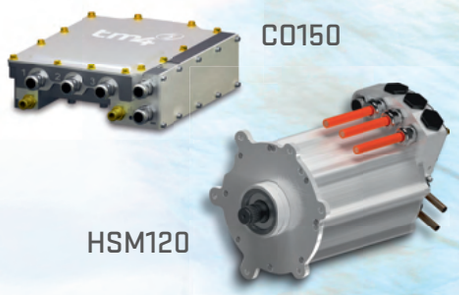
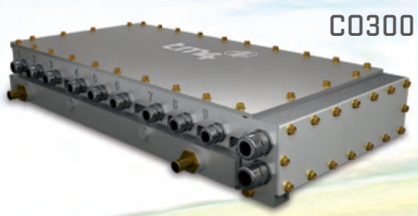


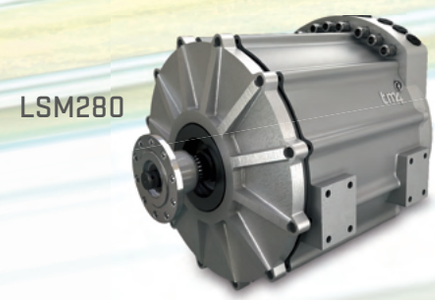
M⌀TIVE SERIES – High RPM Systems

Focusing on automotive and other light duty transport applications, these systems are operating at high RPM to offer maximal power density and can be configured with an inline or offset gearbox.



SUM⌀ SERIES – High Torque Systems

Intended for medium and heavy duty transportation, these powertrains are high torque/low RPM systems that are designed to interface with standard rear differentials without the need for an intermediate gearbox.



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"New joining techniques will probably be required to produce long-lifetime, high-reliability parts that can operate at 300°C," says Barrass. "Almost all power modules have a plastic body – and they are not designed to operate at 200°C, meaning new, high-temperature plastics will be required. There's also a knock-on effect on the rest of the system because other components, such as the link capacitors, are a limiting factor on temperature because electrolytic and film capacitors both have a maximum operating temperature in the 100°C to 125°C range."

It's a tricky situation, but new work on ceramic capacitors could resolve this issue – however, Barrass warns that a lot more development needs to be done before this technology can meet the needs of an EV traction inverter.

Integration, to reduce system package size, throws up additional challenges. "It's very attractive to try to get rid of the [copper] cables," continues the Sevcon VP. "But as power goes up, the size of the electronics tends to increase. The inverter, for instance, simply becomes too big for the motor – especially in the case of high-speed motors. And whether the motors are permanent magnet, induction or switched reluctance, there's a basic law that says the torque – and the cost – is proportional to its volume."

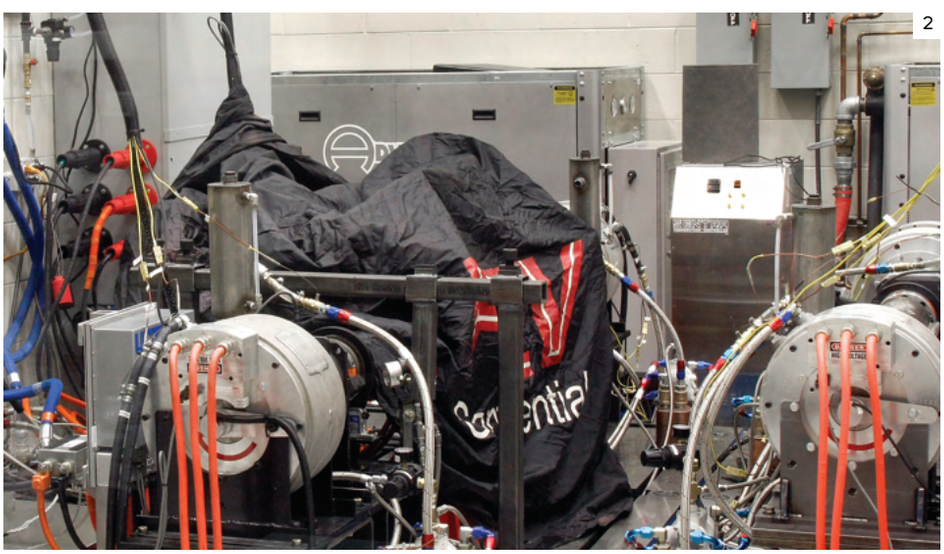
Induction motors, which can match the efficiency of permanent-magnet motors without using magnets, are well suited to traction applications because of their torque speed characteristic and field weakening capability, says Barrass. "There's a lot more activity going on in switch-reluctance motors which, fundamentally, are the cheapest you can make. But we have to overcome things like the torque ripple effect and some of the power converter challenges. However, there are solutions to those problems out there."

"Almost all power modules have a plastic body – and they are not designed to operate at 200°C, meaning new, high-temperature plastics will be required"

Peter Barrass, engineering vice president, Sevcon

1: The compact Gen4-series from Sevcon has been specifically designed to offer the lowest possible cost while maintaining very high reliability in the most demanding applications

2: Advanced electric drivetrain development takes place at FEV



Multiple choice

Dr Martin Pischinger, vice president of electronics and controls at FEV's North American technical center, sees system optimization and a reduction in usage of costly materials as being fundamental inroads that need to be made. "PM synchronous motors use [costly] rare earth materials and a goal could be to become less dependent upon these, although we won't be able to completely avoid permanent magnets. There will be all kinds of [electric] motors in the future, although maybe we won't find high-voltage DC motors because they are not so appropriate for EVs."

The general thinking is that switched reluctance and induction motors will offer viable alternatives to the automotive world, but Pischinger says there are pros and cons to all the main motor types when considered for EVs. PM synchronous motors score well for torque and power density and efficiency, but less so for overall costs, avoidance of rare earth materials and safety. PMSMs are relatively good for controllability and power electronics costs, but the FEV VP rates them as neutral for reliability and technical maturity.

According to Pischinger, DC motor technology fairs well when it comes to matters of controllability and power electronics costs, and relatively well for overall costs and technical maturity. "However, they're not altogether favorable when it comes to power density, efficiency and reliability," he adds. Pischinger rates induction motors well for costs, reliability and technical maturity, reasonably well for overall efficiency – but is only neutral for power density, controllability and the costs associated with power electronics.

Finally, when it comes to switched reluctance designs, Pischinger regards them as being reasonable for efficiency, overall costs and reliability, but remains only neutral when taking into account power density and technical maturity. "Disadvantages of SRMs are their controllability, power electronics costs, and in particular their NVH behavior," he adds.

Back to basics

Walter Burow is managing director of Heinzmann, a German company that produces hub and disc electric motors for specialist applications. Burow says that most basic designs will come under scrutiny for development in the drive to increase power density, improve efficiency and reduce costs. "The extended AC motor is big, has low efficiency, and low power density. However, you can improve this design by adding squirrel cages made from aluminum, rather than copper, and you can gain [efficiency] by revving this motor higher."

An alternative is the reluctance motor – an old concept, available in four main guises, that has never really been recognized in the past as an option. "Today, they're being viewed in a more positive light and I've seen them used in very demanding industrial off-highway applications, as well as in on-highway vehicles," says the Heinzmann MD. "The design doesn't use copper in the squirrel cage, only in the windings, and it has a toothed rotor, but without magnets. There is a big penalty in terms of power density, but they are significantly less expensive compared with permanent magnet motors and they are extremely rugged."

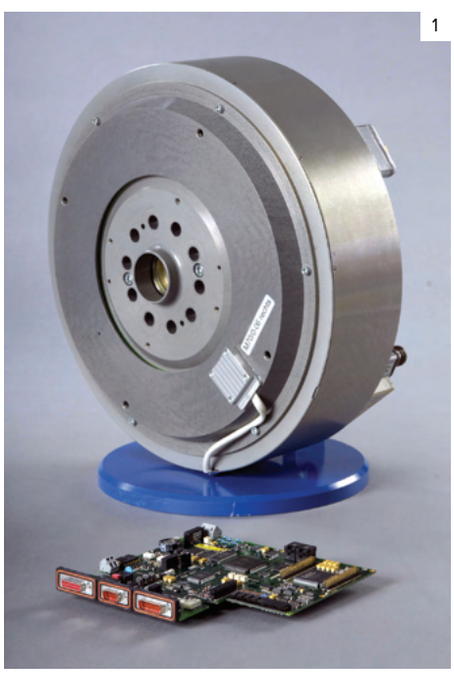
VIRTUAL ADVANTAGES

Electric motor designers are turning to engineering simulation to perfect systems for EVs. Scott Stanton, technical director for advanced technology initiatives at Pennsylvania-based Ansys, says demand for the company's software has soared in recent times. "With the explosion of hybrid technology, it's really taken off, not just in North America, but also in Europe and Asia," he says.

For more than 40 years, Ansys has helped manufacturers to see how product designs will behave in real-world environments ahead of producing costly prototypes. "Our simulation software allows EV designers not only to analyze an existing design, but also to help them design new motors and to optimize those for peak performance," explains the technical director. "Designers can look at tens of thousands of variations of the design without cutting a single piece of metal or building anything."

But Stanton is keen to make the point that motors do not work in isolation: "Therefore we do extensive work on the analysis of battery designs and power electronics for conversion of the DC voltage from the battery to the AC voltage needed to drive the machine and control it. With our integrated solution, designers can use different software to analyze the battery, its connection to the power conversion electronics, and connection to the electrical machine, to see how the whole system operates."

This, says Stanton, gives OEMs the advantage of being quick to market with a right-first-time system. "Whoever is first in the market gets name recognition, and when you get name recognition you end up leading the market in sales. To get to the market first is where our tools come into play."



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1: The M70 from Magnet-Motor weighs only 34kg and offers continuous power of 50kW and maximum torque of 1,050Nm

2: For parallel hybrid applications, Magnet-Motor's Integrated Starter Generator can be arranged in-between the IC engine and the conventional gearbox, taking only 70mm additional length for 65kW of continuous electric power

2

One drawback to the SRM, says Burow, is that it needs special power electronics. Currently, there's no high-volume standard range of modules available and until the first OEM decides to go with an SRM design, it's unlikely any of the major power module or semiconductor producers will invest in such a range.

Despite this, if Burow were a betting man, he'd put money on SRMs being developed for various applications – including automotive EVs. They can be produced with a high degree of automation, making mass-production extremely cost-effective. And objections to SRMs based on their reputation for being noisy do not hold water anymore: "They can be run at very high revs without exceptionally-high noise levels. It's about [careful] design of the stator and rotor to overcome noise issues," he says. Heinzmann's research and development engineers are looking at SRMs and Burow believes that other manufactures – including traction motor makers – are studying their potential. However, the MD believes wheel hub motors are probably too expensive for passenger car applications at present.

Manfred Heeg, CEO of Magnet-Motor – part of the New York-based L-3 Communications group since 2006 – says there will be a drive for up to 30% more energy-efficient use of electric power, including electric motors in the industrial sector, in the coming five to 10 years. He believes this situation will be achieved by a transition to permanent-magnet motors and the respective smartpower electronics – and that rises in magnet prices won't slow this.

"With induction motors, where electric excitation generates the magnetic field, if you can replace this active excitation with permanent magnets, you immediately gain up to 5%. This is particularly so for electric motors used in industrial applications. Car electric motor applications already have a very modern PM type, and very few are reluctance motors."

The Mission R electric superbike boasts 14kWh of energy storage and a 100kW compact AC induction motor, meaning it accelerates to 100km/h from standstill in just three seconds

But, the Magnet-Motor CEO agrees reluctance motors are cheaper to produce: "If you want gains in efficiency, you are certainly looking at PM motors – especially for industries where we have a lot of inefficient motors," he says. "However, when we look at prices and the cost of these technologies – where the market puts pressure on the suppliers to get very cheap electric systems in volume-produced cars – there will be a move to the switched-reluctance type of electric motor. This is mainly true for generators/alternators in the lower power range, such as range extenders. Traction motors will always have to be of the PM type if you want to satisfy the demand for excellent efficiency, low weight and volume."

Size reductions

Reducing component size can be one route to reducing costs. Engineers at Mission Motors in California are skilled at reducing electric motors and associated equipment, having successfully designed and developed the Mission R electric superbike. With 14kWh of energy storage and a 100kW AC induction motor, they packaged nearly 90% of a Chevy Volt's power and energy into the compact motorcycle that reaches 100km/h from standstill in just three seconds, before hitting a top speed of over 255km/h (160mph).

In the coming 10 years, they will be looking to reduce costs, increase power density and enhance efficiency of electric drivetrains for cars, motorcycles and other vehicles, says marketing manager, David Salguero. "Electric motors are already quite efficient, especially when they are compared with internal combustion motors. But there's always room for improvement – although the last 10% is always 90% of the chore," he warns.

1: The highly-praised liquid-cooled controller from Mission Motors enables up to 150kW

2: Mission's AC induction and permanent magnet traction motors have been designed to meet vehicle torque and power requirements in a smaller footprint with less weight

> "Electric motors are already quite efficient,but there's always room for improvement – although the last 10% is always 90% of the chore"
>
> David Salguero, marketing manager, Mission Motors

"We increase power density by cooling loops, which make the motors much smaller and thereby increases power density. We're also using software as a way of improving efficiency. Being based in San Francisco, we've got some of the best software engineers in the world. They come from the aerospace industry, from Google, from Apple, and other such organizations, and in addition to that, we have [recruited] from the automotive industry. They're working together to develop some phenomenal technology, because software – and the control system for these motors – is really where you get the efficiency gains. Liquid cooling is not unique. But we concentrate on making ours much smaller. That reflects the fact that we started out focusing on motorcycle platforms, where [reduced component] volume is an absolute premium."

Salguero says the search for alternatives to the precious metals that have become an issue for permanent-magnet motors will intensify. "One major auto manufacturer has, for example, recently built a permanent-magnet motor using none of the metals that are going up in price right now." And with prices expected to only increase, suppliers and OEMs alike are stepping up their efforts to realize the next big thing in electric motor design.

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Transportation Weight Loss Diet Conference 2012

The Transportation Weight Loss Diet Conference will bring together designers, engineers, program leaders, and heads of industry from the global aerospace, automotive, and rail industries for a two-day conference dedicated to cutting-edge research and technologies aimed at reducing weight and decreasing overall carbon footprint, without compromising safety, efficiency, or operational ability.

Presentations will include real examples of how challenges and compromises can be overcome and avoided through intelligent design choices and initiatives, as well as new materials and engineering practices.

The conference provides an unparalleled opportunity for a transfer of ideas between transport sectors, highlighting the best new approaches with the greatest potential to reduce weight, save fuel, enhance performance, and lessen environmental impact. Don't delay – make sure you book your place in Boston this October!

PRELIMINARY CONFERENCE PROGRAM

DAY 1 Wednesday, October 24

Setting the scene: the future of mass reduction

The opening session of the conference will highlight key trends and motives for mass reduction in the automotive, aerospace, and rail sectors, as well as examining potential future supply issues for lightweight materials.

Keynote presentation
Matt Zaluzec, manager, Materials Research and Advanced Engineering Department, Research and Advanced Engineering Center, Ford Motor Company, USA

Lightweight rail transportation at Bombardier
Jacques Belley, R&D director, Standardization and Innovation, Bombardier Transportation, USA

Less is more: automotive downweighting opportunities with mixed materials
Greg Schroeder, research analyst, Manufacturing, Engineering & Technology, Center for Automotive Research, USA

Lightweight materials

This session will look at a range of materials for use in vehicle mass reduction applications. New-generation meta and para aramids, intermetallic replacements for Ni-based superalloys, magnesium alloys, metal matrix composites, and 'fuzzy fiber' will all be profiled. The session will also cover manufacturing CFRP parts.

Advanced lightweighting materials: Nomex, Kevlar, and beyond
Dr Ley Richardson, principal application research associate - Aerospace, DuPont Protection Technologies, USA

Gamma Ti alloys: commercial solutions for carbon reduction
Cameron May, director, GfE Materials Technology Inc, USA

How metal matrix composites have been redesigned for more machinability and lower cost
Patrick McGowan, vice president, GT Alloys, USA

Magnesium applications for lighter-weight vehicles
John Mowrey, CEO, ZD Metal Products, USA

Passenger environments

Transportation needs to be attractive and easy to use. Transportation operators and manufacturers need to satisfy passengers and customers. Consumers must view mass reduction as an improvement to their transport experience. This session will look at how this can be achieved.

Designing efficient passenger environments
Paul Priestman, director, Priestmangoode, UK

Cabin Concept 2050 based on a bionic structure
Ingo Wuggetzer, vice president Cabin Innovation and Design, Airbus Operations GmbH, Germany

Employing new design techniques to deliver lightweight seats
Alexander Pozzi, vice president Advanced Design Group, Seating Products, B/E Aerospace, USA

Low-calorie light infotainment
Ashutosh Tomar, senior researcher, Jaguar and Land Rover, UK

OCTOBER 24-25, 2012
BOSTON, MA, USA

Low-cost multifunctional-use composite to reduce weight
Prof Khalid Lafdi, professor, Department of Chemical and Materials Engineering University of Dayton Research Institute and Wright Brothers Institute Endowed Chair in Nanomaterials, USA

Developing volume manufacturing processes for carbon-fiber reinforced automotive body structures
Donald Lasell, president and chief engineer, Think Composites, USA

Manufacturing with lightweight materials
This session sees presentations covering high-speed automated manufacturing processes and techniques using composites; and looks at how smartphones may deliver new, strong, lightweight glazing solutions to transportation, as well as new mixed materials.

High-volume, high-speed preforming for structural composites
Daniel Buckley, manager of R&D, AGFM, USA

The development of effective prepreg solutions for the transport sector
Alasdair Ryder, business unit manager - High Volume Manufacturing, Umeco Structural Materials, UK

Strong, lightweight glass laminates for transportation weight reduction
Phillip Bell, product line manager, Corning Incorporated, USA

EASI: steel cord reinforcement for injection molded parts
Dr Dries Moors, innovation manager, Bekaert, Belgium

Lessons from aerospace: integrating lightweight materials information into engineering workflows
Dan Williams, product manager - Automotive, Granta Design Ltd, UK

Objective composites manufacturing process control: reducing uncertainty, overdesign and weight
Scott Blake, president, Assembly Guidance, USA

Lightening the way ahead
Phil Hall, managing director, Caterham Composites, Germany

Lightweight design of composite structures
Dr Robert Yancey, senior director - Global Aerospace, Altair Engineering, USA

Technologies for lightweight design and performance verification
Ravi Chilukuri, director, EASi, USA & Michael Lee, project manager, EASi, USA

Polyetherimide-carbon fiber as metal substitute in aircraft food tray arms
Dr Mohammad Moniruzzaman, product development engineer, Sabic, USA

Innovative solutions for railway floors and interior panels using cork
Antonio Coelho, R&D director, Amorim Cork Composites, Portugal

Automotive case studies and applications
What are the major vehicle manufacturers achieving in terms of mass reduction? This session looks at specific case studies of vehicles and programs.

VSL Project: sustainable and affordable technology for CO_2 emission
Tomasz Krysinski, chief engineer, PSA Peugeot Citröen, France

Weight reduction lessons and achievements: product development
Ramkisan Gite, PAT lead - Weight Reduction, Tata Motors, India

The BMW i3: a battery electric vehicle – right from the beginning
Oliver Walter, responsible product manager BMW i3, BMW, Germany

Using alternative plastic materials for weight reduction on heavy trucks
Dr Srikanth Ghantae, senior technology specialist - Plastics, Volvo Trucks North America, USA

Use of composites in bus structures for significant weight reductions
Mukul Mitra, program manager, Ashok Leyland Limited, India. Pradeep Kumar, manager - Global Bus & Coach Programme, Ashok Leyland Limited, India

Weight reduction through value engineering
Manoj Surana, manager - Engineering Research Centre, Tata Motors Ltd, India

Light-duty vehicle mass reduction and cost analysis: midsize CUV
Greg Kolwich, manager, Value Engineering Services, FEV Inc, USA

Reducing vehicle weight with composite materials
James Jones, CCG manager - Americas, Composites Consulting Group, USA

transportation weight loss diet conference 2012

DAY 2 Thursday, October 25

Simulation and integration

The design and engineering challenges of integrating composite materials into structures and parts is addressed in this session, with presentations focusing on simulation, design optimization and process control techniques.

Intelligent adhesive bonds that provide an early warning system for structural failures

Prof Shaker Meguid, professor and director Engineering Mechanics and Design Laboratory, Department of Mechanical and Industrial Engineering, University of Toronto, Canada

Design and fabrication of multi-material structures

Prof Glenn Daehn, professor, Ohio State University, Materials Science and Engineering, USA

Laser cleaning pre-treatment for bonding of lightweight metals

Georg Heidelmann, president, Adapt Laser Systems, USA

Achieving weight reduction through design, material selection, and application-specific products

Tony Padula, product manager, Amphenol Pcd, USA

Mechanical performance of friction spot-welded joints in 2198-T8 alloy

Dr Jorge F. dos Santos, head of department, Helmholtz-Zentrum Geesthacht, Germany

Aerospace materials for aircraft lightweighting applications

Dr Ralph-Dieter Maier, manager, Aerospace Technologies, BASF Corporation, USA

Design-driven innovation and cross-pollination for lightness

José Rui Marcelino, design manager, Almadesign, Portugal

Parametric study and topology optimization for platform concepts

Anthony Norton, senior director, Global Automotive & Off-Highway Vehicles, Altair, USA

Lord UltraConductive film and coatings for lightning strike protection

Ross Zambanini, senior global market segment manager, Aerospace & Defense, Lord Corporation, USA

Experiences with the electrical use of carbon fiber

Walter Kiersch, CEO, Carbon Conduction Technologies (CCT) GmbH, Germany

Automotive case studies and applications

Edison2's Very Light Car: a new automotive architecture

Oliver Kuttner, CEO, Edison2 LLC, USA

Half-weight vehicle with new materials: chassis, body, and driveline

Mogens Løkke, CEO, ECOmove ApS, Denmark

Full vehicle lightweight designing based on CAE techniques

Javier Rodriguez, director Vehicle Integration & E/E, EDAG Inc, USA

Prospective view of CFRP as a technology for weight reduction of automobiles

Toru Yamanaka, general manager, Automotive Center, Toray Industries Inc, Japan

HiAnt simulation: simulating structural continuous fiber-reinforced thermoplastics parts

Vasant Pednekar, senior engineer Application Development, Lanxess Corporation, USA

Automotive safety

One of the key concerns in downweighting vehicles is the issue of safety. This session looks at the issue not from the perspective of how far we can compromise safety for mass reduction, but rather how mass reduction actually increases safety and what lessons may be learned from motorsport.

Enhancing vehicle safety and crashworthiness with weight-loss improvements

Byron Bloch, director, Auto Safety Expert LLC, USA

Designing a lightweight body structure meeting federal impact requirements

Gregory Peterson, senior technical specialist, Lotus Engineering Inc, USA

Characterization of crash properties in aluminum extrusions

Jonas Braam, research engineer, Sapa Technology, Sweden

New materials and design technologies for motorsports

Prof Pete Hylton, director of Motorsports Engineering, Indiana University Purdue University Indianapolis, USA

OCTOBER 24-25, 2012
BOSTON, MA, USA

Aerospace design developments

Looking specifically at aerospace, this session considers specific examples of mass reduction developments and the lessons learned in significantly increasing composite percentages in aircraft structures, as well as some interesting designs for drag reduction and innovative uses of carbon fiber.

Future aircraft composite weight savings opportunities and challenges

Dr John Fish, senior manager Airframe Technology, Lockheed Martin Aeronautics Co, USA

Challenges, and opportunities, of introducing composites into the 787 airplane design

Robert McIntosh, chief engineer - Weights, Boeing, USA

Weight opportunities of wide-body aircraft composite ailerons

Gulsen Oncul, A350 Ailerons EPM, TAI, Turkey

Multimodel structural optimization of commercial aircraft

Prof Santiago Hernandez, professor, University of Coruna, Spain

Understanding weight reduction relationships for rotorcraft

Dr Daniel Schrage, professor, Georgia Tech, USA

Drag-reduction technologies for low-speed applications

Prof Konstantinos Kontis, professor and deputy director, The University of Manchester, UK

Multi-disciplinary optimization of a pylon for mass and drag reduction

Freddie Colsoul, account manager, LMS North America, USA

CLOSE

Lightweight seating

Safe, comfortable seats – sometimes in large numbers – are a key requirement for most vehicles, especially aircraft and trains. Hence seating can add significantly to vehicle weight. This session is dedicated entirely to looking at this critical area for mass reduction with a range of approaches and products discussed.

Weight reduction in seat cushions

Mike Brock, market development manager, Rogers Corporation, USA

The use of high-strength polymers for metal replacement

Gary Seale, managing director, Cobra, UK

Lightweight structural solutions for transportation seating using expanded polypropylene (EPP)

Steven Sopher, technical director, JSP, USA

Weight savings through the use of suspension textiles

Neil Gross, president, Acme Mills Company, USA

Weight-saving possibilities on dress covers

Gerret Suhl, head of Sales, Car Trim GmbH, Germany

Win, win, win: lightweight leather

Nico Den Ouden, sales and marketing director, E-Leather Group, UK

CLOSE

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Through the wire

Cables and connectors are the forgotten component champions of today's EV – but now the automotive industry is demanding new designs that are lighter, stronger and cheaper

WORDS: **MIKE MAGDA**

Northwire has developed specifically designed cables that can survive in tough environments

Efforts to reduce weight, control temperatures and increase efficiency in electric vehicle batteries and motors are being closely matched in the EV wiring and connector segment. But add to those requirements the increasing scrutiny of safety issues and EV reliability, and one soon gets a picture of just how important these often overlooked subsystems are to the automotive industry's green revolution.

"It's not the most glamorous system in the vehicle, but we pay a lot of attention to it," states Chuck Gray, chief EV powertrain engineer at Ford. "It's important for safety, and it's important not to be intrusive to the rest of the vehicle in terms of packaging or electrical interference with traditional systems."

And just as the major powertrain suppliers are constantly pressured to reduce costs, wiring companies are also working with new materials and manufacturing methods to help further improve the bottom line as EV production increases.

"We must build a wire that represents an overall value to the end user," says Damien Sebald, product manager at General Cable. "As the demand for high temperature and lower weight product volume increases, expanding our capacity for low-cost manufacturing is the key to success."

Automotive observers say that while high-voltage wire and connectors have been developed for numerous other industries, car makers face critical issues with costs, safety and regulations that might not be as prevalent in other applications.

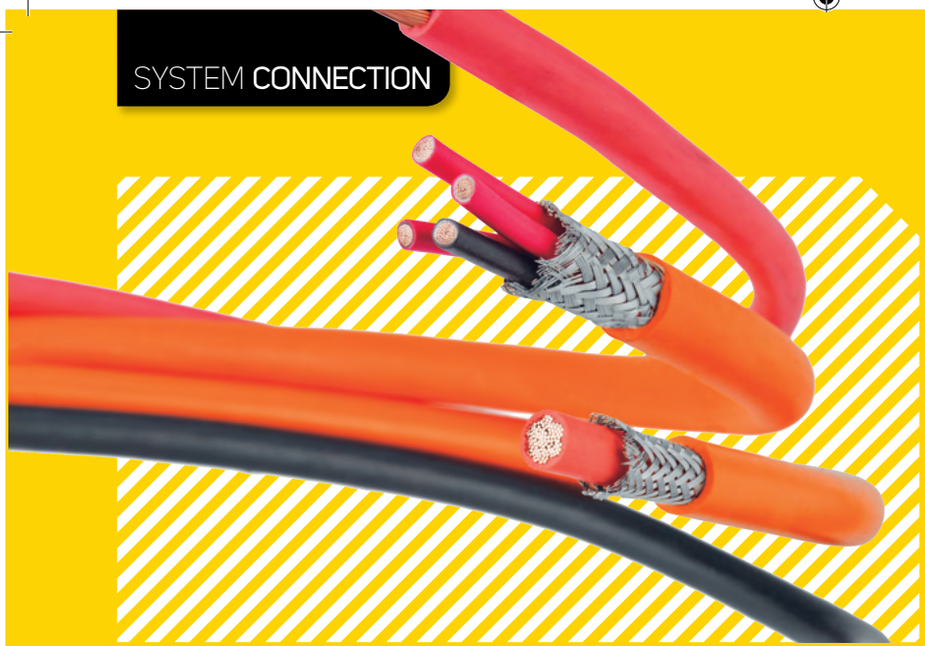
"We're at a stage where we're still learning the high-voltage application in vehicles with the suppliers and developing the tables like they have in low voltage," says Gray. "I don't want to buy any more than I have to, and I don't want issues either. So that involves testing and further development, and also, communication between the OEs and suppliers to really know what the part can carry in terms of strength and what we're going to impart in the application."

All set for aluminum?

Copper continues to be the conductor of choice, but developments in aluminum wire are being considered for weight reduction. Aluminum, however, presents its own challenges in that larger wires must be used to handle the same current flows. And there could be a challenge mating aluminum wire with a copper connector.

"In selective low-voltage applications, the suppliers are showing us technology for aluminum wiring," continues Gray, "and I think that's a frontier that's coming quickly."

However, Kevin DePratter, director of research and development at Northwire, has a different take on the matter: "We can produce bi-metallic conductors, such as aluminum core surrounded by a layer of



Huber+Suhner develops and produces high-quality electrical and optical connections for varied industries and applications. The Radox cable family includes single core cables, battery cables, high-voltage cables and databus cables

copper, but this is currently not recognized for electric vehicle use. This could significantly impact the weight and cost of electric vehicle cables."

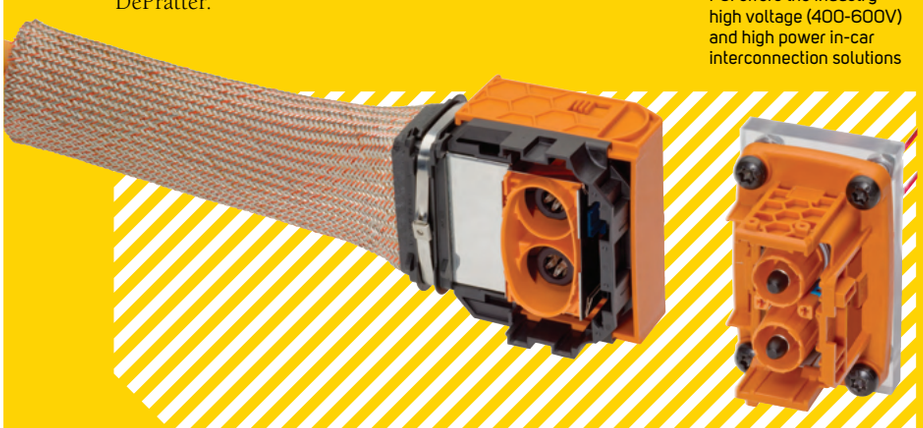
As there are often few choices in conductor materials, insulation and shielding often take center stage in differentiating supplier solutions. "It has to be higher voltage capable," explains Gray. "So let's say there's another layer of engineering that's more difficult."

Huber+Suhner's Radox cable uses optimized small constructions that allow a smaller outside diameter but maintain the needed minimum wall thickness for higher voltage applications. "Smaller diameter means less insulation material is needed, less weight, smaller connector concepts, and therefore lower costs," outlines Heinz Oesch, product unit manager for the supplier.

Advances in new materials are also helping matters, as DePratter explains: "New materials under consideration are carbon nano-tube technology for insulation shielding and conductive fiberglass for overall cable shielding. Next-generation low-smoke, zero-halogen materials, and environmentally friendly materials that will meet all UL62 requirements and be cost-effective are also under consideration."

According to Northwire, only PVC, rubber and TPE are recognized under the National Electric Code for insulation. "However, with advances in material science there are materials that are PVC-free, and bromine- and phthalate-free, that meet all the requirements," continues DePratter.

FCI offers the industry high voltage (400-600V) and high power in-car interconnection solutions



"Wiring is not the most glamorous system in the vehicle, but we pay a lot of attention to it. It's important for safety, and it's important not to be intrusive to the rest of the vehicle"

Shielding is another technical challenge as the car makers increase emphasis on infotainment, electronic controls and GPS requirements. "You have two solutions," suggests Luc Maillet, marketing manager for the motorized vehicle division at FCI, noting that there is a choice between individual cable shielding and peripheral cable shielding with a shielded braid surrounding the cables. "The two solutions are very similar in performance, but when you consider economics, it's an advantage using peripheral shielding."

Mating the wire and connector continues to be a critical issue for the manufacturers, especially in situations where the wire and connectors come from different suppliers.

"You have to be able to reliably make the connection in the assembly plant or from the component supplier every single time," stresses Gray at Ford. "You cannot tolerate a poor joint in terms of contact."

And this situation presents a special challenge should aluminum conductors be introduced. "That connection has to be hermetic so you have oxidation occurring, which causes a resistance increase and therefore temperature issues," continues Gray. "So crimping – the simple step you and I take for granted as laymen – is now a science that's evolving with aluminum wire."

Gray says the use of aluminum wire will likely be introduced in low-voltage applications before escalating to high-voltage use.

The actual performance of the wire is also being examined on the OEM level. Gray remembers a technical review with a wiring supplier in which small differences resulted in a noticeable loss of vehicle range on paper.

"What could be a few milliohms, when you multiply it times 400 battery cells, could be 100W," says Gray. "And 100W is almost a mile of range on a BEV, depending on the car's efficiency and the driving conditions. We can't just accept that."

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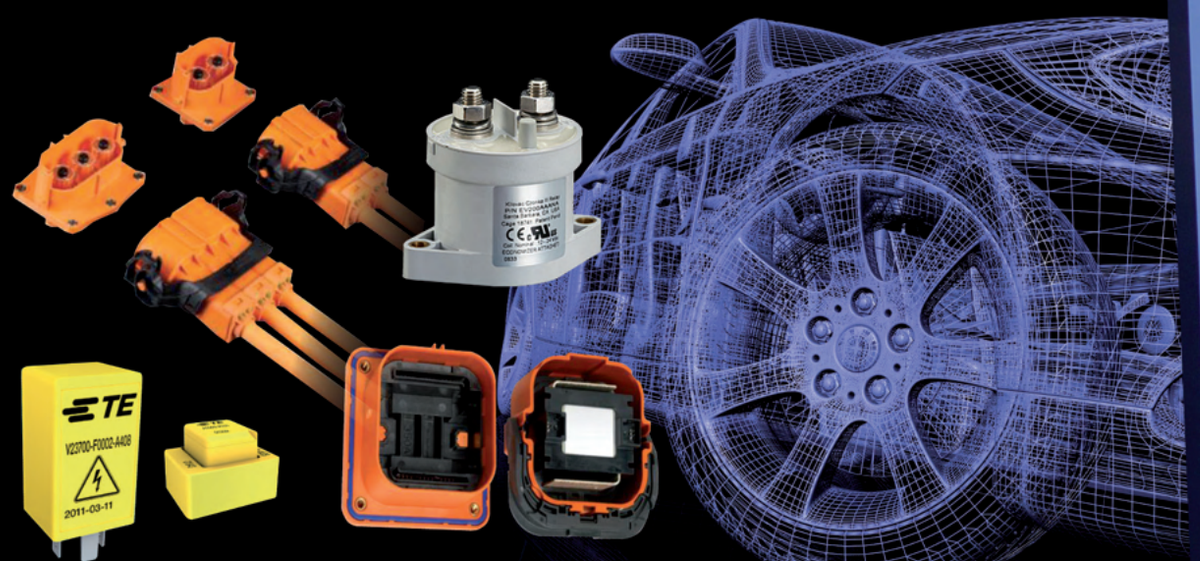

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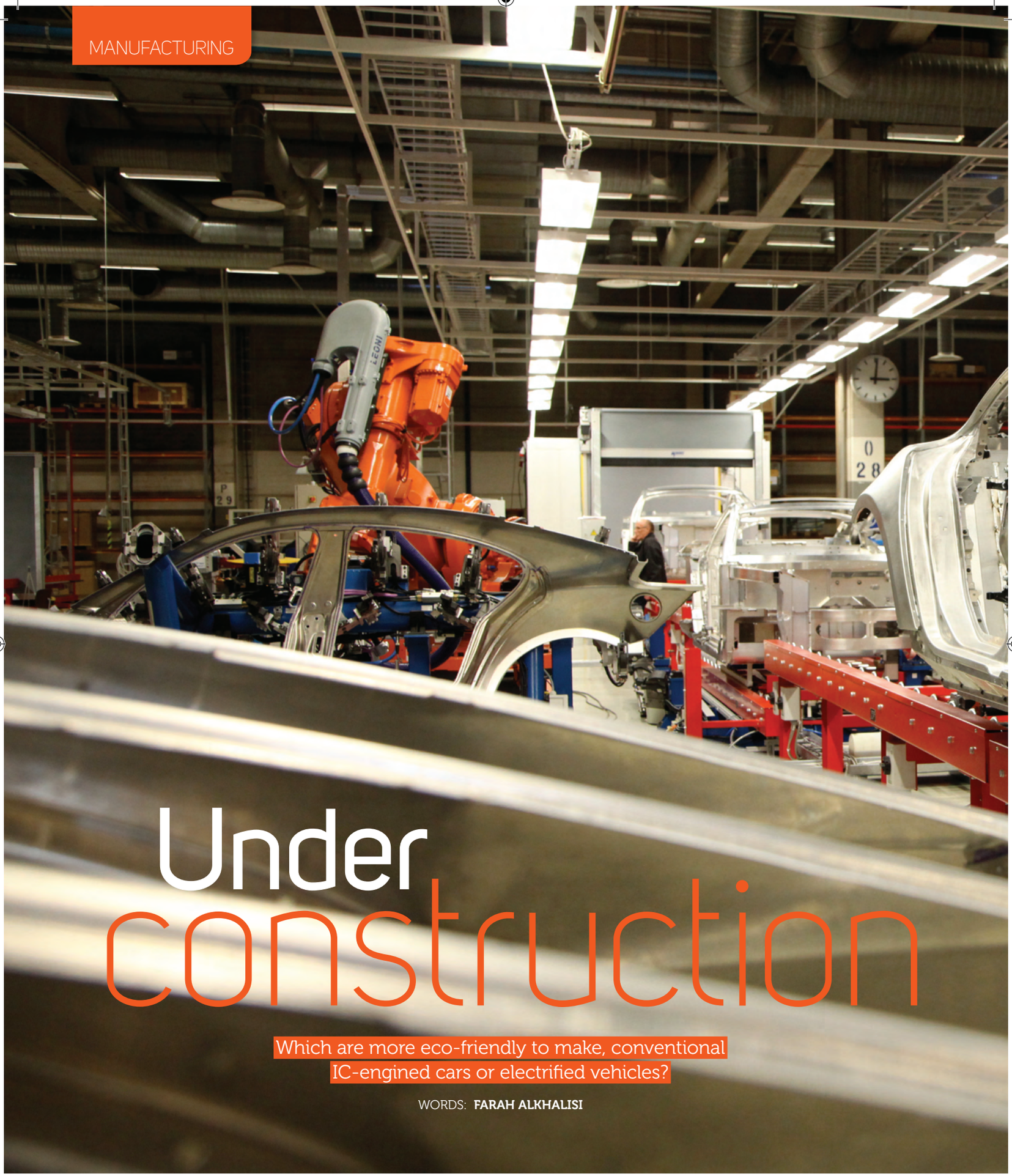


Under construction

Which are more eco-friendly to make, conventional IC-engined cars or electrified vehicles?

WORDS: **FARAH ALKHALISI**

During discussions about just how 'green' electric and hybrid vehicles really are, much emphasis is usually placed on the source of the electricity that powers them, and whether this negates the benefits of zero emissions from a metaphorical tailpipe. However, this doesn't tell us the whole story: to fully assess the carbon footprint of electrified vehicles, it's necessary to go back to the manufacture of the cars themselves and study their production processes and techniques. Putting it bluntly, there's a growing school of thought out there that claims EVs and hybrids are far less 'green' to manufacture than conventional IC engine cars.

A study by Ricardo last year for the UK's Low Carbon Vehicle Partnership (LowCVP), which set out to develop an understanding of a vehicle's whole-lifecycle impact, found that for a typical battery EV, 46% of its total carbon footprint was generated in its production before it even hit the road. It is 35% for a plug-in hybrid, 31% for a hybrid and 23% for an average petrol-engined car (based on data projections for 2015-specification vehicles and predicted fuel and electricity supplies).

The study concluded that over a typical 10-year or 150,000km lifespan, electrified vehicles would give an overall carbon saving due to their lower in-use emissions. It stated that a typical medium-sized IC engine family car would create around 24 metric tons of CO_2; an equivalent EV would create 18 metric tons, while the lifecycle impact of a diesel was found to be similar to that of a petrol-engined car. However, it was clear, it said, that 'the introduction of battery packs, electric motors and power electronics into a passenger car increases the embedded CO_2 emissions associated with the vehicle's production'. As a result, embedded carbon (CO_2e) for the IC engine car was around 5.6tCO_2e, but 8.8tCO_2e for the EV, 43% of which arose from the battery.

A follow-up piece of research, presented in February 2012, assessed a popular mid-market SUV in standard, electric and range-extended EV forms, and took into account revised projections on factors including embedded emissions for battery pack production, carbon intensity of electricity and lifetime mileage. Again, a lower proportion of the IC-engined vehicle's lifetime embedded carbon was in its production – 21%, which is less than the 35% for the EV and 29% for the RE-EV. But the EV still came out ahead overall and, crucially, the payback time (the point at which its in-use carbon savings compensated for its higher-carbon production) was around 65,000km – well within the predicted vehicle lifetime.

REDEFINING MANUFACTURING INTELLIGENCE

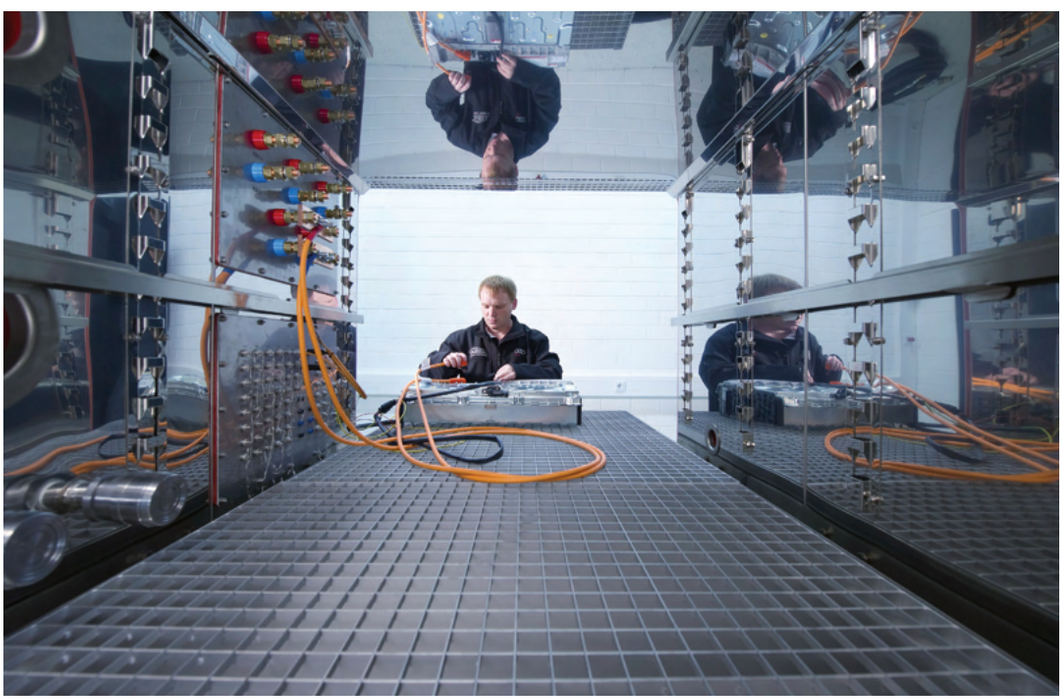
Launched last month, FlexNet Manufacturing Process Intelligence (MPI) 2.0 has been created by Apriso to deliver real-time visibility in order to improve manufacturing and supply chain performance.

Earlier this year, Tesla Motors confirmed that it was implementing Apriso's MPI technology as an operational intelligence and analytics solution to complement its existing FlexNet Manufacturing Execution System (MES).

The EV maker's VP of manufacturing, Gilbert Passin, says, "Tesla delivers exceptionally well-designed and engineered products. Apriso's Manufacturing Process Intelligence solution can help ensure the highest quality in our Model S. One of the benefits of a platform-based approach to manufacturing operations is the ease of adding new or updated capabilities. MPI can provide Tesla with real-time visibility into manufacturing performance to immediately contain costs and identify opportunities for continuous process improvement."

Tesla joins a growing automotive user list for MPI, with the likes of GM, Volvo, Honeywell and Saint-Gobain all already familiar with the technology.

"A good technology reduces impact not only in production, but at end-of-life and at disposal"



Two years ago, Audi commissioned a new development and testing center for electric drive systems at its Ingolstadt site. Around 840 employees work here, further advancing electric drive systems and batteries

Factory focus

Even if the overall picture from lifecycle analysis (LCA) is positive, work still needs to be done to reduce the extra impact of EVs and hybrids at a manufacturing level.

"We need to look at the production chain, individual processes, and components," outlines Jane Patterson of Ricardo's Technology, Innovation, and Strategy Group, lead author of the report. Understanding the

carbon costs at every stage of the production process tells you where you might want to focus your efforts, she says. "Such as, making changes in a factory, rethinking the materials used or a redesign. This gives opportunities of taking cost out as well as reducing embedded energy. As in-use emissions from all vehicles come down, the embedded emissions become more significant; it's something we do need to think about."

Both manufacturers and suppliers have long been working to address energy-saving and carbon emissions from their production facilities as part of their ongoing sustainability policies. Solar arrays such as the extensive complex at SEAT's Martorell plant and the rooftop panels at Toyota's production lines in Burnaston, or wind turbines like those at Nissan's Leaf factory, are becoming more common as manufacturers update, extend or otherwise upgrade their facilities, and this could ultimately be of benefit to production of all vehicles, not just the next-generation of EVs and hybrids.

By the start of 2013 the Leaf will roll out of three global production sites operated by Nissan: Oppama, Japan; Smyrna, Tennessee; Sunderland, UK

"All our Z.E. vehicles are produced in the same factory as the others," says Andy Heiron, Renault UK's head of electric vehicle program. "For example, the Kangoo Z.E. is on the same production line as the IC engine version, so apart from the battery, the vehicle is the same.

"In our eco2 program, we're looking at reuse, recyclability and reducing the overall impact of our factories, such as their use of water as well as energy, and we are taking a holistic view that applies not just to EVs, but that has more to do with the way we manufacture as a whole."

Material matters

Likewise, targeted improvements to reduce embedded carbon in specific components, and detail-changes to improve fuel efficiency, can apply to IC engine and hybrid vehicles as well as EVs. This could entail using (and finding new) low-carbon alternatives to steel or aluminum, such as composites, as well as greater use of recycled materials – which could also be of benefit in reducing total vehicle weight.

For certain types of vehicle, especially low-cost and efficiency-optimized small city cars, simplicity is key, too; reducing the number of necessary components and subsystems enables quicker, less energy-intensive construction and installation.

In addition, suppliers are also developing compact, lightweight powertrain solutions in easily-integrated modules. Zytek Automotive, for example, says the motor, Vocis-designed gearbox, and inverter package it created for the Gordon Murray T.27, offers added benefits in terms of the highly compact electric drivetrain, meaning that as less material is used in the manufacture of the electric machine, the carbon footprint associated with the manufacture of each drive is very low.

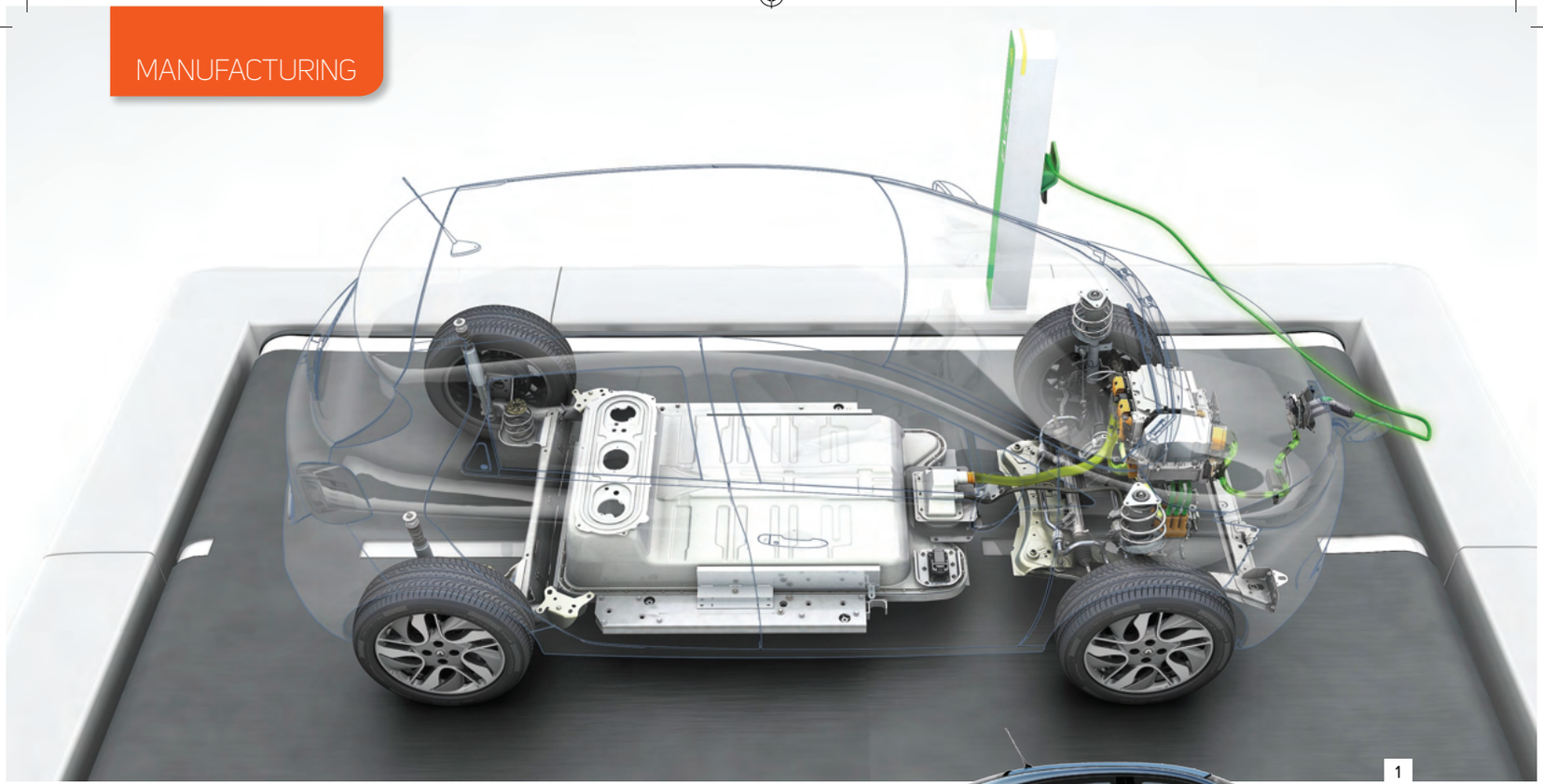
NICHE SOLUTIONS

Economies of scale are not necessarily an issue for mainstream manufacturers such as Renault, who can produce their EVs and hybrids alongside IC engine vehicles, but low-volume auto makers and small start-ups building niche vehicles do have the benefit of flexibility. They can also take a more radical approach in developing their production processes.

"For the most part, making EVs is identical to making combustion-engine cars," says a spokesperson at Valmet Automotive, which produces the Fisker Karma at its facility in Uusikaupunki, Finland. "However, as EVs are in the frontline of lightweight structure evolution, they benefit from using new materials and sophisticated solutions – there is room for groundbreaking innovations."

Most notably, Gordon Murray Design's patented iStream design and production process – for assembly of models including its T.27 electric city car and available for license – is a "complete rethink on high-volume materials and the manufacturing process, and will lead to a significant reduction in CO_2 emissions over the lifecycle of the vehicles produced using it, compared with conventional ones", claims Murray. Reducing vehicle weight is key, but also of note is that the design is based around a basic platform that is easy and cheap to manufacture, easily modified and highly scalable – in the assembly process, pre-painted composite panels are bolted onto a near-complete chassis, with no need for a paint shop. Murray says that replacing metal presses with machines for bending and welding, and the simplified assembly process, mean that the manufacturing plant can be designed to be 20% the size of a conventional factory.

Licensed iStream factories can be sited nearer to the marketplace or point of sale, reducing transportation emissions, a factor also considered by EV Innovations, a consultancy developing a low-cost electric truck and small EV for Bluebird Automotive. "The flatpack electric car can be assembled in a factory using simple hand-tools, with low start-up costs. It is a true world car, built locally," says a spokesman.



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"We're looking at reuse, recyclability and reducing the impact of our factories, and we are taking a holistic view that applies not just to EVs, but that has more to do with the way we manufacture as a whole"

Solutions reducing battery dependency can also play a role: KERS, other flywheel energy storage technologies and supercapacitors can enable the use of smaller batteries with a lower embedded carbon content.

The end of the line

Yet when developing a vehicle for production, the end of its useful working life must also be considered, and specifically the potential for recycling and reuse of its constituent parts and materials, especially the materials that go into batteries.

"It comes back to taking a holistic view of R&D," says Ricardo's Patterson. "A good technology reduces impact not only in production, but at end-of-life and at disposal." She notes nonetheless that, "Most published LCA studies suggest end-of-life makes a relatively small contribution to the overall lifecycle footprint of a vehicle, which is why we have focused more on the environmental impacts from use and production, but we feel that it needs to be investigated further."

Honda claims to be the first OEM to extract rare earth elements in a mass-production process at a recycling plant, with an 80% recovery rate from its end-of-life nickel-metal hydride batteries.

1: Renault will produce its electric city car, the Zoe, at its Flins plant in France. This facility will also soon start to assemble batteries for the Alliance. Production capacity is targeted at 100,000 batteries a year

2: The Renault Fluence Z.E. is built alongside the IC-engined Fluence model in Bursa, Turkey

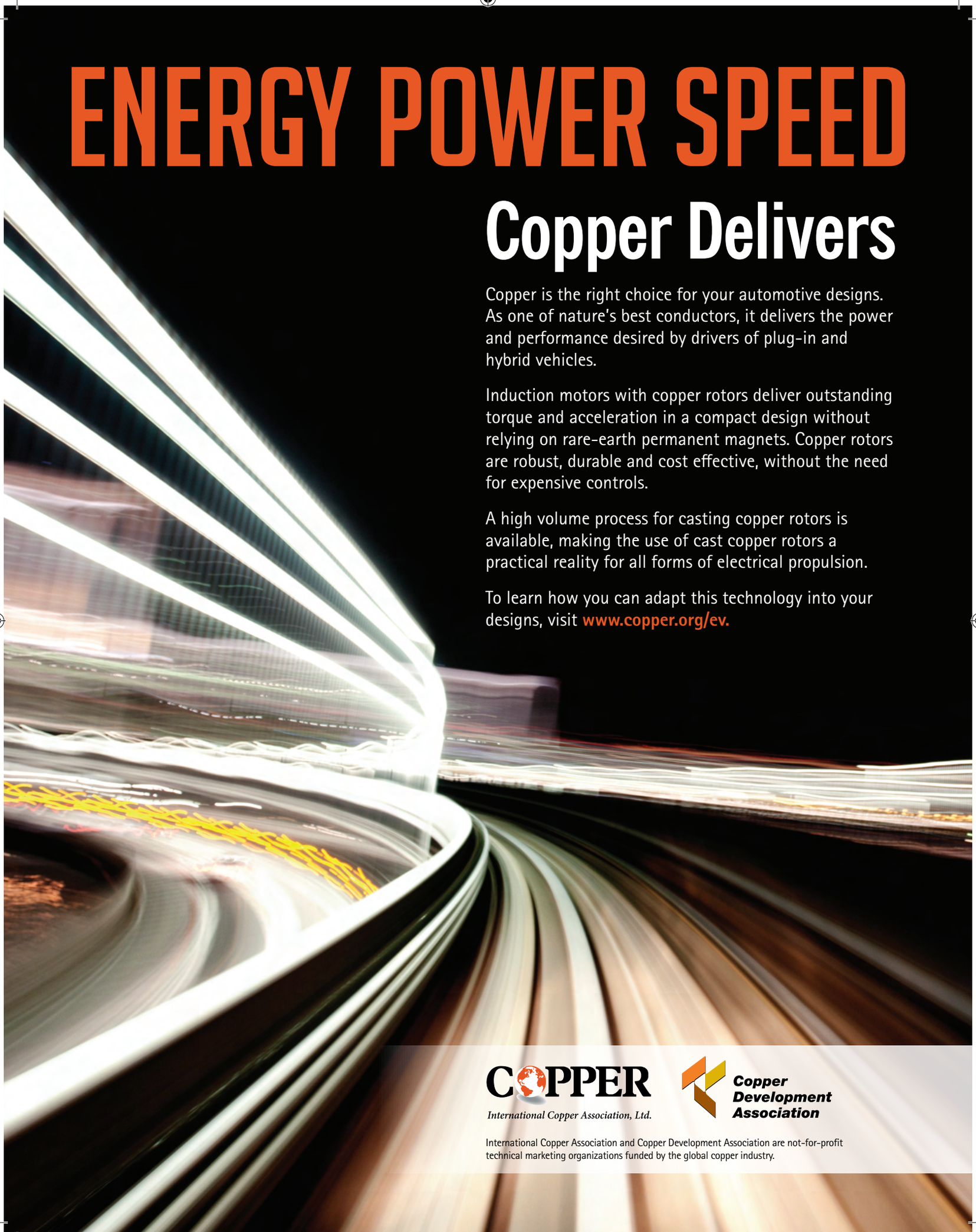
3: When it comes to battery production and end-of-life, Renault has a different perspective on things due to its innovative leasing program

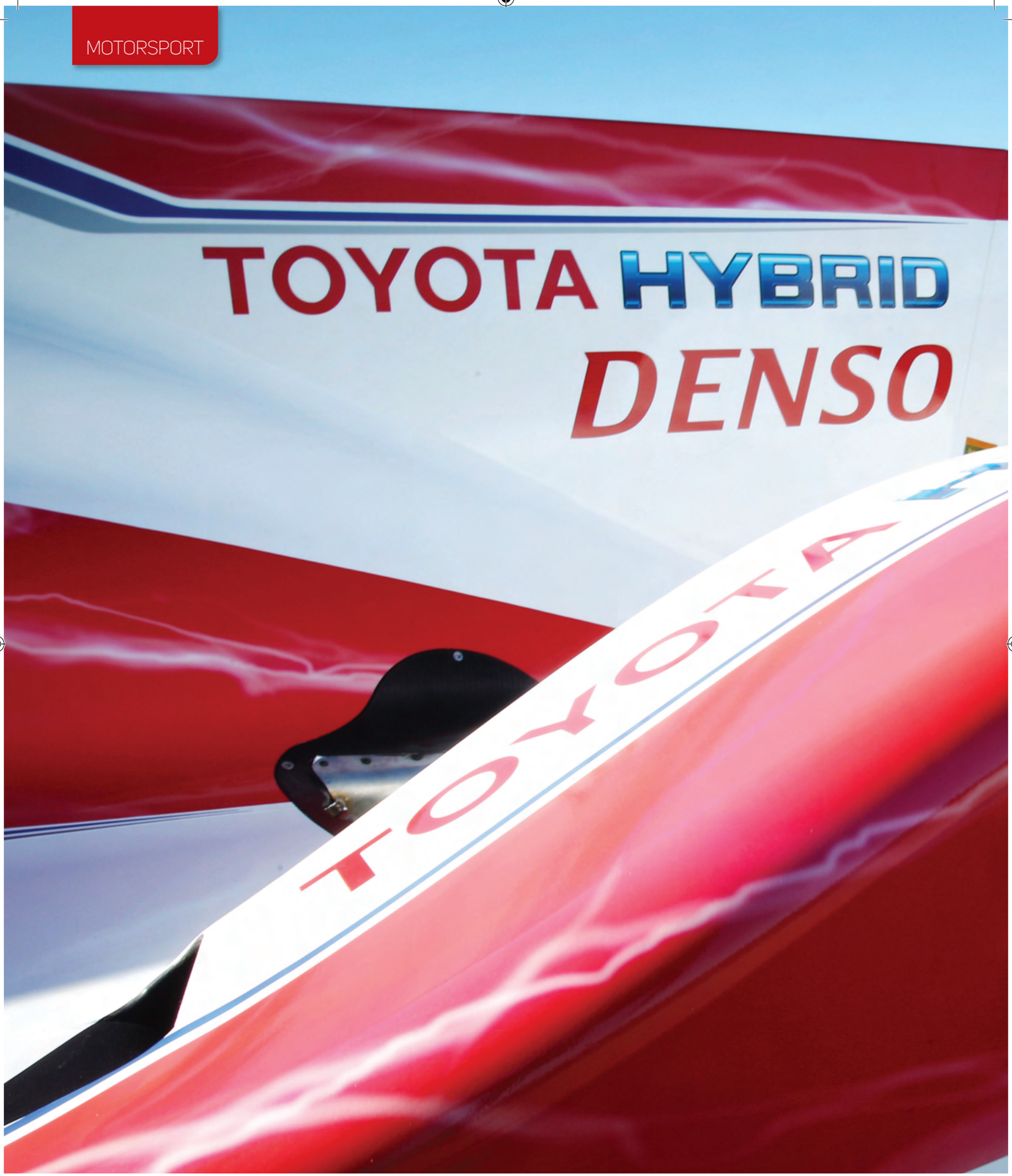
3

Meanwhile, Renault is also concerned about battery reuse, not least because its EV-leasing program (in which the batteries are leased on a separate contract to the cars or vans themselves) puts it in a potentially costly position.

"The issue we've got is that we own the batteries," adds Heiron, who explains that a number of projects are underway with Renault's Alliance partner, Nissan, to study battery 'second-life', including research into repurposing car batteries for static domestic energy storage and grid-balancing. "We're looking at two sides of it: the first is the practical, such as how you weld the batteries together, and whether you break them down into cells and rebuild them or whether you let them go 'sold as seen'; and the other side is the business case." The Renault head says that until batteries come back in a critical mass, second-life schemes will not be viable on any scale until the next decade. "So in the short term, small-scale domestic use is as advanced as we need to be."

Ultimately, reducing the environmental impact of EV and hybrid manufacturing will probably be driven by financial concerns more than ecological. "As more electric and hybrid vehicles come into the marketplace, the focus is on cost reduction," Patterson concludes. "If you marry that with the 'clean and lean' approach, linking lean manufacturing with lifecycle assessment, then you take out cost and carbon, which has to be good for everyone."




TOYOTA HYBRID
DENSO
TOYOTA

Recovery position

Toyota Motorsport is returning to racing with a trip to its old stomping ground – and it's taking its signature powertrain technology along for the ride

WORDS: **CHARLES ARMSTRONG-WILSON**

A lot of water has passed under the bridge since Toyota last fielded a car at Le Mans, not least the company's hugely committed, but ultimately disappointing, Formula 1 program. Its Cologne-based TMG factory received enormous investment to become a rival for any F1 facility in the world, but sadly it was not matched by results, and the team finally pulled out after the 2009 season.

One could be forgiven for assuming that a cold wind has been blowing through the empty halls of the factory since then. However, you would be wrong. Apart from the facility reinventing itself as a commercial service to the motorsport industry, the ability to compete in its own right had not entirely disappeared.

The evidence of this is the TS030, a car entirely designed within Toyota and built and run out of Cologne. It slips neatly into a sportscar tradition at Toyota, following on from the TS010 and TS020 – TS for Toyota Sport – that raced at Le Mans in the 1990s before the company's ambitions switched to 'greater' things.

The new car, however, benefits from the resources and knowledge accumulated during the F1 years, as the project's technical director Pascal Vasselon admits. In his view, the only real difference is the duration of the race. However, their wings have been clipped a little. Obviously the venture is working within a much smaller budget and, although they have a world-class facility at their disposal, the project had to take its turn behind the commercial clients.

Brand new engine

That limited budget did not prevent Toyota coming up with a brand new engine for the car, though. It already

THE RESULT?

Toyota Racing experienced some thrilling highs and extreme lows during an eventful Le Mans 24 Hours which ended in the 11th hour for the Japanese team.

An impressive start to the team's first race saw the TS030 Hybrids fighting at the front, reaching a pinnacle when Nicolas Lapierre, sharing the #7 with Alex Wurz and Kazuki Nakajima, took the lead as the six-hour mark approached.

However, the team's joy at seeing its super capacitor-based hybrid powertrain lead the field was ended only seconds later due to a heavy accident for Anthony Davidson in the #8. Davidson was driving alongside Stéphane Sarrazin and Sébastien Buemi.

He was hit by a lapped car and suffered heavy impact with the tire barriers at Mulsanne Corner, which comes at the end of the Mulsanne Straight when cars reach a top speed of more than 330km/h (205mph).

After getting out of the car on his own, Davidson was taken to the circuit medical center suffering from shock and back pain. A safety car period followed the incident and, when the green flags waved, Kazuki fought for the lead. However, he was also unlucky with lapped traffic and made contact with another car, causing a puncture and rear bodywork damage.

That began a challenging period for the team, with several problems losing the #7 significant time in the pits as the crew worked hard to achieve the target of taking the chequered flag. In the end, an engine failure after 10-and-a-half hours forced the difficult decision to retire the #7 and end Toyota Racing's first race prematurely.

The team says that having proven the performance of its TS030 hybrid chassis and hybrid system in one of motorsport's toughest races, it plans to return to action at the WEC Six Hours of Silverstone on 26 August.

Left and right: Toyota has returned to the 24 Hours of Le Mans for the first time since 1999. Ahead of Le Mans, the TS030 made its race debut at the 6 Heures de Spa-Francorchamps

has a very serviceable 3.4-liter V8 – the RV8K raced by Rebellion Racing. Derived from the Formula Nippon unit, it has proved powerful and reliable – if not quite state-of-the-art to Audi and Peugeot standards. But Toyota is at pains to point out that the engine in the TS030 is brand new, owing nothing to the older unit. Beyond that, the company is revealing little about the normally aspirated V8, except perhaps a lower crank height, which suggests a more committed design.

Technically, the most interesting feature of the TS030 is the use of hybrid technology in the powertrain. It does not make it the first hybrid car to race at Le Mans, however. That honor goes to the Flybrid flywheel-equipped Hope Racing entry that competed last year. The Toyota is not even going to be the only hybrid taking part this year – Audi is also going hybrid – but Toyota's design is an original route to capitalizing on the ACO rules.

The TS030's hybrid system is an electrical system – but using super capacitors as the storage medium. Ironically a similar system was used in F1, but not by Toyota; it was BMW that experimented with this technology with mixed results, while the Toyota F1 team used batteries.

According to Histake Murata, Toyota's hybrid project leader, the first hybrid system to compete internationally was in 2002, when a Toyota Prius finished the 5,000-mile Midnight Sun Rally, an FIA-sanctioned event. But the Japanese OEM's first competition experience with this technology dates back to the 2006 Tokachi 24-hour race, where a Lexus GS 450h was entered. The system was then improved, enabling the Supra HV-R to win the race in 2007.

"The main advantage of supercapacitors is the very quick energy recovery rates, which enable the system to fully recharge in a short period of braking"

"The Toyota Hybrid System – Racing (THS-R) is an evolution of the technology that helped the Supra HV-R win at Tokachi," says Murata. "Of course, there have been significant advances over the past five years so the system is more efficient, lighter and delivers better performance, but it can be considered part of the same story." The Toyota engineer believes this was an essential step in the evolution of hybrid systems for motorsport. "Toyota learned a huge amount from this experience. We were able to better understand the demands and challenges of racing a hybrid system, so this experience took us a big step closer to the dream of racing a Toyota hybrid at Le Mans."

In recent years, the ACO has opened up the rules to encourage hybrids, but with certain limitations. The maximum energy that can be generated in any braking event is 500MJ and that can only be harvested and delivered to either the front or rear wheels. Rather than committing to one or the other, Toyota has kept its options open by configuring the car to do either. This does not come without some compromises – most significantly weight distribution.

Placing motor generators in the front adds weight. However, taking them and their associated driveshafts away causes a rearward weight shift at odds with the aero downforce balance, so they have to be replaced with ballast. This aggravates a problem with the weight of the system, which is believed to be more than 150kg – a big part of the 900kg total.

For the rear version, a Denso-developed motor-generator is hooked up to the transmission. The company is an official partner and was also responsible for the 2007 Supra units. At the front, an Aisin AW motor generator is being evaluated.

If a front-mounted system is used, then there is the theoretical possibility of using it to influence the handling. However, the rules dictate that the front-mounted option cannot be used to power the car below 120km/h (75mph), severely limiting that potential.

According to Vasselon, the benefit is not just the performance, but efficiency: "For any given performance level, a hybrid powertrain will achieve this with less fuel, so it is an extremely relevant technology and one we are excited to bring to endurance racing."

Packaging was less of an issue in a sportscar than it would have been in a single seater, and the Nisshinbo capacitors occupy the space provided for a theoretical passenger. "The main advantage of supercapacitors is the very quick energy recovery rates, which enable the system to fully recharge in a short period of braking," says Murata. "This is a key point in developing a hybrid system that will deliver extra laptime performance." With the amount of power storage required, lithium-ion batteries would have performed far worse, as well as generating unwelcome heat.

The TS030 can even operate in electric-only mode for short distances and was an eerie sight in pre-season testing, trundling up the pitlane on electric power before letting the engine kick in. "Just leaving the garage on the electric power is very futuristic," says driver Alex Wurz. "Then when you let the clutch go and the IC engine kicks in, it's like an old friend has returned."

And this is not just a marketing exercise, says Murata: "We expect the knowledge we gain from our WEC program to contribute to hybrid road car development, but it is too soon to say positively that supercapacitors will be part of that technology transfer. The demands of a road car hybrid system are very different to motorsport in terms of energy recovery and braking distances, so the energy storage method is not necessarily interchangeable."

Q+A: YOSHIAKI KINOSHITA, TOYOTA RACING TEAM PRESIDENT

What is your assessment of Toyota Racing's first race?
It was very promising but ultimately disappointing. It was our dream to lead the race and to do so, even for only a short time, was fantastic. Of course, Anthony's accident was a scary moment, and a turning point in the race. We all wish him a speedy recovery; it was difficult to enjoy the race after that. Unfortunately we faced some problems on #7 and had to retire. It is normal we had to deal with some technical issues in the race because our car is very young and we have not had enough testing, but nevertheless it was an extremely sad moment for us. We leave Le Mans with several areas to improve for future races but we can also be proud; the whole team gave everything they had and I want to say thank you for their great efforts.

In your opinion, how did the Toyota Hybrid System perform?
In the first place, it is a significant achievement from the Motor Sport Division and the Toyota Motor Corporation hybrid department team to bring such technology to Le Mans. In terms of performance we are happy with how the hybrid system contributed to our overall speed. I think we showed that our concept has strong promise and we continue to work hard on reliability.

How did you enjoy the competition with Audi?
We did not know if we could fight with Audi, so we enjoyed the battle while it lasted. Big congratulations to Audi on their well-deserved victory. Le Mans is an extremely hard race to win and they did a fantastic job. As well as being tough competitors on the track, Audi were also very welcoming and friendly; it was a pleasure to race with them. It was also an honor to join their victory party on Sunday and hear the appreciative words of Dr Ullrich. We look forward to some exciting battles in the future and some fun moments between us as well.

What is the team's plan for the rest of the season?
We will compete in the rest of the FIA World Endurance Championship races with one car. That means five races in which to learn about our car and hopefully improve; our target is simply to show our best possible performance at each race.

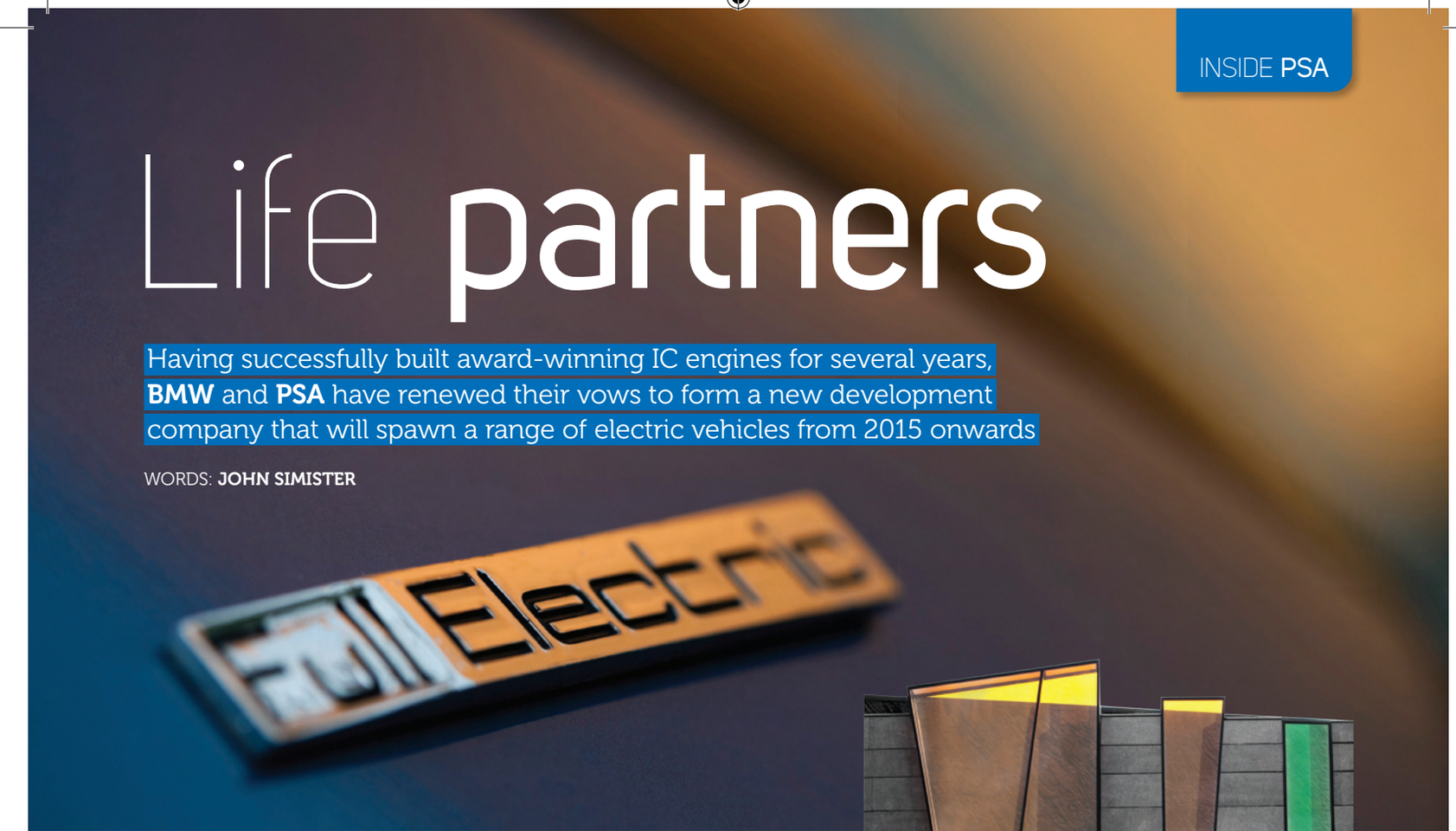
Toyota's driver line-up included the two-time Le Mans winner Alex Wurz, emerging endurance star Nicolas Lapierre and ex-F1 driver, Kazuki Nakajima

"Just leaving the garage on the electric power is very futuristic. Then when you let the clutch go and the internal combustion engine kicks in, it's like an old friend has returned"

Life partners

Having successfully built award-winning IC engines for several years, BMW and PSA have renewed their vows to form a new development company that will spawn a range of electric vehicles from 2015 onwards

WORDS: **JOHN SIMISTER**



Around a year ago, PSA and BMW signed a memorandum of understanding in which the two companies would join forces to develop and manufacture electric and hybrid powertrain components. Following the signing, all went quiet for around six months and then, suddenly, just before the Geneva Show in March, the new joint-venture company announced its fully fledged plans.

Said company is called BPC Electrification, those first initials standing – not surprisingly – for BMW Peugeot Citroën. Its research and development is based at BMW's technical center at Garching, near Munich, and production will take place at a new facility in PSA's plant in Mulhouse, eastern France. The investment so far totals US$525 million, with a workforce of 400 Garching engineers and 250 Mulhouse employees when the project is fully operational. The first new vehicles with these components will arrive in 2015.

So how has the project come about, and what will be the results of its efforts? The chairman of BPC's board is Wolfgang Güllich and the MD is Jean Leflour – their names correctly suggesting from which side of the partnership each originates. "Our purpose is to develop everything we need for electric and hybrid cars, and to create as many of our own components as we can," outlines Güllich. "It's a real synergy between BMW and PSA."

1: BPC Electrification MD, Jean Leflour, says the new JV company will handle the entire development process, from innovation to production and purchasing

2: The current product range from both PSA and BMW – including models such as the Peugeot iON – will not be affected by the forming of BPC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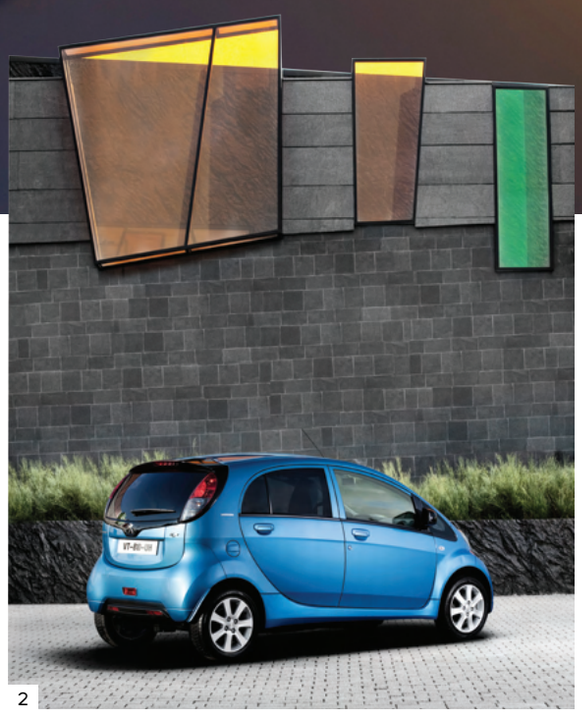
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"This time we have a formal joint venture company. We'll make modules, batteries, motors, generators, electronics, control software – everything – together"

EVs not ICEs

But the focus for BPC is electrification; IC engine development is not in the plan. "This cooperation is entirely for electric systems," reaffirms Leflour. "The combustion engines remain with the parent companies. The ICE is out of our scope."

BMW and PSA have history, though, having developed and produced numerous IC engines in recent times, including the award-winning 1.6-liter turbo that's housed in Mini, Peugeot, and Citroën applications. Will this IC engine familiarity influence how the new company is run? "We have had 10 years of ICE cooperation, right up now to Euro 6 designs," says Güllich. "Our relationship for the 1.6-liter engines has been smooth for 10 years. Well, ok, maybe there were a few little bumps at the start, but we soon fixed those. This time, though, we have a formal

joint venture company. We'll make modules, batteries, motors, generators, electronics, control software – everything – together."

Leflour emphasizes that BPC Electrification will handle the whole process, from innovation to production and purchasing. That means that some basic components will be bought in, but BPC will then make them into the required units and modules.

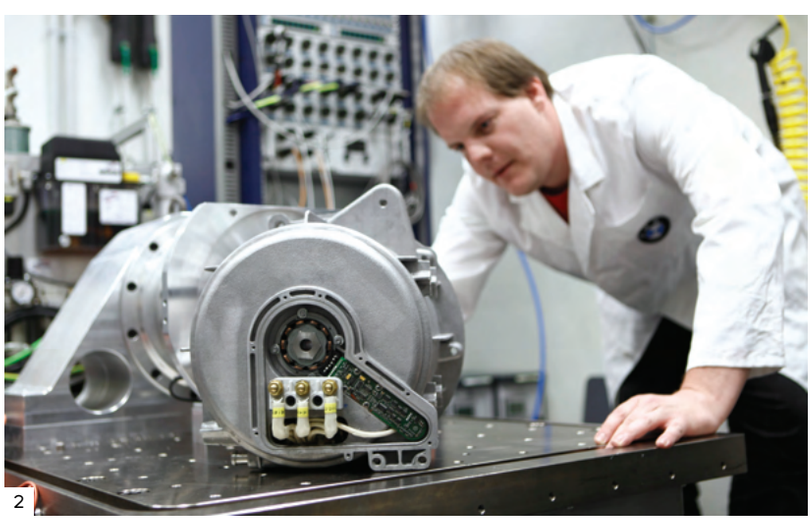
"Take the battery systems," Güllich says. "We buy the cells, but we develop and build the battery. They will be in modules, three, four, five of them, in different sizes of battery cases. This gives us high commonality. Until now, BMW and PSA have been running their own projects, but now with this reshuffle we can run one train instead of two."

i included?

BMW already has its own range of EVs, the upcoming i3 and i8, which are nearing production. Will they make use of BPC electronics? "They won't," answers Güllich. "They were started within BMW and will remain there, but their successors will use systems from the new company."

And it's the same story at PSA as far as its current product range is concerned. The French OEM will stay with its current outside suppliers for its existing range of vehicles, says Leflour. "But our next project, a plug-in hybrid, will use systems made at Mulhouse, including the battery pack and the motor."

Güllich adds: "The new systems will cover the whole range of vehicles in a variety of car sizes, shapes, and weights. As well as different sizes of battery pack, there will be different sizes of motor – let's say more than two."



1: Could the JV lead to the creation of new EV products that are similar to that of PSA's lightweight urban vehicle concept

2: BPC electric drivetrain development will take place in Garching, Germany; the company's production home will be based in Mulhouse, France

FIRST BMW, NOW GM

It's not just BMW that's going to partner PSA Peugeot Citroën in future low-emissions vehicle development: the French car maker has also signed a groundbreaking strategic deal with GM that will aim to combine the strengths and capabilities of the two companies.

According to the deal, the new partnership will ultimately contribute to the profitability of both OEMs, as well as improve their overall competitiveness in Europe. The agreement will also see GM become the second-largest shareholder in PSA by securing a 7% stake. Both GM and PSA say that the alliance is structured around two main pillars: the sharing of vehicle platforms, components and modules; and the creation of a global purchasing joint venture for the sourcing of commodities, components, and other goods and services from suppliers, with combined annual purchasing volumes of approximately US$125 billion.

However, each company will continue to market and sell its vehicles independently and on a competitive basis, as Philippe Varin, chairman of the managing board of PSA Peugeot Citroën, explains: "This alliance is a tremendously exciting moment for both groups and this partnership is rich in its development potential. With the strong support of our historical shareholder and the arrival of a new and prestigious shareholder, the whole group is mobilized to reap the full benefit of this agreement."

Initially, GM and PSA intend to focus on small and mid-size passenger cars, MPVs, and crossovers, but the companies will also consider developing a new common platform for low-emissions vehicles. The first vehicle on a common platform is expected to launch by 2016. The total synergies expected from the alliance are estimated at approximately US$2 billion annually within about five years.

So the shared electric propulsion systems are well underway, but is that the same for the shared platforms as well? "Well, that would be great," Güllich answers with a smile. "But it's out of our hands a little bit," counters Leflour, "although there is a lot of front-wheel drive synergy between the brands."

Questions regarding platforms would seem to be off the agenda for now, then, but what about the outside suppliers to BPC? Who are they and why were they chosen? "We can't say who they are yet because we are still in negotiation," Güllich replies, "but in six months' time we'll be able to name our battery supplier."

Turning the question around, is the idea that BPC Electrification can supply its products and expertise to other vehicle manufacturers? "Absolutely," insists Güllich. "If you shape the products intelligently, you can attract other customers and generate an economy of scale. It means we'd be sharing our intellectual property, but that's the trade-off."

Leflour adds that the joint venture was also open to a third party – he can't say who – but in the end BMW and PSA decided to keep it between the two of them. However, the new systems are to be designed on an open technology platform to make it easier for suppliers on one side, and customers on the other, to integrate with them. "We want our company to be one of the leading suppliers in the field of electric powertrains over the next years," states Güllich.

In 2015, then, the industry will see the first new products using BPC Electrification systems. For BMW, sources suggest it will be a small- to medium-sized car. "And for us, it will be a bigger one," says Leflour. "Which will be a plug-in hybrid."

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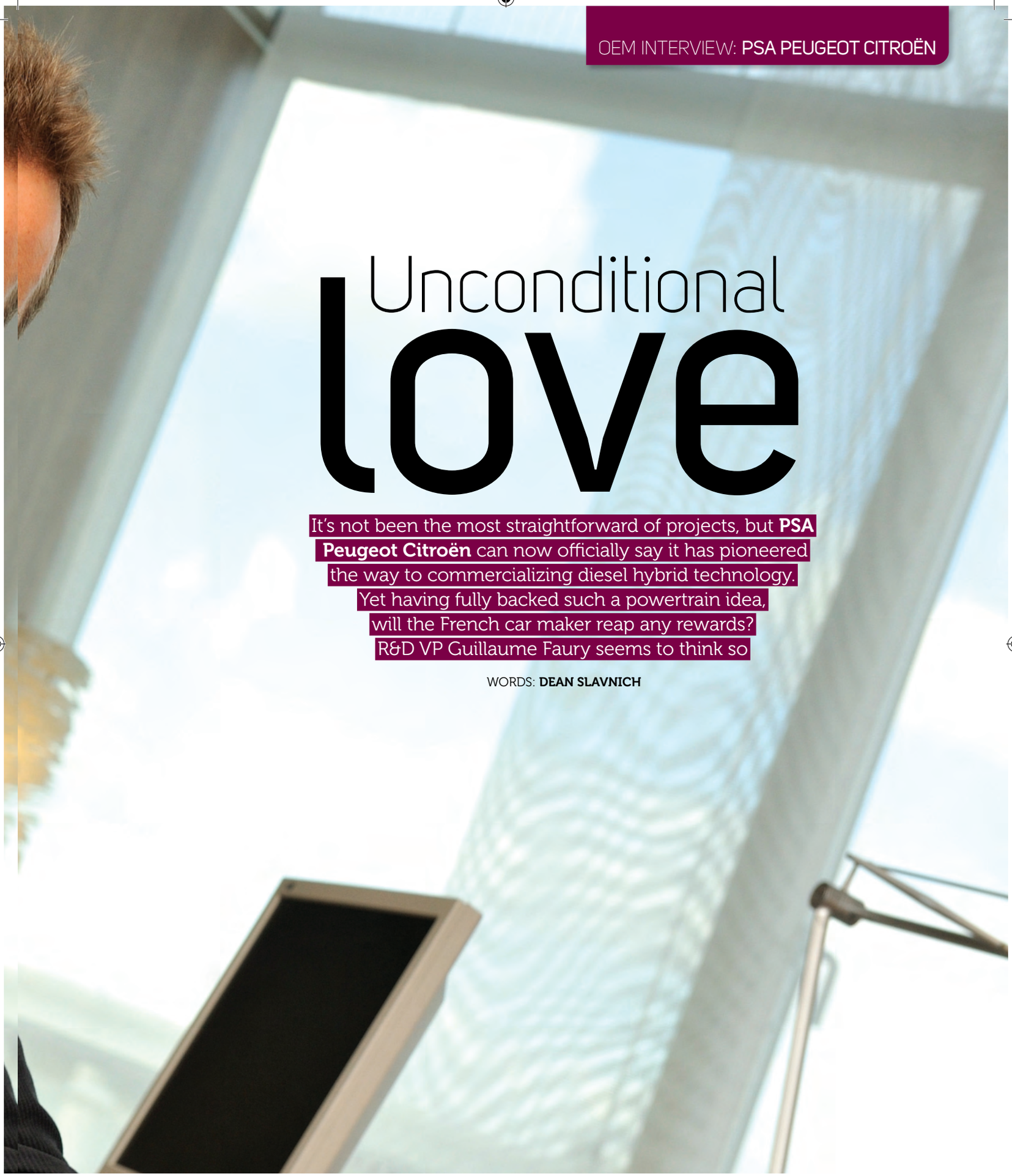

Unconditional love

It's not been the most straightforward of projects, but **PSA Peugeot Citroën** can now officially say it has pioneered the way to commercializing diesel hybrid technology. Yet having fully backed such a powertrain idea, will the French car maker reap any rewards? R&D VP Guillaume Faury seems to think so

WORDS: **DEAN SLAVNICH**

With Hybrid4 being a modular technology, Faury says PSA managed to save on development costs

When it comes to diesel hybrid technology, Guillaume Faury is a confident man. But then, some would say that PSA Peugeot Citroën's executive vice president for research and development has no other option but to be self-assured as the general feeling is that the French car maker has put a whole load of its eggs in one basket.

Hybrid4, which is PSA's marketing tag for its diesel hybrid innovation, is the result of a five-year project that so far has seen total investment surpass US$625 million – a lot of money for any powertrain development.

There are those that question the financial rationale of adding an electric element to a diesel IC engine, and then there are others who are massive supporters of the idea. But regardless of where one sits, PSA must be given credit for daring to go it alone in a commercial, mass-market sense. In fact, such has been the company's commitment that PSA has so far filed some 300 patents for the world's first diesel hybrid, with 1,500 engineers and technicians having been involved in the creation of the technology and some three million miles of testing having been undertaken to validate all subsystems and components before market launch. As such, when it comes to Hybrid4, one can't accuse PSA of doing things half-heartedly.

"What we did first was develop the technology to be based on the appropriate sizing of the electric components"

With investment figures like those, it's understandable that Faury is keen to talk up Hybrid4. "Diesel hybrid is a new technology that offers many assets in one package," he says. "First of all, it allows for the capability of a C or D segment car to come to market with a big driving range, but emitting below 100g of CO_2 – this is incredibly eco-friendly for such a family car. At the same time, though, it offers full four-wheel drive capability, it allows for full electric driving below 70km/h (45mph), and in sports mode it generates 200bhp from the diesel engine and electric motor. So, it's four cars in one."

One can't argue with Hybrid4's environmental credentials: it uses 45% less fuel when compared with a similar-sized petrol engine, and some 35% less fuel and 30% fewer emissions than a similar-sized diesel. But, the proof is in the pudding, and for the 3008 Hybrid4,

1: The Peugeot 3008 was the first vehicle to benefit from Hybrid4. Despite being a crossover, it emits fewer than 100g/km of CO_2, a terrific achievement for a car that also boasts 200bhp

2: Hybrid4 is mated to PSA's proven manual compact automated transmission, which has been specifically optimized for hybrid operation

3: The 3008 Hybrid4 offers four driving modes

emissions come in at 99g/km of CO_2, while fuel consumption on combined mode is rated at 3.8l/100km (61.8mpg). Such green credentials shine even more when taking into account the 163bhp that's gleaned from the 2-liter HDi FAP diesel engine, and the further 37bhp from the electric motor.

Natural evolution

Faury believes that development of diesel hybrid technology was a natural evolutionary step for PSA, with the diesel IC engine being at the very core of what the car maker is all about. "We are a world leader for diesel engines in passenger cars," he says. "As a company, we have commercialized more than 17 million HDi engines since the launch in 1988, and since 2000, we have sold more than five million diesel particulate filters, which is

1: Industry rumors suggest that the next application for Hybrid4 will be the RCZ sports car, with a layout that sees the diesel engine at the front and the battery pack at the rear

2: The DS5 is the first Citroën vehicle to feature Hybrid4

"This system is shared on four different cars to add to the appropriate volumes, and what's important to remember is that no specific car was developed for this technology – it was integration of the hybrid powertrain instead"

A designer adds the final touches to the Citroën Hypnos HYbrid4 concept

a very strong contributor of low emissions for diesel engines. Today, all our diesel engines have DPFs." If that's not impressive enough, PSA is currently rolling out stop/start technology on all its diesels, a program that started last year and builds on its reputation of being the first to apply such a technology to its gasoline engines.

But having dared to go it alone, all of a sudden, the French car maker finds it has company in the diesel hybrid arena: both Volvo and Mercedes have confirmed diesel hybrid production plans, and industry whispers

HYBRID4: UP CLOSE AND PERSONAL

Bringing Hybrid4 to market was not easy and there were challenges to be overcome at every level before PSA could launch its diesel hybrid savior. Starting with the 2-liter HDi FAP diesel engine, a new accessory housing was needed with a strengthened belt. Faury says that the engine was specifically calibrated to further decrease fuel consumption and emissions. A manual compact automated gearbox was optimized for hybrid operation and this included the use of a high efficiency oil, specific calibration for lower noise and vibration in ZEV mode, and improved torque driveability thanks to torque compensation by the rear powertrain.

On the electric side of things, Hybrid4 uses a Bosch hybrid power control unit that comprises the power converter, microprocessor and inverters. Much work was done to the inverter control to meet acoustic and vibration requirements. The Bosch electric motor makes use of permanent magnets for a more compact design and better torque density, with torque of 200Nm being transmitted to the wheel via a 7.46:1 ratio. Bosch also developed a tailor-made

ESP. The high-voltage Sanyo battery was designed to be rated at 5.5Ah/1.1kWh for a 4km (2.5 miles) range in ZEV mode. Faury says NiMh was used as it offered a mature technological solution that offers "reliability, cost, and performance". Finally a GKN-created 'dog clutch' reduction gearbox is also used, with optimized bearings to decease energy losses. The gears have been designed to meet noise and vibration specifications, as well as to automatically disconnect at 120km/h (75mph), which is the top speed for the electric motor. GKN also supplied its eAxle system.

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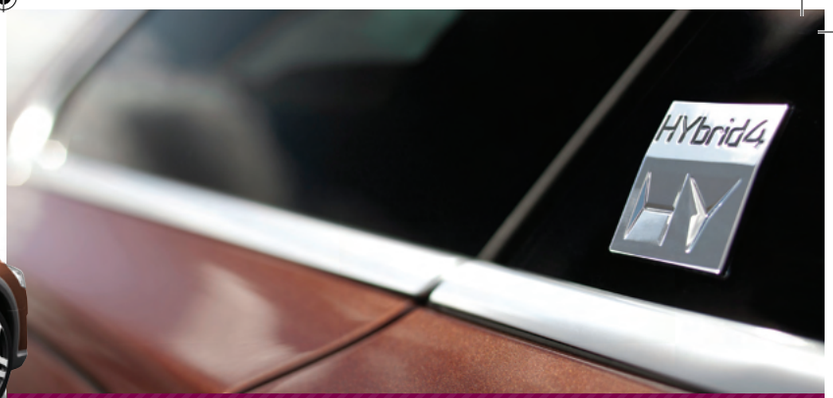

PSA: EVERYONE'S BEST FRIEND

In a world where there's less budget for research and development, PSA's longstanding model of joint ventures and partnerships makes much business sense. For one project or another, the French car maker has successfully managed (or in some cases continues to manage) JVs with BMW, Fiat, Mitsubishi, Ford, Renault, Toyota, and now General Motors.

So what's the chance that Hybrid4 will be licensed to any one of these, especially the latter with whom the French car maker recently signed a cooperation deal? "In the form of the alliance [with GM], we will look to make synergies where it makes sense," says Faury. "We will evaluate the possibilities to share all the technologies across both companies."

suggest that at least five other car makers are seriously evaluating the technology, including VW Group and one large Chinese OEM. Faury, however, is keen to focus on PSA's baby: "We can say that Hybrid4 is a world premier and one that's made in France," he says proudly.

The PSA R&D manager makes a valid point. With Europe's Euro crisis refusing to go away, it's all too easy for large conglomerates to outsource development to parts of the world that offer low costs. "DS5 Hybrid4 is built in Sochaux and the 508 sedan and RXH Hybrid4 are constructed in Rennes," he states. "The 2-liter engine is assembled in Trémery, the compact automatic gearbox is manufactured in Valenciennes, and the multi-arm rear axle is put together in Mulhouse."

Faury says the aim is for PSA to sell 40,000 Hybrid4 vehicles a year, as from 2013. To realize that goal, the technology has been made available in the Citroën DS5, Peugeot 3008, 508 RXH and the 508 sedan. However, with Hybrid4 being completely modular, the thinking is that it'll also be made available in other PSA models. A plug-in hybrid is also on the horizon, says Faury, but that will probably be scheduled for 2014 or beyond.

Cost-effective

Most engineers agree that a diesel hybrid – in a technical sense – is the optimum powertrain solution for today's automotive needs, but cost and cost alone has been the barrier that has ensured the technology has remained firmly within the R&D labs. Faury says that the modular nature of Hybrid4 helped the company to overcome cost restrains: "What we did first was develop the technology to be based on the appropriate sizing of the electric components. So there's a 25kW electric motor with a nickel metal hydride battery, which is very capable and doesn't add to the cost like some of the batteries used in the pure electric vehicles. This system is shared on four different cars to add to the appropriate volumes, and what's important to remember is that no specific car was developed for this technology – it was the integration of hybrid powertrain instead."

2

The Hybrid4 powertrain is a true French development.
1: The 508 RXH rolls out of a facility in Rennes
2: The 2-liter diesel engine is put together in Trémery
3: The 3008's production home is located in Sochaux

3

Fellow French car maker, Renault, has accelerated down the pure EV route, and by the end of this year it'll have four different EV models on the market. With pure electric vehicles maturing at a rapid pace, some battery experts say that the range anxiety associated with these vehicles will soon be a thing of the past, a scenario that could cause a massive problem for Hybrid4. Faury, however, has a different take on things: "The range can't be challenged by battery electric cars – and that's neither now nor in the future. One of the weaknesses of BEVs is that the battery is heavy, expensive, and in certain conditions, the limited range becomes even more limited. With our technology, the range is not only as good as the IC engined car, but even better because the fuel consumption is significantly improved. I don't think Hybrid4 will be surpassed by battery electric vehicles."

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The Battery Show is the world's premier and free-to-attend advanced battery showcase. Taking place November 13-15 at Novi, Detroit, Michigan, the exhibition demonstrates the very latest advanced battery technologies and solutions, ranging from electric vehicle applications to raw material suppliers. Its two-track business and technology conference examines battery market development and opportunities, including how technical advances are likely to impact performance, safety and cost.

Co-locating with The Battery Show 2012 will be the Charging Infrastructure Expo, a free-to-attend exhibition and conference focused on electric vehicle charging technologies across the entire supply chain. Charging Infrastructure Expo is an opportunity for providers of electric vehicle charging technology to meet with charging station operators from both commercial and government sectors. The co-located exhibition gives visitors access to engineers and executives from electric vehicle manufacturers and utility companies, providing a valuable crossover and unrivalled access to genuine decision makers.

Show organizer James Reader is delighted with the growth and development of The Battery Show, including the exciting new addition of Charging Infrastructure Expo 2012. "The advanced battery market covers many applications as our show reflects, but our success in Michigan is naturally linked to the electric and hybrid vehicle market and projected growth in this sector," says Reader. "An effective infrastructure is essential to the success of electric vehicles. Charging Infrastructure Expo – as a dedicated zone within The Battery Show – provides prospective charging station operators with a fantastic opportunity to meet the industry and experience the technology first-hand. Best of all, entrance to the event is free of charge. All you need to do is register online."

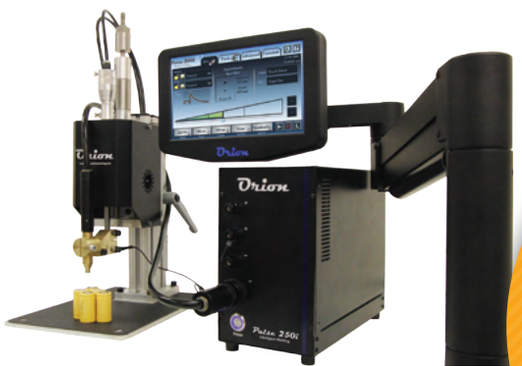
Visit www.thebatteryshow.com for more information and to register as a visitor.

THE BATTERY SHOW | DETROIT
The Expo for Advanced Batteries | NOVI Detroit | Michigan | USA

WELDING WITH STRENGTH

Sunstone Engineering specializes in designing, manufacturing and engineering micro-welding products. The company has developed new technologies for welding EV and other high-capacity battery packs that run more efficiently and more powerfully. The technology enables users to weld copper tabs up to 0.02in thick.

In addition, resistance welding products for welding cells or assembling packs are available. At The Battery Show, Sunstone will perform sample welds and, as always, invites customers to bring their own items to be welded. New and updated models of the Pulse-Arc and Resistance welders will be launched at the show.



RANGE OF MATERIALS

Pred Materials, which is Hohsen Corp's exclusive North American distributor, will exhibit small table models of its line of lab and pilot level cell-making components, tools and machines. Hohsen offers high-quality precision tools and components for development work in electrochemical products.

In addition, the US organization will unveil for the first time at a trade show its new line of carbon nanotube dispersions (CNT dispersions). Additionally, representatives of China Steel Chemical Corporation (Taiwan), a leading producer of mesophase carbon powders, will be on hand with Pred Materials to launch its new composite anode powders.

AUTOMATION SUPPORT

SMC Corporation of America will present its pneumatic equipment for LIB battery manufacturing processes, such as products applicable to dry room (up to -70°C dew point) and clean room, copper/zinc-free products, an intrinsically safe directional control valve, vacuum pads for delicate work pieces, and corrosive-resistant products.

CHANGING THE FACE OF EV CHARGING FOR GOOD

Qualcomm has confirmed its presence at this year's Charging Infrastructure Expo (part of The Battery Show), where it will showcase how it is pioneering the development of wireless electric vehicle charging (WEVC) technology as a way of bringing EVs to the mass market. At the heart of the Qualcomm Halo WEVC technology is simplicity and ease of use, two key features that the company says will help drive global EV adoption.

WEVC technology uses magnetic induction to transfer power from a base charging unit (BCU) to a vehicle charging unit (VCU). Power is transferred via magnetic coupling, with comparable efficiency to plug-in or conductive charging systems, and is used to charge the vehicle's batteries. Communication between the VCU and BCU provides authentication, validates charging requirements and ensures minimal impact on the grid.

While WEVC technology is ideally suited to stationary wireless charging, it also opens up the possibility of dynamic charging, which is charging the battery while the vehicle is being driven. The adoption of WEVC technology will lead to a shift in charging behavior, says Qualcomm, with drivers charging their EVs in less time, and potentially using dynamic charging to complement local stationary charging, thus removing range anxiety. As a result, batteries could become smaller, leading to a reduction in EV cost and vehicle weight.

Visitors to Charging Infrastructure Expo will have the chance to discuss the exciting future possibilities with Qualcomm's representatives later this year.

SUPPORTIVE SOFTWARE

Greenlight Innovation is excited to be returning to The Battery Show and is co-exhibiting with AeroVironment.

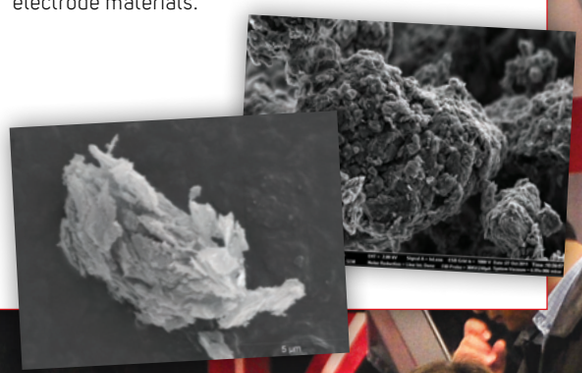
Greenlight's Emerald Software suite and data acquisition system will be demonstrated in conjunction with AeroVironment's battery cyclers. The software supports the entire range of battery cyclers, and provides both single and multichannel automated turnkey battery-testing solutions.

Emerald offers a flexible feature set to support integration and control of multiple third-party test equipment, such as coolant modules, data acquisition systems, environmental chambers and diagnostic devices. The software is equipped with enhanced graphing and data-logging capabilities, enabling the user to rapidly process and view test data. Its automation capability directly translates test protocols and drive cycles for 24/7 automated testing. Emerald also provides configurable safety features, including email and SMS warning, or alarm notifications to operators.

THE SCIENCE BEHIND ELECTRODE MATERIALS

XG Sciences works closely with customers to develop high-performance electrode materials for lithium-ion batteries, supercapacitors, and fuel cells. Its commercial xGnP graphene nanoplatelets are formulated into electrodes, inks, and pastes that deliver high charge storage and superior current-carrying characteristics. They are also used in printable electronics for conductive powders, inks, and papers, and as additives for high-strength lightweight composites, anti-wear lubricants, and water treatment solutions.

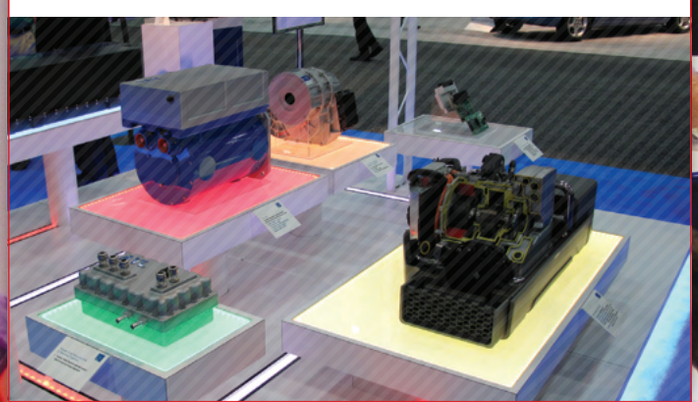
At The Battery Show, XG Sciences plans to launch a new high-capacity silicon anode and will showcase all of its graphene-based battery and supercapacitor electrode materials.



ELECTRIC AND HYBRID OFFERING

AVL, the world's largest privately owned and independent company for the development of gasoline, diesel, alternative fuel, electric and hybrid powertrain systems, offers combined solutions for powertrain engineering, simulation software, testing and instrumentation systems. It will showcase its Open Development Platform (ODP) and Integrated Tool Chain Methodology (ITCM), incorporating the engineering capabilities, processes and technologies that are used to develop, test and integrate advanced powertrain systems for hybrid and EVs.

Representative hardware and software tools, and testing technologies, will demonstrate how the ODP and ITCM support a seamless, front-loading, system-oriented development and testing process.



THE CONFERENCE

Among the many speakers at this year's Battery Show Conference is **Dr Adrian Steinmetz**, who is vice president of business management at BASF. He will be discussing how an integrated approach to battery materials can deliver innovative materials and functional components to enable safe, efficient and affordable electromobility.

Steinmetz, who is responsible for the global commercial management of the business, its application, and product technology, including advanced cathode materials and electrolytes for lithium-ion batteries, explains, "Together with partners in industry and science, BASF is developing materials and technologies for today's, and the next generation of, lithium-ion batteries, as well as for future battery systems. So I will present a unique perspective on future developments of battery materials."

Steinmetz says his involvement in the conference will enable those in attendance to recognize that BASF's strategy is to create chemistry for a sustainable future: "We hope that sharing our perspective on the development of battery materials will help drive the future of electromobility."

New this year, here's some of the highlights at the

CHARGING INFRASTRUCTURE EXPO

BATTERY PERFORMANCE ENHANCEMENT

BASF will showcase its unique range of solutions to enhance battery performance, from NCM and LFP cathode materials, and advanced electrolytes for lithium-ion cells, to engineering plastics and polyurethanes for battery packs. BASF is the only company worldwide that is licensed to produce and market lithium-ion cathode materials by both the Argonne National Laboratory (the global leader in NCM technology) and LiFePO4+C (which licenses a leading patent portfolio in LFP technology).
The recent acquisitions of Merck's electrolyte business and Novolyte, combined with BASF's internal developments, have produced an impressive portfolio of high-purity electrolytes for lithium-ion batteries. In addition, the acquisition of Ovonic offers NiMH technology and know-how.

KNOWLEDGE AND SKILLS

P3NA is part of the P3 Group, a global company with more than 1,400 consultants and engineers. Offices can be found across the USA, offering strategy consulting, professional management services and engineering solutions to the automotive, aviation and communications sectors. With a broad client base that includes leading OEMs and Tier 1s, P3 has executed high-impact projects, leveraging its technical and analysis capabilities along with extensive industry knowledge.

P3NA's automotive business offers strategic and technical services for alternative powertrain development (vehicle and component level), EV batteries, vehicle-to-vehicle communications, infotainment and telematics systems, and commercial vehicle powertrain development.

At this year's Charging Infrastructure Expo, the company will be represented by experts in the fields of battery technology and manufacturing, sourcing and supplier development, smart charging, and vehicle connectivity. A series of white papers will also be available at its booth, offering insights into a range of topics including the secondary use of EV batteries and vehicle connectivity. The authors of these white papers will be available for discussions with visitors.

STOP/START ENABLERS

Johnson Controls Power Solutions, which was the first company in the world to produce lithium-ion batteries for mass-production hybrid vehicles, will showcase its work on lead-acid automotive batteries and advanced batteries for stop/start, hybrid and EVs. Its 50 manufacturing, recycling and distribution centers (plans to build a US$200 million automotive battery manufacturing facility in Tianjin, China, have also been announced) supply more than one-third of the world's lead-acid batteries to major auto makers and aftermarket retailers.

The company's full spectrum of energy storage solutions will be on show, including Varta Start-Stop Plus with AGM Technology (Absorbent Glass Mat), AGM technology with high-compression fleece separator, and its latest OE technology for advanced stop/start vehicles, which has at least three times more cycle life, and meets the demands of all stop/start vehicles and high-end luxury vehicles.

SOLAR CAPABILITIES

With headquarters in Michigan, USA, **Patriot Solar Group** engineers and manufactures solar tracking systems, including fixed pole mounts, single- and dual-axis trackers, and ground mounts for large commercial or utility-scale projects. A single-axis carport is a recently developed product that staff will be keen to discuss at the expo. The company distributes solar panels of all sizes, inverters, on- and off-grid systems, and a full range of consumer solar products. The company says it is dedicated to providing high-quality solar products and materials that support renewable energy, for home and commercial use.

CHARGING INNOVATIONS

Also exhibiting at this year's show is **Polar Power**, which manufactures DC generators that provide level 2 and 3 fast charging for all EV and commercial vehicle range extenders. Polar's diesel, propane, and natural gas powered chargers are compact, lightweight and automated.

Portable rapid chargers are necessary on test tracks, intermodal freight yards, automotive dealerships, and tow-trucks. These applications which will be showcased at the expo, require rapid charging of vehicles away from the utility grid.

Polar's natural gas-fueled chargers also enable rapid charging at offices, homes and service stations.

ADVANCED BATTERY TECHNOLOGY

AllCell Technologies will display lithium-ion battery packs for transportation and renewable energy applications, plus a battery swapping station and an electric scooter developed by one of its customers. Its patented thermal management technology enables production of compact, lightweight and long-lasting batteries. AllCell's thermal management technology uses phase-change materials to surround each lithium-ion cell, absorbing and conducting heat away to dramatically extend the life of the cells and prevent fire or damage to the battery. One of AllCell's customers, French light EV manufacturer Matra, worked with the company to develop Bat'Lib, a fully integrated e-Mobility solution using electric scooters and a battery swapping station. AllCell manufactures Matra's new high-density battery, which has 1.1kW/h of capacity and weighs just 7.7kg, with a drive range of almost 56km (35 miles) and 1,800 charging cycles.

A FLEXIBLE APPROACH

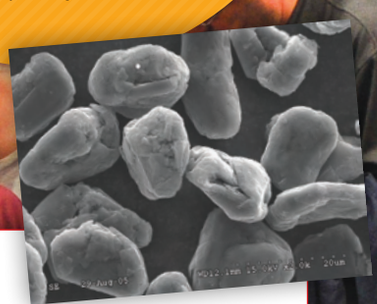
Readco Kurimoto will present its continuous processor, which is used for the continuous mixing of Teflon, carbon and graphite. It is also used to mix lithium-ion battery materials and offers complete flexibility in paddle designs, and an infinite number of configurations that solve the issues surrounding the dispersion of Teflon and carbon black materials.

The continuous processor is used extensively in the battery and chemical industries as a replacement for labor-intensive batch processes with lower power. It can be supplied as a standalone machine component, or as a complete turnkey system.

A SELECTION OF SOLUTIONS

Siemens Industry will be on hand to discuss its automation, drives and networking solutions for battery machine builders and battery manufacturers. The global supplier has experience in, and knowledge of, battery production processes, especially for lithium-ion and lead-acid batteries.

At The Battery Show, Siemens will showcase its controllers, safety and networking capabilities at both the machine and plant-wide level through a digital battery plant simulation. Through totally integrated automation, the company's field devices, controllers and panels transparently provide data up to the SCADA and MES level, helping identify bottlenecks, increase quality and improve yield.



ANTENNA SOLUTIONS

Visitors to **WP Wireless**'s booth will see a selection of antenna solutions, both embedded and external. These are an integral part of the battery charging infrastructure for EVs, helping ensure consistent communication with the smart grid, cell phone systems and other mesh networks. Critical data transmitted by the EV charging stations can include billing information, battery charging status updates for customers, notification of charger locations and availability, and charging station condition and performance monitoring.

Representatives will demonstrate the benefits of switching to embedded antennas. Not only do these antennas cost less in production than the external variety, but antenna maintenance expenses and product down time, due to antenna-related issues, are effectively eliminated. Embedded antennas also facilitate unique product designs, enhancing both provider differentiation and customer acceptance.

ENERGY MATERIALS RANGE

Manufacturer of graphite/carbon energy materials for battery and fuel cell applications, **Superior Graphite** will showcase its Formula BT product line at the event.

Used as anode material for Li-ion battery applications, Formula BT SLC series provides high reversible capacity, low irreversible loss, excellent high-rate capacity and high adhesion and long cycle life to meet EV requirements.

Customized for conductive enhancement additives, Formula BT ABG & LBG series provides high levels of electrical conductivity, high lubricity, compressibility for high mechanical strength and chemical stability levels.

Combined with a variety of milling and surface treatment processes, Formula BT products consist of high crystallinity, high purity, defined particle morphology and defined particle size distribution.

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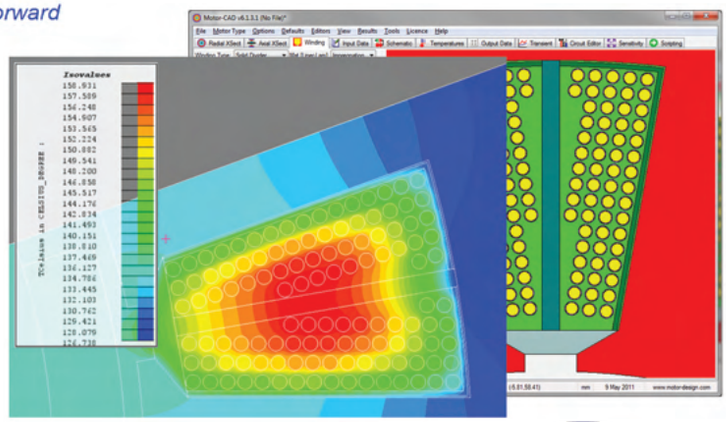

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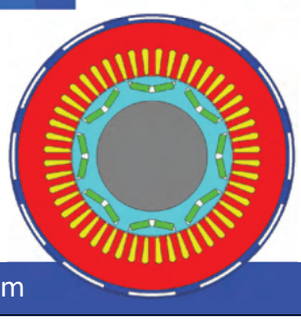

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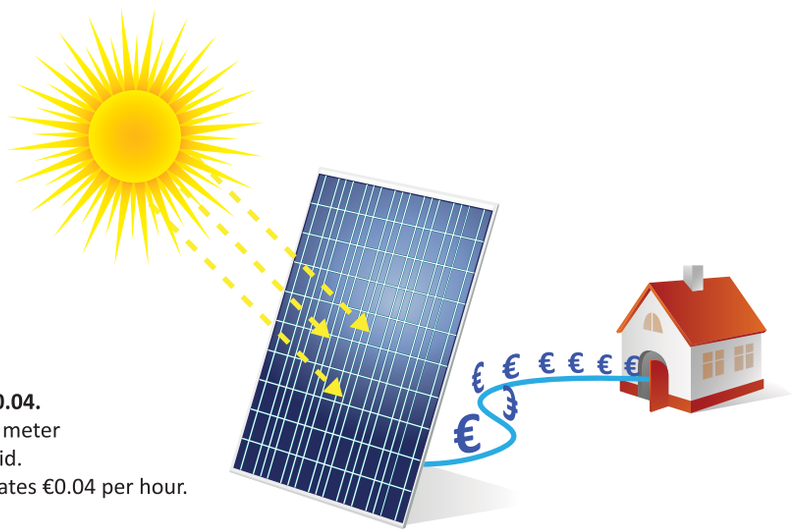

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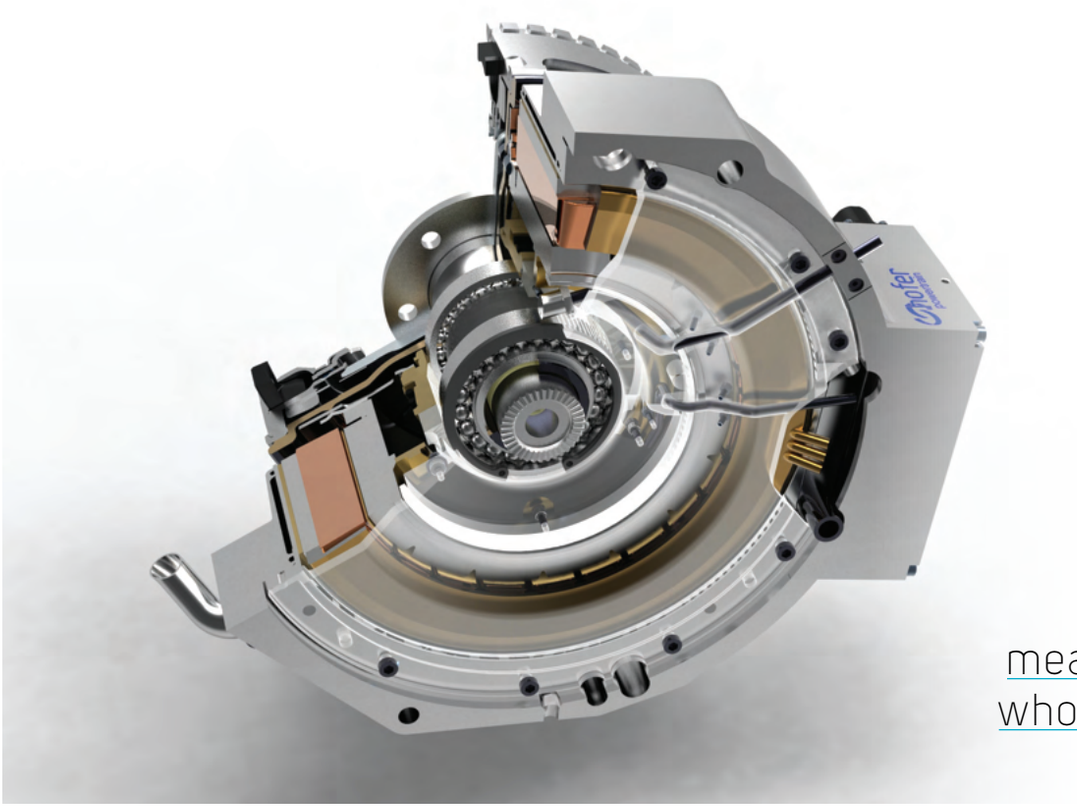
Systematic thinking

WORDS: **KARL VADASZFFY**

Martin Berger, Hofer MD, says that a top-down systems methodology makes business sense for EV development

Challenges for developers of electric drive products have become multidimensional, but there's one company that is championing an innovative top-down approach to find the most optimal solutions

With more than 15 years' Tier 1 experience in series development of electric drive systems for hybrid and electric powertrains, Hofer Powertrain, which is able to complete integration that spans a variety of applications including gears, shafts, clutches and transmissions, recognizes that challenges for electric drive products are plentiful and complex. In fact, managing director Dr Martin Berger goes as far as to say that the said challenges are intertwined, so an answer cannot simply be found at component level. As a result, he and his team have developed a top-down systems methodology, which he describes as being "vital" for the future of effective and widely successful electrification.

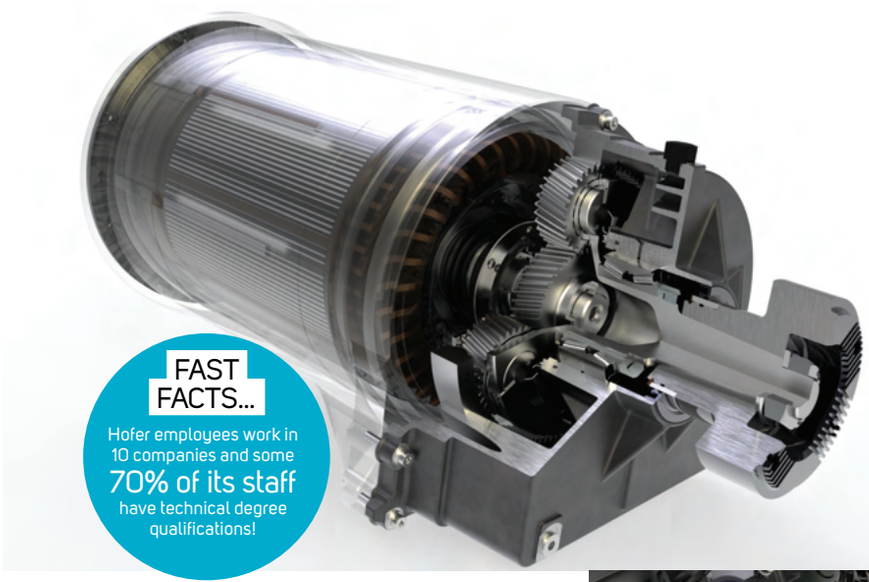


A plug-in hybrid module developed completely by Hofer, including the e-motor, cooling system, clutch system and mechanical integration

In essence, there are several challenges beyond power and torque density, argues 38-year-old Berger, in the journey to a completed automotive product with an electrified drive. So Hofer's top-down thinking, which is applied to both high- and low-volume projects, explores the wider issues: cost, efficiency, scalability and modularity, volume, functional safety and NVH and EMC.

Volker Hartmann, who is director of business development at the German supplier, adds, "A functional safety approach cannot be handled on component level exclusively, so you have to find the right answers in the complete system and understand the dependencies between the components and how they act in the vehicle, before you go to component development. Our system approach means that we explore the whole drivetrain efficiency, coming from the energy source to the wheels, and not just for the components themselves – there's a dependency on things like drive cycles, driving strategy and the thermal usage of the components."

"Our system approach means that we explore the whole drivetrain efficiency"



FAST FACTS...

Hofer employees work in 10 companies and some **70% of its staff** have technical degree qualifications!

FLEXIBLE FRIEND

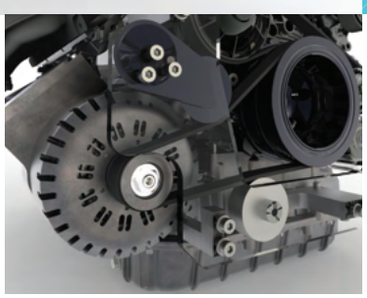
Hofer and Semikron have announced that they have developed a flexible inverter system for hybrid and electric vehicles. The new Semikron SKAI 2 IGBT system, which was first presented in May this year, has just been launched and is available as a custom-specific solution including control hardware, software, and also safety functions from Hofer. The portfolio covers a power range of 600V IGBTs for applications up to 150kVA, and 1,200V IGBTs for up to 230kVA.

The custom-specific SKAI systems fulfill current requirements and qualification standards as regards EMC, vibration, IP protection class, safety functions and lifetime in automotive industry. The verified safety functions enable the use of both asynchronous and synchronous motors, and guarantee reliable operation, say the partners. The SKAI modules are also suitable for multi-electrical drive systems.

On a mission

Key to the early stages of Hofer's work with clients, which last year resulted in a turnover in excess of US$52m, is to understand the vehicle mission: whether the project is, for instance, a hybrid, an EV, a sports car, a fun car, or a city car. The Italian MD continues, "If there's a concept available, we go into consulting to understand needs, give a proposal on a system engineering level, do some calculations and simulations, complete detailed system engineering, and then go through component specifications." That's then followed by development for all the components of the electric drivetrain on an electrification level, including electric motors, power converters, software, transmissions and other mechanical components for integration purposes.

Berger's team of 100 engineers is currently involved in some exciting projects. These include two high-end sports car projects, both of which are pure electrical vehicles with an approximate range of 160km (100 miles) and capability of accelerating from 0-100km/h (0-62mph) in under four seconds. There are also projects for power hybrids and plug-in hybrids of around 80kW of electrical power. In addition, there are also small electric city vehicle projects that promise to bring electric driving to a far greater consumer base.

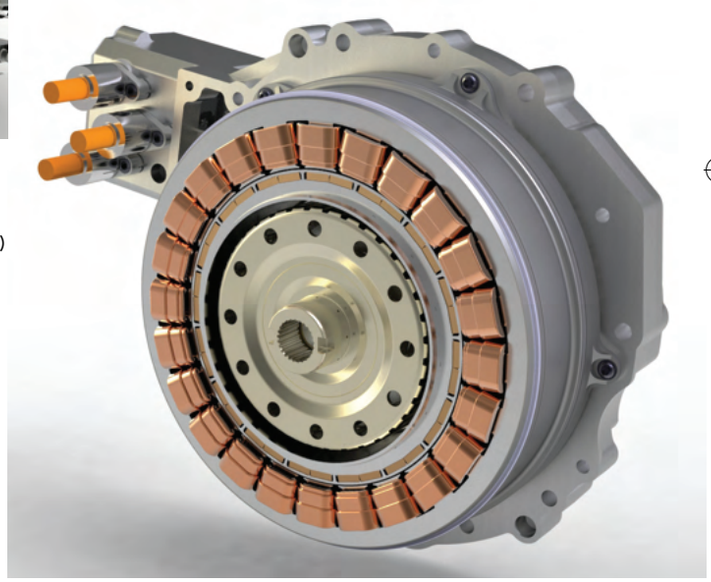


Top: An integrated solution for bus and truck applications that combines an induction motor with a planetary gear set

Above: Belt starter generator (induction motor)

Right: Advanced plug-in hybrid module with a permanent magnet motor

Volker Hartmann, director of business development at Hofer Powertrain, says the company is primed to help the industry to push forward to further EV development



> "You need the corresponding tools to be able to answer eDrive questions and challenges before you start to optimize components"

Each new customer, such as those that brought the above projects, provides Hofer with a fresh and exciting challenge. Hartmann says, "There's not a single answer to the question: what has to be investigated to find the right concept? That's why our multidimensional top-down system approach works so well and is used to the end of a project."

And finding the optimal concept always depends on what the customer wants. "It will always come down to what the focus of the final product is," adds the 39-year-old German. "You need the corresponding tools to be able to answer eDrive questions and challenges before you start to optimize components, which means you need to be an expert on all the components that are involved in the transformation of electrical energy into mechanical energy at the end of the process. That's where we thrive – we are those experts."

AUTOMOTIVE INNOVATION ›
FROM THE INSIDE OUT

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transportation weight loss diet conference 2012

The Transportation Weight Loss Diet Conference is a unique event that will bring together key innovators from across the automotive, aerospace and rail industries, as well as leading academics, to highlight major breakthroughs in mass reduction.

SEE FULL PROGRAM ON PAGE 60

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stop/start may hesitate or stall, causing driver anxiety about the stop/start function."

SpeedStart, which in tests has achieved over 1.2 million start events, has been applied to a number of demo vehicles. One is a series-production 1.4-liter turbocharged Volkswagen TSI model. "We've taken the 1.4-liter petrol and replicated the performance of the 1.8-liter petrol, but with the fuel economy of the 2-liter diesel," Pascoe adds. To do this, a diesel-type gearing was inserted; long gear ratios destroy driveability, so to address this issue, CPT fitted its electric VTES supercharger (since sold to Valeo) to restore the low-engine-speed torque, then fitted stop/start and energy recuperation.

Acceleration was 0-100km/h in under nine seconds, equivalent to the larger 1.8-liter and 2-liter models. CO_2 figures were below 130g/km, almost matching the diesel. And the cost saving was significant: at market prices, a little more expensive than the 1.8-liter, but delivering the economy of the US$6,000-more-expensive diesel. Compared with a full hybrid, savings would be impressive.

The move from 12V to 48V means a transfer from cranking to motoring, and steady state generating to transient recuperation. "At 48V, we're generating 5.5kW steady state, and more than 7kW in a transient mode, which increases the amount of energy recovered on each braking cycle," says Pascoe. "That step alone is worth somewhere between 4% and 8% of additional fuel economy on NEDC. We'd expect this to be more in the real world.

"With 48V, more power can be returned to the crankshaft. However, the real objective is to increase the amount of recuperation that's possible. A vehicle that's slowing down has a lot of kJ, if not MJ, of energy available, so if you capture that during a short braking event and put it back into the powertrain later, you have energy for free."

1

2

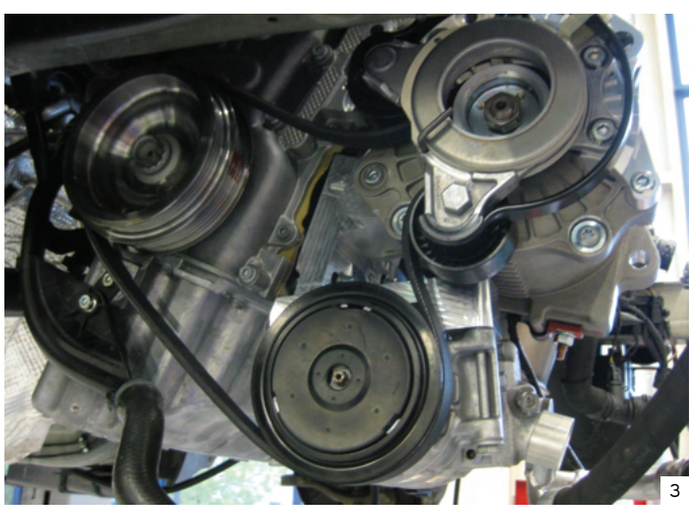
RECUPERATION TIME

Over the next few years, CPT will turn its attention to exhaust-gas energy recovery, and according to Pascoe, about one-third of what's pumped in to an IC engine comes straight back out in the exhaust.

CPT's Turbogenerator Integrated Gas Energy Recovery System (TIGERS) , also based on SR motor technology, has been in development for seven years. The project is exploring how to optimize and utilize thermal energy within a vehicle. "Combining very hot exhaust gas with an electric machine and power electronics is difficult," outlines CPT's CEO, Nick Pascoe, "but it's progressing well. We're exploring how to use the controllability and how to be selective about when the energy is harvested."

It's going so well, in fact, that CPT expects to have the recuperation device in a running vehicle by next year, with the product on the market in about five years' time.

"At some point," Pascoe observes, "it'll be better value to have a low-voltage vehicle with both crankshaft and exhaust-gas recuperation machines in place than to have a high-voltage, full hybrid."



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1. The LC Super Hybrid lead-carbon battery installation

2. CPT's liquid cooled turbine-integrated gas energy recovery system known as TIGERS

3. LC Super Hybrid features CPT SpeedStart stop/start technology and Mubea belt tensioner

The next technological step

Both recuperation and electrical torque assist systems may well be the next technological steps to obtaining greater fuel efficiency levels. But Pascoe warns, "You have to be careful with the implementation of recuperation systems because, on the whole, they affect vehicle driveability." And this is where the SR electric motor is beneficial: "Again, its controllability enables the vehicle OEM to implement a characteristic appropriate for each customer's fuel economy and brand objectives."

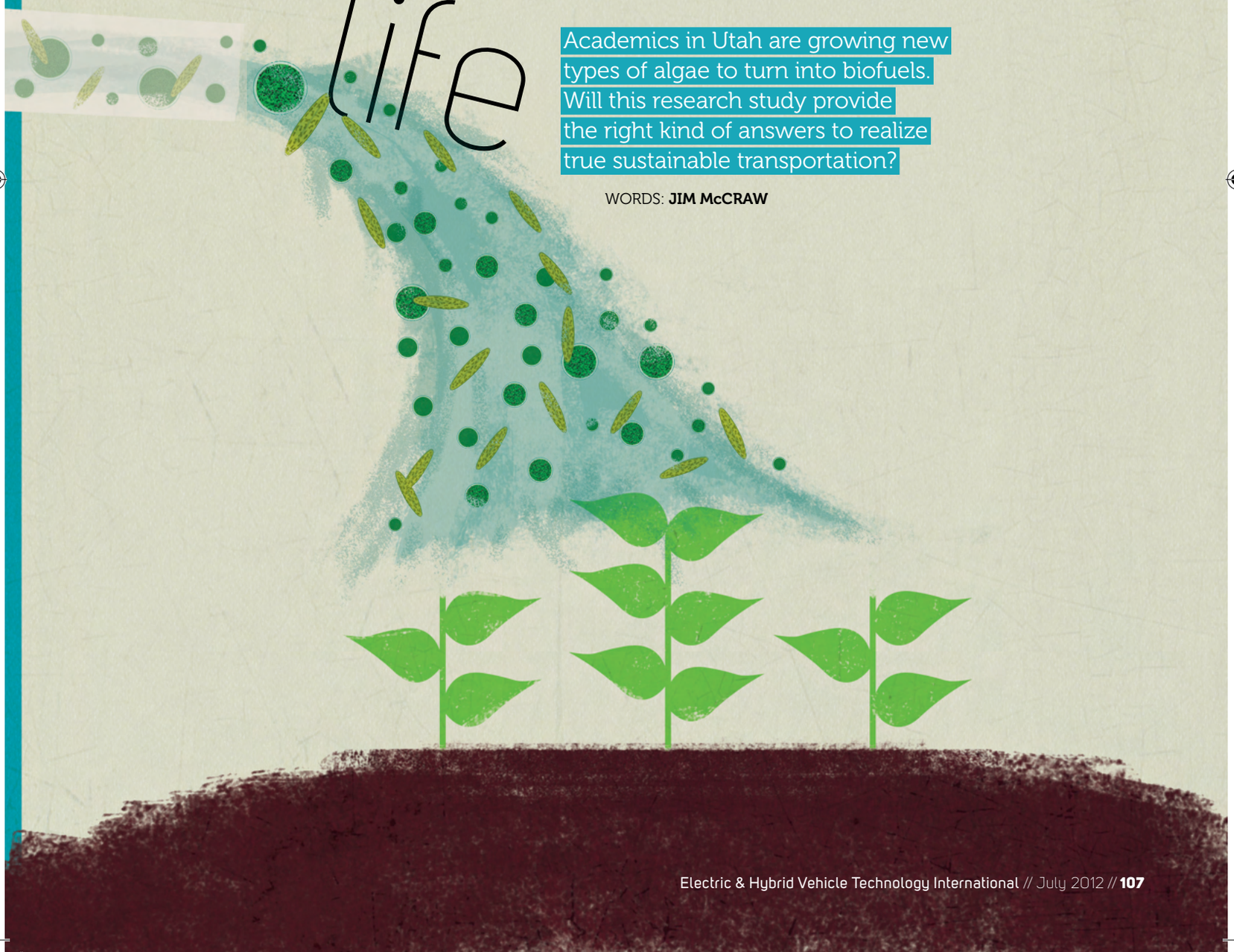
CPT's 48V technology should be on the market by 2016, initially as an intermediate step with a parallel-electrical architecture where the conventional vehicle electric loads run on 12V and the high-current-use devices run on 48V. By 2020, however, Pascoe envisages a 48V standalone architecture for a vehicle.

Illustration courtesy of Ben White

Pond *life*

Academics in Utah are growing new types of algae to turn into biofuels. Will this research study provide the right kind of answers to realize true sustainable transportation?

WORDS: **JIM McCRAW**



Just a few years ago, a bright young scientist named Kevin Shurtleff had an idea: why don't we build some portable ponds, grow algae in those ponds, harvest the algae, and then process it into engine fuel?

Shurtleff, who holds a BS, an MBA, and a PhD in physical chemistry from Brigham Young University in Provo, Utah, initially did some post-doctoral work on semiconductor solar cell materials for spacecrafts at the University of Utah, his first job in energy. From there, he started his own fuel cell company, then an oil extraction company, and then went to work for the Utah Science, Technology and Research Initiative, or USTAR, where he found himself working at Utah State University in the algae-to-biofuels group.

"Being an energy entrepreneur, interested in all forms of energy, I saw that as an alternative for traditional oil production. So I went to work for the Energy Dynamics Laboratory at Utah State University," he outlines. "People have been looking at algae since the last oil embargo in the late 1970s. The Department of Energy started an aquatic species program, looking at algae and algal species as potential energy sources, and they funded that for years and years, but it was really low-level, basic research. This time around, as oil prices increased, they started taking algae more seriously, and about five years ago, USTAR received a proposal from professors at Utah State to develop an algae fuel program. I came into the project two years ago."

Commercializing algae

Shurtleff's brief was simple: to figure out a way to commercialize algae-to-biofuels conversion and large-scale harvesting and production, combining his scientific background with his business and commercial acumen.

"When I got here, we were growing algae like other people, in test tubes in the laboratory, in flasks, and in other small containers. They were using a 220-liter rectangular loop – called a raceway."

Shurtleff says there are two schools of thought when it comes to algae production. One group favors a closed photobio reactor, something akin to a fermentation tank that's closed and is closely controlled, with some algae growing in light, and some growing in the dark, and feeding the algae sugar that is then converted to alcohol. According to Shurtleff, some of these strains of algae have been bred to produce oils or lipids.

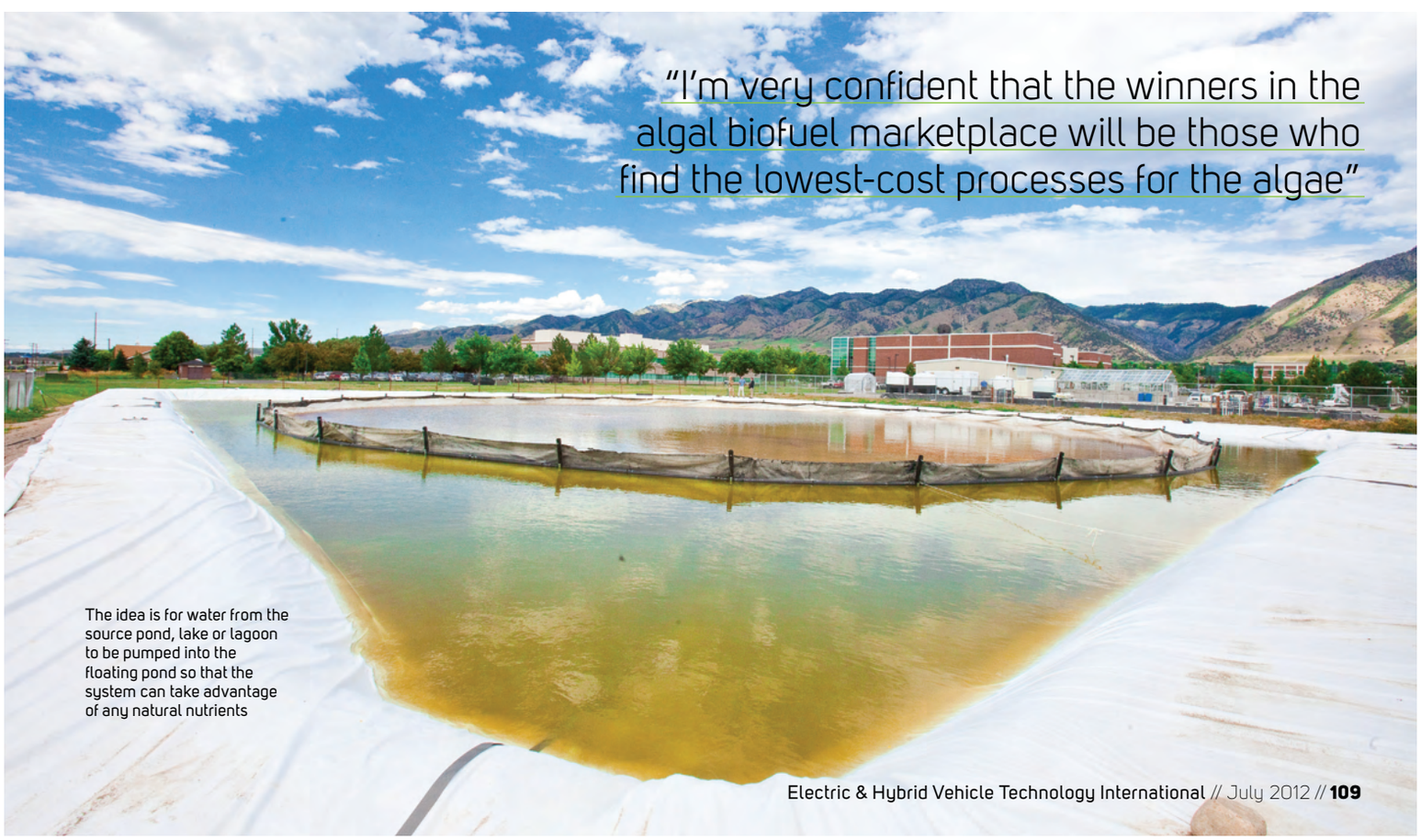
The second thinking to algae production is making use of hanging bags that's placed in sunlight where algae are fed. When the sun goes down, scientists add LED light to the bags in order to maintain production 24 hours a day.

For Shurtleff, the agricultural model is the favored approach, where algae are grown in large open ponds, in particular the huge salt ponds and salt lakes that are unique to Utah, which works out nicely, as the State of Utah is funding the project both directly and indirectly.

The big idea

"The Great Salt Lake is a wonderful resource. It doesn't freeze during the winter, it's huge – from 18,000-35,000ft^2 [1,672-3,252m^2] depending on weather – and it grows algae that grows well and produces lipids or oil. When I came on board, two things hit me immediately: I wanted to grow on the Great Salt Lake, but the problem with natural bodies of water is that it's difficult to harvest."

That was when 'the big idea' came



"I'm very confident that the winners in the algal biofuel marketplace will be those who find the lowest-cost processes for the algae"

The idea is for water from the source pond, lake or lagoon to be pumped into the floating pond so that the system can take advantage of any natural nutrients

along. "I wanted to grow in interesting bodies of water. To do that, I had to isolate the algae in the top 6-12in [152-300mm] of water, where they can get the sunlight. We are doing this photosynthetically, letting the sun be the source of energy rather than feeding them sugar. That's where the mobile floating pond concept came from."

With the mobile floating pond concept, Shurtleff says his team can grow on open bodies of water, on wastewater facilities, especially on the wastewater lagoon in Logan, Utah, which is one of the largest in the USA.

The mobile floating pond that Shurtleff and his team came up with is based on economics, and therefore is made of easy-to-get, cheap materials that are light and durable. In practice, the floating pond isolates the top 155mm of any body of water, using nylon-reinforced plastic sheeting that's connected at the edges with a floating buoy system made of high-density polyethylene pipe, measuring 305mm in diameter all the way around the plastic sheet. Water from the source pond, lake, or lagoon is then pumped into the floating pond so that the system can take advantage of any natural nutrients.

The novel floating algae pond concept is crucial to the academic project

"When I came on board, I immediately wanted to grow algae on the Great Salt Lake, but the problem with natural bodies of water is that it's difficult to harvest"

To harvest, Shurtleff's team adds a chemical that the algae needs – essentially a substance that causes the algae to clump and settle out of the water. The water is then pumped out, leaving an algal slurry. The slurry can then be pumped out, or be left in a place to dry in the sun for up to 48 hours before being collected.

Additives included

Filamental algae will settle out easily, Shurtleff says, but the micro algae – single-celled creatures – seek sunlight and don't clump as well, so chemicals such as aluminum sulfate, ferric chloride or acrylic polymers, have to be added to the mix.

The process sees water being pumped out of the pond, leaving an algal slurry. The slurry can then be pumped out, or be left in a place to dry in the sun for up to 48 hours before it is then collected

To combat the high cost of these additives, Shurtleff went looking for a cheap alternative and found an answer in readily available agricultural fertilizer – triple super phosphate.

With photobio reactors, algae are harvested and the lipids or oil they produce is extracted. Other groups are trying to force the living algae to excrete the lipids as a waste product, but at this point in time, this remains only a very small-scale research project. The most popular method is slurry centrifugation, where the slurry is spun to separate water from algae, drain off the water, and then collect the algae, but the cost of power to operate the centrifuge is so high that the cost/benefit equation goes upside-down again.

Shurtleff says that his method of settling the algae in the floating pond looks to be the least expensive method developed so far.

He adds, "It's the ratio of cost-per-gallon of oil produced; photobio reactors can be seven to 10 times more productive in terms of gallons of algal oil per acre [0.4ha], but they cost more than 10 times than that of low-cost agricultural growing, so you're upside down. It's not just about maximizing productivity; it's maximizing the dollar cost of your product. Sometimes, the economics dictate the science, and in the case of the algal industry, I'm very confident that, in the end, the winners in the algal biofuel marketplace will be those who find the lowest-cost processes, from feeding and growing the algae, to harvesting, and then converting into biofuels. We're competing with a commodity, which is fossil diesel and fossil gasoline. Sometimes we have to give up the most efficient technology to get a lower-cost technology."

Shurtleff says that a good dry algae biomass that's one-third protein, one-third carbohydrate, and one-third oil, can be used to produce alcohols such as ethanol or biobutanol from the carbohydrate, or to make biodiesel from the algal oil.

Shurtleff's current work is a combination of selectively breeding the algae with the fastest growth rate and highest oil content, and then finding the best possible size for the floating ponds in terms of cost, maintenance, harvesting and production. His team found its early 0.4ha floating ponds, 78m in diameter, too unwieldy to build and move, so now they are using 0.2ha round ponds, 56m in diameter.

Dr Stephen Russ, an engine and fuels expert at Ford Motor Company, says that, although the methodologies used by Shurtleff and his team are scientifically sound, the economics are not currently favorable, citing one study that yielded one/two barrels of biodiesel fuel from 0.4ha – but this won't stop Shurtleff in his quest to advance his project. Watch this space!

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QUICK FACTS

The plane is only **1,600kg,** in weight and has a wingspan **of 63.3m,** the same as the Airbus A340

The concept of an airplane propelled by solar power that can fly day and night was, until 2010, just that: a concept. No such flying machine had been designed to store sufficient energy to maintain aircraft and pilot in the air outside daylight hours. That was until Solar Impulse, a project that began back in 2003, achieved a 26-hour non-stop flight, instantly establishing three world records.

"Solar Impulse really is a symbol," says Bertrand Piccard, chairman and initiator of Solar Impulse. "Our airplane is not built to carry passengers, but to carry messages. We want to show what can be achieved using clean technologies that reduce our society's dependence on fossil energies."

As with any solar-powered vehicle, the key to the success of Solar Impulse HB-SIA is a combination of a lightweight body frame and extensive use of solar technology. The plane is only 1,600kg, the same weight as an average family car. In order to minimize induced drag and offer maximum surface area for solar cells, it has a wingspan of 63.3m (208ft), approximately the same as the Airbus A340. Its carbon fiber-honeycomb sandwich structure, propulsion chain and flight instrumentation, have all been designed to save energy.

"The question of energy defines the project," says André Borschberg, CEO and co-founder of Solar Impulse. "To increase the energy reserves during flight, we had to make maximum use of every single watt supplied by the sun, storing any surplus in our batteries.

Co-founder of Solar Impulse, André Borschberg, commences simulator training (below) in preparation for the 26-hour non-stop flight (above)

Clever use of materials and a lightweight frame has helped to offset the batteries, which account for more than one quarter of the plane's total mass

"We tracked down every possible source of energy efficiency. By tapping into each team member's experience and using the combined potential of them all, we managed to find solutions."

Take off is powered by the energy of the batteries charged by the sun the day before. During the day it climbs to around 7,925m (26,000ft), where it remains while keeping its batteries charged. When the sun goes down and the batteries are fully charged, the pilot switches off the solar generator. After four hours the plane descends using very little power, taking advantage of the energy accumulated while climbing. After midnight the plane is at 1,525m (5,000ft), and must remain at this altitude until sunrise because at this level the air is denser, meaning less energy is required to fly. The pilot connects to the batteries and the batteries begin to discharge. Once the sun comes up, the pilot turns on the solar generator once more, the batteries start recharging, and the sequence begins all over again.

The key to the success of this cycle lies with the pilot, who must approach each night with full batteries and use energy as economically as possible in order to stay airborne until sunrise.

Solar dream

"The upper wing surface is covered with a skin of embedded solar cells," explains Borschberg. "Each of the 11,628 photovoltaic monocrystalline silicon cells are 145 microns thick and were chosen for their lightness, flexibility and output of 22% energy conversion efficiency.

THE SOLAR-POWERED CAR: IS THE DREAM STILL ALIVE?

Automotive solar challenges have been a feature of the calendar for years, populated chiefly by entries from academia. Last year, a vehicle entered a race that observers noted looked less like "a rolling ping-pong table" and more like a functional car, complete with monocoque construction and vehicle doors rather than topside entry. The SolarWorld GT, as it is known, is a stunning collaboration between solar panel manufacturer SolarWorld and Bochum University of Applied Sciences in Germany.

"Unlike some of our previous efforts, what we have created is a fully road-legal vehicle," says Tim Skerra, head of research and navigation for the SolarWorld project. "It was built for the 2011 Word Solar Challenge in Australia. Our initial focus was the race, but afterward we thought we would circumnavigate the globe. We are already one-third of the way round."

The car travels at an average of 50km/h (31mph) with a top speed of 110km/h (68mph). It employs three solar cells mounted on the roof, with an additional three stored in the back for extra charging during pit stops. The solar cells are made from gallium arsenide. Skerra says these are highly efficient and work at close to 29% energy conversion efficiency, but the drawback is that they are extremely expensive and rarely used in commercial products.

Such has been the clever thinking behind the scenes, that the SolarWorld GT weighs a mere 300kg, around one-quarter the weight of an average car. But that doesn't mean the industry is ready to launch solar powered passenger cars. "Unfortunately the concept of the commercial solar powered car is not really on the radar today," says Skerra. "Big car manufacturers are more interested in electric plug-ins and hybrid vehicles. The cost of high-quality solar cells remains too high for use in commercial vehicles. Perhaps in 20 years or so when there is greater development in batteries, battery systems, and management systems, we will see the first commercial vehicles that are truly powered by solar cells, but I am not certain. It is a huge jump from what we have created, to an affordable and practical solar-powered car."

Skerra says that, based on his encounters on the tour to date, a lot of people are "re-thinking the notion of sustainable energy resources" and "recognize solar cells as another option".

The car will complete its circle of the globe in December.

TECH SPEC

Type: Solar powered electric vehicle with two doors and two seats, besides four tires for a stable handling
Length: 4,100mm
Width: 1,600mm
Height: 1,335mm
Basic weight (without pilot): 260kg
Top speed: 100km/h (62mph)
Cd-value: 0,14
Efficiency (cell): 29.2%
Peak performance: 823W

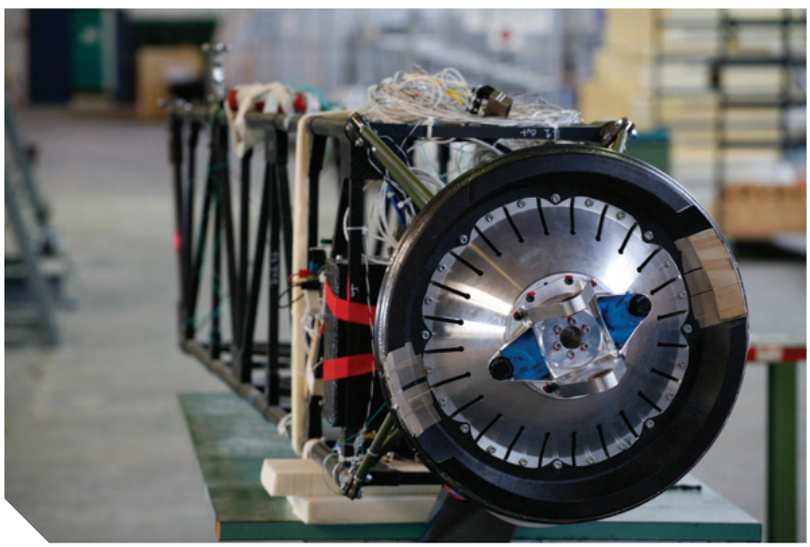
This percentage describes how much electrical power is generated from 100% solar power. To increase this percentage – and therefore the cells' efficiency – would mean adding weight, which would be a problem during night flight."

This phase being the most critical, its greatest challenge is the one imposed by the batteries, which tip the scales at 400kg, or more than one quarter of the total mass of the airplane. Their heaviness part-explains the super lightweight frame to optimize the energy chain and to maximize the aerodynamic performance provided by a large wingspan.

Fitted beneath the wings are four nacelles, each containing a 10bhp motor, a lithium polymer battery set, and a management system controlling charge/discharge and temperature. The thermal insulation has been designed to conserve the heat radiated by the batteries and keep them functioning despite the -40°C temperature encountered at 8,535m (28,000ft).

"Over 24 hours, each square foot of land surface averages out at just 250W/m^2," states Borschberg. "With 2,150ft^2 of photovoltaic cells and a 12% total efficiency of the propulsion chain, the airplane's motors achieve an average power of 8bhp or 6kW – roughly the amount of power the Wright brothers had available to them in 1903 when they made their first powered flight."

"To increase the energy reserves during flight, we had to make maximum use of every single watt supplied by the sun, storing any surplus in our batteries"



Above: Beneath the wings of the Impulse are two 10bhp motors, a lithium polymer battery set, and a management system

Right: The next test for the team is for the prototype to undertake its longest ever flight, which is scheduled for completion in Morocco

Left: The upper wing surface of the aeroplane is covered with a skin of embedded solar cells

QUICK FACTS

With 2,150ft^2 of photovoltaic cells and a 12% total efficiency, the motors achieve an average power of 8bhp or 6kW

From Morocco to Madrid

This year between May and June, the first prototype flies to Morocco, taking off for its longest ever flight, crossing the Pyrenees and the Mediterranean. Both André Borschberg and Bertrand Piccard will take turns to man the aircraft on its 48-hour journey, with a scheduled intermediate stop-over near Madrid to change pilots. The second airplane, known as HB-SIB, promises to further push back the boundaries of solar flight. Its construction has already begun and the first flight tests will start in the second quarter of 2013. By 2014, it should be ready to circumnavigate the globe in stages.

"Our primary goal is not to revolutionize the aviation or the automotive worlds, but the way people think in terms of energy and clean techs," says Piccard. "Our message is for everybody in their everyday life: what we can achieve in the air, anyone can do on the ground."

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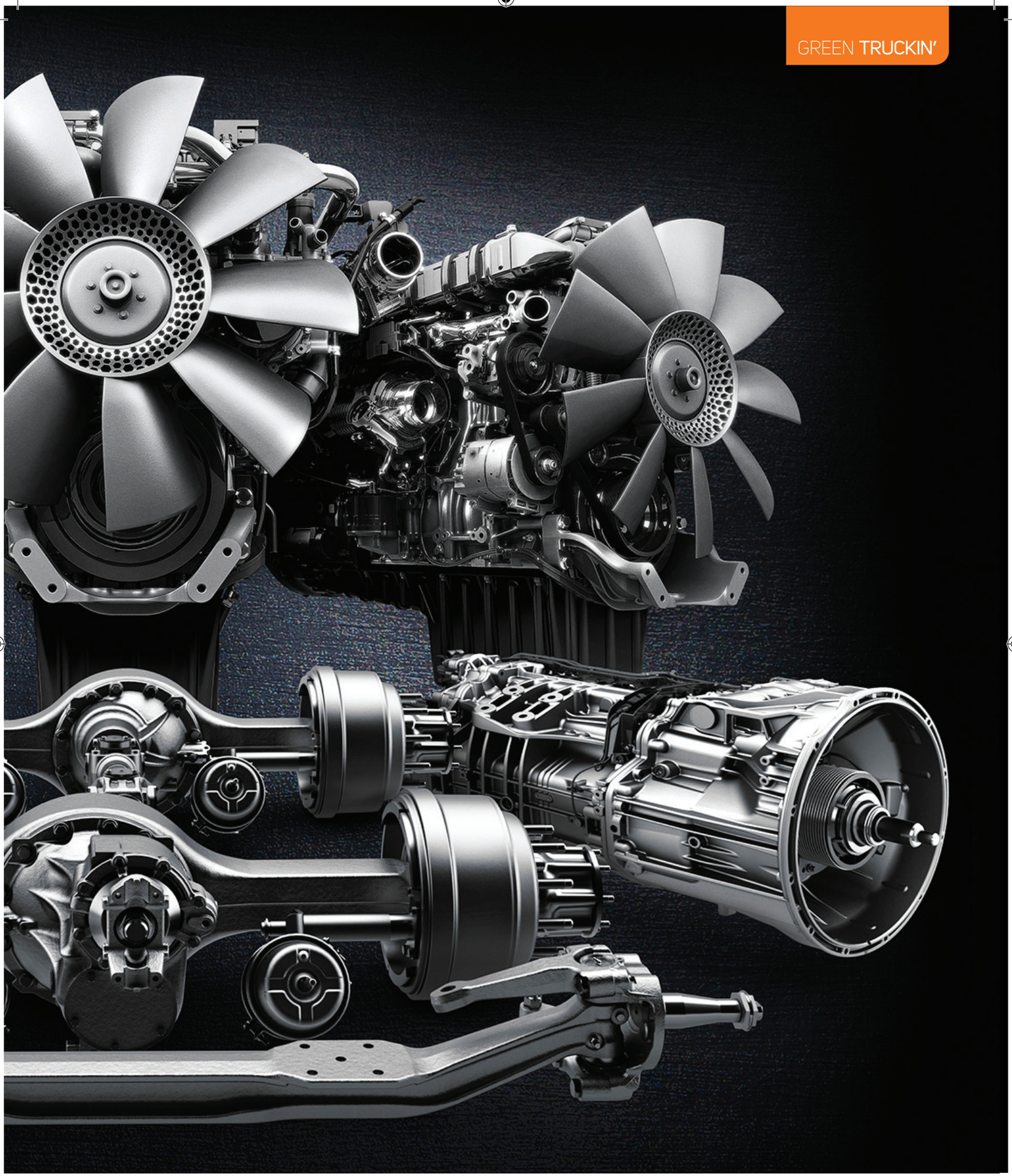
Heavy-duty hybrids

The truck world might be mainly concerned with emissions from IC engines, but there's an increasing amount of hybrid development work going on as well. ***E&H*** investigates the latest technological breakthroughs

WORDS: JOHN CHALLEN

Freightliner is increasingly looking to hybridization, adding electric elements to its existing IC engine lineup



Passenger cars may have led the way in hybrid transportation in recent years, but, not wishing to be left too far behind, the commercial vehicle world is witnessing plenty of diesel-electric applications being both trailed and introduced in series production.

However, the challenges are slightly different for CVs, given the higher vehicle masses involved. In this world, the likes of aerodynamic aids, low rolling resistance tires and increased driver training are all well and good, but the use of electric motors in conjunction with traditional IC engines still offers more potential. Pure electrification of trucks is not a viable option, given the required size of a suitable battery pack, so hybridization is seen by many as the great hope in improving overall truck efficiency and reducing fuel economy and CO^2 levels.

Premium practice run

One of the most recent projects in the truck industry has been Renault Trucks' introduction of a set of 12, 26-ton Premium trucks around Europe on a four-year trial. These vehicles will be operated predominantly in France and the UK, in the hands of a range of transport operators including Norbert Dentressangle. Renault believes that a hybrid setup in this application will bring improvements in fuel consumption by some 20% and reduce noise levels by around 50%.

The electric motor in the Premium is a 70kW permanent magnet synchronous affair, which is mounted behind the truck's six-cylinder diesel engine. This motor generates 120kW of power, 800Nm of torque, and 400Nm of retardation; the DXi7 Euro 5 common-rail engine's figures are 310bhp and 1,153Nm of torque. A 600V lithium-ion battery pack is mounted to the offside of the truck's chassis, comprises 384 cells, and is rated at

1

1 and 2: Renault has started a four-year trial project that will assess the potential of hybrid technology in truck applications. The Renault Premium uses a 70kW PMS motor that's mounted to a six-cylinder diesel

2

"When we can achieve simulated savings of 5% in a prototype, it makes sense to see if we can go further"

Daimler is intent on ramping-up its hybrid truck portfolio having already brought to market the Fuso Canter Eco Hybrid, Freightliner M2e Hybrid and the Mercedes-Benz Atego BlueTec Hybrid

1.2kW. The electric motor has been integrated into the electronic braking system, and is used to maximize the kinetic energy recovered into the electrical storage system. One other major difference from the original non-hybrid truck is in the 12-speed automated gearbox's software, which has been adapted specifically for hybrid use. Primary retardation is now through the hybrid's motor drive unit, with integrated engine braking to further improve efficiency levels and reduce fuel consumption.

"The biggest challenge was to understand that the vehicle is only being used as a trial," explains Dave Ririe, project manager at Renault Trucks. "Above and beyond the hybrid technology, there are a lot of other costs involved, such as the loss of payload. There is an additional 800kg-worth of equipment for the vehicle, which means 800kg less payload for our partner, all of which impacts on its operations."

Despite that important drawback, Ririe still believes that this type of vehicle represents the future for the truck industry. "We will find other benefits from using hybrid trucks in addition to saving fuel," he states. "In the long-term, we'll learn all sorts of lessons from these vehicles that we can feed back to our headquarters, and after the trials we can examine them to see how they have performed. In a few years' time, there will be improvements in motor drive systems and batteries, which will hopefully mean lighter, more efficient vehicles in the future.

Above: A Mercedes engineer undertakes lithium-ion battery test cell measurement for the Atego BlueTec Hybrid

Modern family

According to Ririe, Renault Trucks has no plans to expand the number of hybrid models at its disposal, but the same cannot be said for its competitor, Mercedes-Benz, which would like to see hybrid derivatives of everything it produces, from its small Fuso Canters, to the heavy duty Actros variants.

The German manufacturer cemented its place in truck hybrid history when its Atego range – featuring the Atego BlueTec Hybrid – won the coveted International Truck of the Year award in 2011. This 12-ton medium-duty offering claimed fuel savings of between 10 and 15%, helped by its ability to start in electric-only mode, in which it can travel for up to 2km. The wider powertrain setup includes a four-cylinder 4.8-liter diesel engine, which generates 218bhp and 810Nm of torque. The IC unit is mated to a water-cooled electric motor. This three-phase permanent magnet motor has a peak power of 44kW and maximum torque of 420Nm.

According to Georg Weiberg, head of truck product engineering at Mercedes-Benz, a hybrid system for larger trucks servicing the long-haul market is already in a study phase, with a number of simulations having been completed and the results dissected. "We have one prototype in our global hybrid center in Japan, in a vehicle similar to Actros," confirms Weiberg. "We have already achieved fuel savings in the region of 5%, which is a lot for that class of vehicle." While such a saving is currently only realized when traffic flow is optimized, that figure is the benchmark that Weiberg and his engineering team are working from, with a view to making even greater savings. Such has been the impact of the project that Weiberg all but confirms that the market can expect to see a new Actros hybrid within the next four years: "When we can achieve simulated savings of 5% in a prototype, it makes sense to see if we can go further."

Away from Europe, M-B's US cousin, Freightliner, is doing its best to push heavy hybrids to the forefront of North American customers' minds with the M2 106 truck. The company recently deployed a hybrid setup from Eaton into its model, which now embraces stop/start capability when the vehicle comes to a standstill. "The 'engine-off at stop' feature also includes a hill-hold function, which prevents the truck from rolling on grades greater than 2% when the driver removes his foot from the brake," explains Greg Treinen, segment manager for medium duty and alternate fuels at Freightliner. "Combined, the new features are expected to give customers up to an additional 8% in fuel savings."

HIGH-SPEED HYBRIDS

Volvo has dispelled any myth that people would have about slow hybrid commercial vehicles with the recent development of Mean Green, a record-breaking truck, powered by a stunning diesel-electric powertrain. The truck, which holds the world records for flying kilometer and standing kilometer in a truck, is based on a standard tractor unit, with some bespoke modifications. A highly tuned version of Volvo's D16 engine is used, mated to a modified i-Shift gearbox, which works with the truck's electric motor.

Combined, the power sources generate 2,100bhp and nearly 6,780Nm, with 200bhp and 1,200Nm coming from the electric motor. The company says that while there are no plans to introduce any more high-performance hybrids, it is using the feedback from the project and working it into existing hybrid applications and programs for future Volvo trucks.

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1 and 2: The hybrid setup in the Freightliner hybrid models comes from Eaton. What is more, the US manufacturer says further development work is planned as it continues to drive down emissions and improve fuel economy

Treinen reveals that the Freightliner Custom Chassis Corporation has recently deployed several customer evaluation hydraulic hybrid trucks for fleet testing. "This technology provides for a dynamic engine-off operation to realize dramatic fuel economy improvements by allowing the vehicle to operate solely on hydraulic energy," he says. "Freightliner continues to explore potential improvements to our hybrid products, not only internally through Daimler's global hybrid center in Japan, and its extension in Portland, Oregon, but also with our supplier partners, including Eaton."

But like most hybrid applications, cost is a key hurdle: "The cost of hybrid components remains high in comparison with a standard diesel truck," admits the Freightliner manager. "The fuel savings from hybrid technology are significant, but payback periods remain longer than many fleets find palatable without government incentives." Regardless, the efforts of Freightliner, and Daimler Trucks North America, are not going to disappear, with parallel electric hybrid numbers from the company exceeding 1,500 units since 2003. What's more, development work is ongoing, says Treinen. "We are constantly looking at technologies that increase the electrification of components and limit the amount of time the engine is in operation in order to further reduce fuel consumption," he maintains.

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Forward thinking

Now for something completely different: traditional timber forwarders can create deep ditches, damage tree root systems, and generally be very environmentally unfriendly. So how about a machine that combats all these problems through the innovative use of high-tech electrical drives?

WORDS: **JOHAN SJÖBERG**

Hybrid technology has been a feature of on-highway vehicles for some time – but now it is also venturing off-road. Yet the primary reasons aren't necessarily solely to reduce fuel consumption – El-Forest, for example, is a Swedish company that is pioneering hybrid concepts in forestry machinery by developing a serial hybrid forwarder with each of its wheels individually powered by an electric motor. Compared with a conventionally powered forwarder, the weight has been reduced and fuel consumption considerably cut, with CO_2 emissions slashed by as much as 75%.

But in addition to all these eco-friendly vibes, the electric wheel motors ensure torque is optimally distributed around the vehicle to maximize grip and reduce damage to the topsoil layer in the forest. Because forwarders are designed to transport timber from the felling site to the roadside, they must be able to drive with full load through difficult terrain and are normally equipped with a large diesel engine to get several tons moving from standstill on soft ground.

However, a major concern in modern forest management is the deep furrows made in the topsoil by traditional forwarders. To ensure maximum grip, these machines generally have no differential, so the outside wheels slip as they are forced through each turn at the same speed as the inside wheels. This problem has been eliminated by the technology used by El-Forest.

The vehicle's inventor, Lennart Lundström, grew up on a farm in northern Sweden, close to the town of Örnsköldsvik where El-Forest is today based. In his early years, he worked in forest management on the farm; when trees were felled by hand and the timber moved using a horse. Later, he started working for

electrical engineering company ABB, but frequently came back to spend weekends and holidays on the farm. It was around this time that his father had bought a mechanical forwarder, and Lundström was dismayed to see the damage it had done to the forest floor.

"The deep tracks made by traditional forwarders cause great damage to the root systems, which stunts the growth of the trees that are left," Lundström explains. "The ruts also collect water and turn into ditches that get deeper each time it rains. We've seen an increase in precipitation in recent years, so this is a problem that will only get worse as time goes by.

"In addition, I noticed that the mechanical forwarder used enormous amounts of diesel. I started thinking that there had to be a better way."

New ideas for powertrain

Combining his engineering skills with his knowledge of forest management, in his spare time Lundström started developing a design with steering on all wheels and with the load placed directly above the axles. He applied for a patent, which was granted.

He then started thinking about the powertrain, evaluating a wide range of possible solutions and arriving at a shortlist. From these, an electric drive with one motor on each wheel seemed most promising – as well as most economical. A patent was applied for here as well, although this took longer to get approved, as it was difficult to get the patent examiners to grasp the concept.

Eventually, Lundström was ready to start on the prototype. He quit his job at ABB and moved back to the family farm in the North, where the cowshed was converted into a workshop. A development partner was found in the local company Tordab, based in Örnsköldsvik, which makes bogies for conventional forest machinery. They immediately saw the potential of Lundström's invention and the new-found partners started building the prototype.

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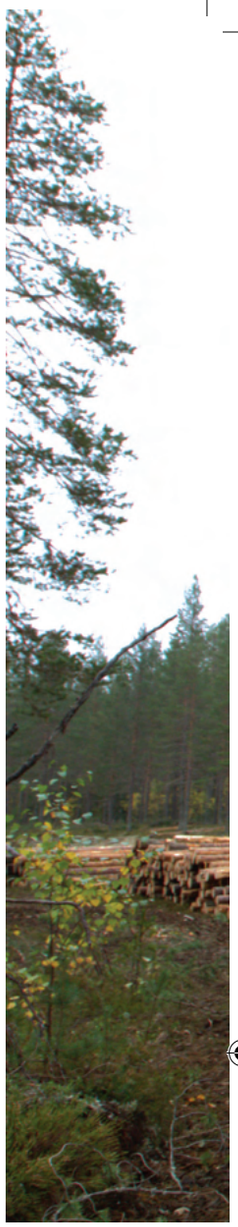

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1: Roger Gustavsson, MD of partner company Tordab (right), with Gunnar Bäck, El-Forest marketing manager and Lennart Lundström, inventor

2: El-Forest's first vehicle, the F-Model, was delivered to Sweden's largest forestry outfit, Sveaskog, in 2009

3: Two joysticks help control the functions of the machine – steering, crane and cab movement

The first iteration was shown in 2005. Based on this, a customer-specific vehicle was produced and delivered in 2009 to Sweden's largest forestry company, Sveaskog. This was the F-model, with 14-ton capacity. A further vehicle (the B-model) has since been produced for Sveaskog.

"The prototype used 30-50% less fuel, depending on duty, compared with a conventional machine," Lundström recalls. "A team from the Skogforsk forestry research institute in Uppsala evaluated our design but were skeptical about our claims regarding fuel efficiency, so they sent out a team to check. When the team confirmed our claims, their management thought there must have been a measuring error, and so sent out a new team, only to have the first result corroborated."

To market the machine, a major company was needed as a partner. Several were interested, but all the potential suitors had their head offices abroad, and with the boardrooms far away, negotiations became protracted. At this point, in 2007, some fellow

4

Swedes – Volvo CE – came knocking and an agreement was reached in a matter of months. Volvo has a wide range of industrial vehicles, but mainly in other market segments.

To date, five machines have been sold and El-Forest is in contact with all Swedish forestry companies. One of these, Holmen, is sponsoring development work. Volvo provides expertise regarding steering systems, cab design and engines, as well as the documentation and assistance with sales and support worldwide.

Individually driven wheels

The F-model has a comparatively low weight at 15 tons, but it can still load 14 tons of timber. Six large wheels provide the necessary ground clearance while minimizing pressure on the soil.

While a conventional forwarder uses an engine of about 150kW, the El-Forest machine is fitted with a Deutz diesel of just 60kW. This runs at a constant speed that is optimized for efficient performance, and runs a generator that produces electricity for the six electric motors that drive the wheels.

> "I noticed that the mechanical forwarder used enormous amounts of diesel. I started thinking that there had to be a better way"

But while the engine speed is constant, power usage varies greatly. When loading, little energy is used. When going downhill, nothing at all is used by the machine; instead, the motors go into generating mode and feed energy back to the battery. When going uphill, the power from the battery and engine is combined to produce the required torque on the wheels – the result is a traction system with a towing capacity exceeding that of a conventional forwarder of equivalent size. The battery used is an 84V gel battery from American manufacturer HDC that weighs 400kg and delivers 200Ah.

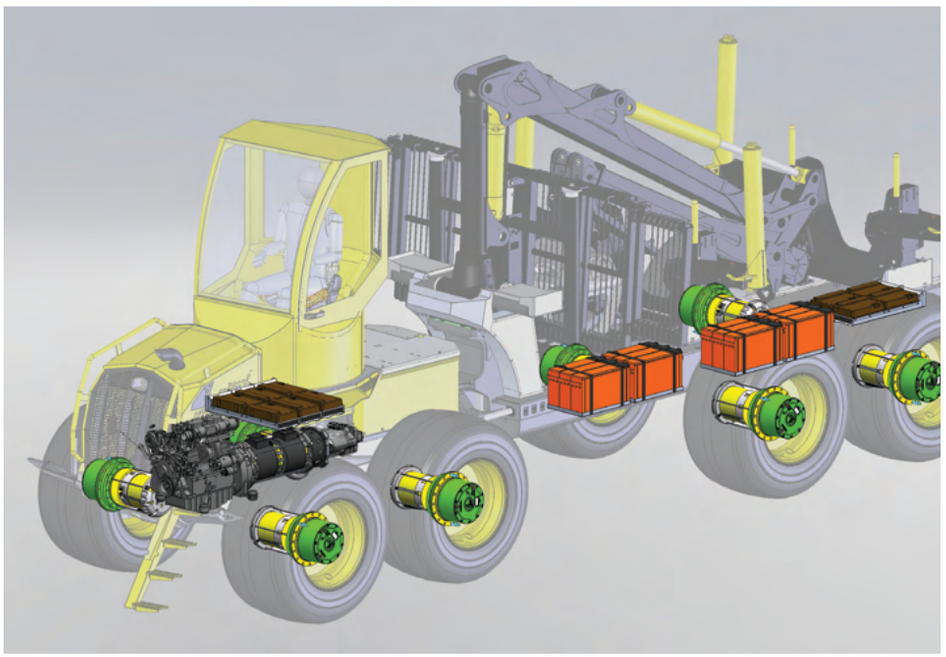
4: The B-model can be fitted with bogies both front and rear, for use in very difficult terrain

The machine also has a hydraulic system for the crane and the steering. The crane comes from local supplier Cranab, with its hydraulic pump mainly driven by the diesel engine. If additional power is required during a particularly demanding loading operation, the generator is used as a 60kW electric motor and helps to drive the hydraulic pump.

The wheels are driven by six 30kW electric motors, of the type normally found in indoor forklift trucks. The motors are controlled using variable frequency by an inverter that converts the DC supply from the battery into AC. Running on 84V ensures that they can be serviced in an outdoor environment without danger to personnel. Brushless AC motors were selected as their rugged design eliminates the need for maintenance.

A hub gear from the Italian manufacturer Bonfiglioli reduces the speed and increases the torque from the electric motors. Each wheel is individually driven, with its rotation checked by an encoder in the hub. The reference speed is set by the driver through the accelerator pedal. A control unit checks the speed against the desired speed and adjusts the power to each wheel through the inverter.

The F-model's three wheel pairs are steered independently, with the second and third pair following exactly in the track of the first pair. When turning, the machine adjusts the speed of each wheel individually; there is no need for any wheel to spin to keep up. Torque is reduced by the motors on the inside wheels and increased on the outside, while the angle of the wheels is adjusted with traditional hydraulic steering. By contrast, a conventional forwarder steers mechanically and forces the wheels through the turn, causing deep ruts.



Above: The 60kW Deutz engine drives the generator behind it, as well as the hydraulic pump. The generator charges the battery (red). This in turn drives the motors (yellow) which power the wheels through the hub gear (green). The power to each wheel is controlled and distributed by two ECUs (brown)

The vehicle has an outer turning circle of just 6.2m, about the same as that of a normal passenger car, which is exceptionally tight for a vehicle that is 8m long. This means it only needs about half the area of a traditional forwarder with articulated steering and differentials, resulting in less damage to the vegetation. In order to further improve maneuverability, the driver cab can turn through 360°.

> "The prototype used 30-50% less fuel, depending on duty, compared with a conventional machine"

Small yet efficient

The design concept also reduces the weight of the vehicle. This has been achieved by eliminating many heavy mechanical components, such as shafts and differentials. So while a conventional forwarder weighs about 17 metric tons, the El-Forest model weighs only 15 metric tons.

The comparatively low weight, combined with a diesel engine running at constant speed, results in low fuel consumption and more environmentally friendly operation, with CO_2 emissions reduced by as much as 75%. Combined with less physical impact in the forest and reduced chance of hydraulic oil leakage as many hydraulic systems are replaced by electrics, the result is a vehicle with a very small environmental footprint.

"Although the vehicle is currently driven with diesel, we could see other alternatives in the future, such as fuel cells. This would reduce CO_2 emissions even further," says the company's marketing director, Gunnar Bäck.

With fewer lubrication points, the vehicle is also easier to maintain than one with a traditional powertrain, and the electric components are easy to replace. Yet it is no more expensive to manufacture than a traditional vehicle, which translates into lower ownership costs.

Looking to the world market

Bäck hopes that the company will be able to secure a 5-10% share of the world market, which currently stands at 1,500 vehicles per year. It may also take a slice of the market currently held by skidders, a type of vehicle that transports logs by pulling them along. This method is traditionally used in many parts of the world, but it causes even more damage to the forest floor than a mechanical forwarder.

As things currently stand, the company is now starting commercial production. In El-Forest's home town of Örnsköldsvik in northern Sweden, a cluster of high-tech specialist suppliers has emerged around the Hägglunds group of companies, manufacturers of off-highway and military vehicles, cranes, and hydraulic equipment, also located in or around the town. Much of El-Forest's manufacturing has been contracted out to local suppliers of subassemblies, which are then delivered for final assembly at the company's plant.

In a recent development, Fouriertransform AB, the Swedish state-owned venture capital company for the automotive industry, also became part owner, strengthening the company's financial position.

"El-Forest's patents are very valuable," says Christian Zeuchner, the company's investment director. "We are keen to help the company demonstrate that the technology works, and we can provide access to a strong network in the automotive industry. We also see opportunities to license this technology to other companies."

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Generator breakthrough

A newly-developed high-speed generator is pushing switched reluctance boundaries

A recent Technology Strategy Board funded program in the UK involving Nidec SR Drives has pushed the operating envelope of magnet-free switched reluctance (SR) machines in the development of a high-speed generator for a microturbine-powered EV range-extender.

The exciting, high-tech project, involving microturbine specialist Bladon Jets and leading vehicle developer Jaguar Land Rover, sought to develop an all-new SR generator that would create power levels of up to 50kW when driven at a speed of 45,000rpm.

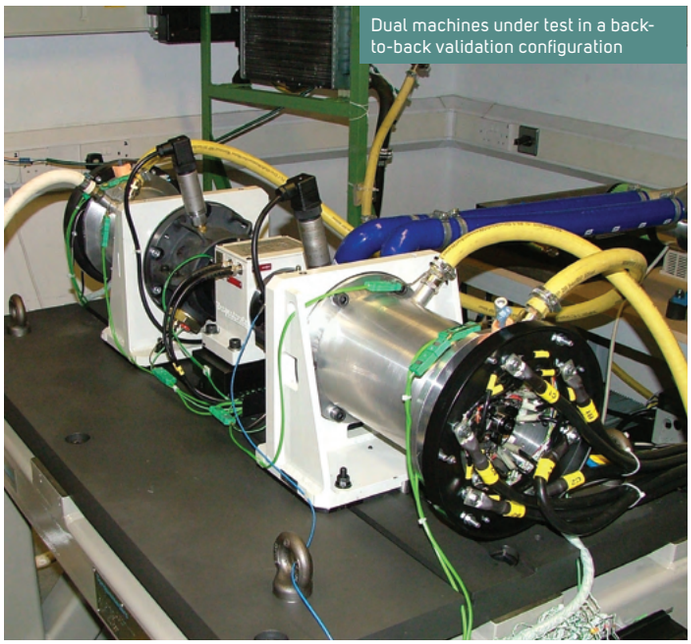
All electrical machines tend to be sized largely by their continuous torque rating. For a given physical size of machine, increasing the operating speed boosts the rated power in direct proportion to speed. High-speed machines therefore offer high levels of power density and are appropriate for use in turbine-driven generator applications powered either from a dedicated engine as developed by the likes of Bladon Jets, or from an exhaust turbine in exhaust gas energy recovery applications.

Pre-flight checks are undertaken by an engineer prior to actual running

Permanent magnet (PM) systems are commonly used in high-speed applications. The relatively torque-dense construction of PM machines is well suited to enabling the close bearing centers and small rotor diameters demanded in high-speed machine design. PM technology is, however, not without its disadvantages in such applications. The well-documented price volatility of the rare-earth materials required to produce high-performance magnet materials is one factor, while other important considerations include the complexities of retaining the rotor magnets against the substantial centrifugal forces associated with high-speed operation; and the potential of demagnetization if exposed to excessive temperatures.

SR technology has numerous benefits in such applications and in many cases provides an attractive alternative to PM. Though typically not quite as torque-dense as PM systems, SR machines offer a very simple construction that is tolerant to operation at high temperatures. The SR rotor employs no windings or magnets, comprising only a stack of electrical steel laminations, and it therefore avoids the complexities of sleeving the rotor to retain the magnets and the temperature sensitivity of the magnets themselves.

The SR machine developed during the project was based on a low pole-count architecture that's suitable for very high-speed operation. The prevalence of high-flow air movement in this application was used to provide cooling to the motor by diverting some of the air flow into the microturbine through the interior of



Dual machines under test in a back-to-back validation configuration

the motor. Two such machines were constructed and operated in a back-to-back configuration, where one machine operates as a motor and the other as a generator.

As part of the project, the system has been fully evaluated and the targeted 50kW of generated electrical power has been achieved with some margin. Critical speed levels have proven higher than originally anticipated and it is likely that further testing will reach speeds of up to 60,000rpm where generated powers in excess of 60kW are expected.

Prior to the high-tech project, the envelope of high-speed SR machine operation has been defined by systems such as Controlled Power Technologies' TIGERS system and Valeo's Electric Supercharger system, both of which use SR Drive technology and operate up to around 70,000rpm, but at power levels of less than 5kW.

Nidec SR Drives is a leading engineering and technology provider in the field of advanced electrical machines and drives systems, with a particular focus on switched reluctance technology. The company has pioneered the development, application and commercialisation of switched reluctance technology under its SR Drive trademark and is now a world leader in this area.

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Mild HEV applications demand 400V IGBTs

The automotive industry's first 400V IGBTs on 40µm thin wafers have been developed, enabling OEMs to reduce operational costs

The ongoing expansion of the market for electric and hybrid vehicles is currently mainly driven by HEVs and PHEVs. Looking at the different hybrid styles, there is a strong need in mild HEV applications for IGBTs with lower breakdown voltages compared with the typical 600V/650V devices to reduce the conducting and switching losses. Leveraging from its innovative thin wafer technology and huge power semiconductor experience, Infineon has developed the industry's first 400V IGBTs on 40µm thin wafers. OEMs will benefit from the lower losses and fast switching behavior of the new power modules. In addition, the new 400V IGBTs are offered in a proven and reliable power module package.

Hybrid cars use a combination of an electric motor and a traditional IC engine to power the vehicle. There are three basic types of hybrid cars: mild HEV, full HEV, and PHEV. The full hybrid is a vehicle that can run on just the engine, just the batteries, or a combination of both. A large, high-capacity battery pack is needed for battery-only operation.

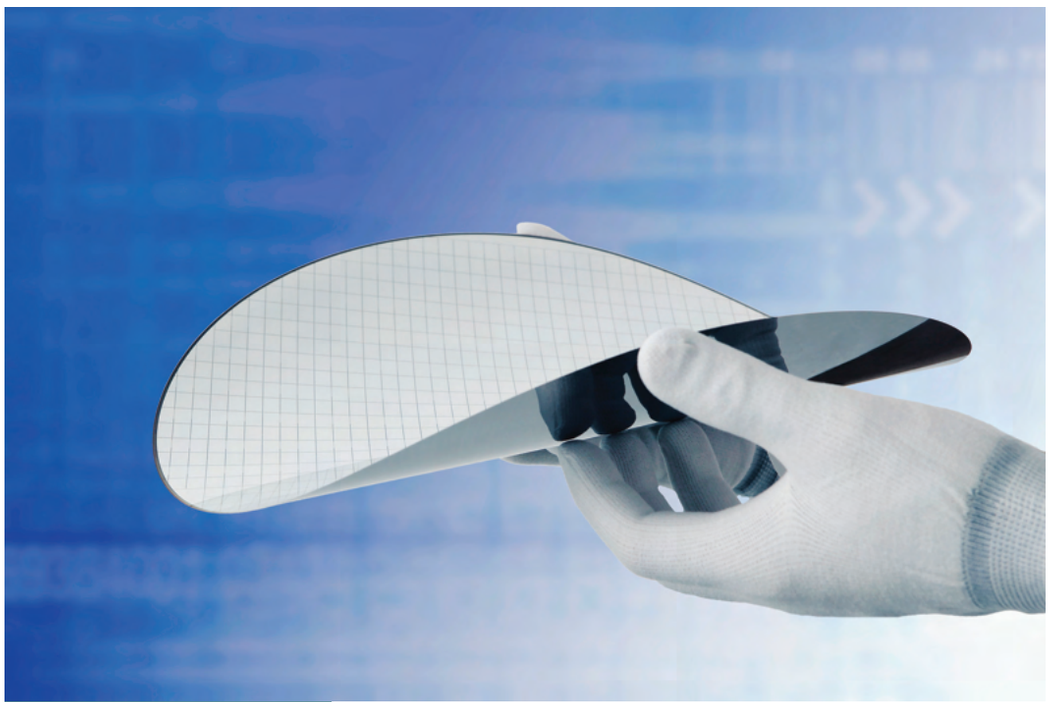
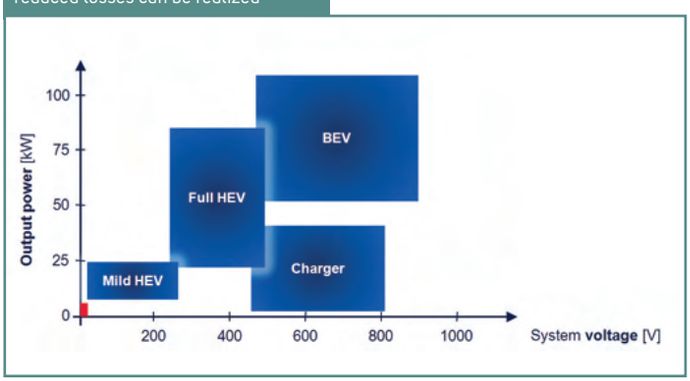


Figure 2: IGBTs that offer decreased losses can be achieved by a reduced chip (wafer) thickness

Figure 1: Compared with full hybrids, mild hybrids with < 20kW have smaller batteries with inverter DC link voltages in the range of 100V to 200V. This means that IGBTs have lower breakdown voltages and reduced losses can be realized



The mild hybrid is a vehicle that cannot be driven solely on its electric motor. A mild hybrid is essentially a conventional vehicle with oversize starter motor; allowing the engine to be turned off whenever the car is coasting, braking, and yet also restarting the car quickly and cleanly. Accessories can continue to run on electrical power while the gasoline engine is off, and as in other hybrid designs, the motor is used for regenerative braking to recapture energy. As compared with full hybrids, mild hybrids with a power range of < 20kW have smaller batteries with inverter DC link voltages in the range of 100V to 200V (as shown in Figure 1). Therefore there is no need for 600V power modules. In addition, mild hybrids have a smaller, weaker motor/generator, which allows manufacturers to reduce cost and weight.

The PHEV uses essentially the same technology as a normal HEV, but needs much larger high-voltage batteries to power the electric motor and has a longer all-electric range. But, unlike the batteries in the HEV (which are recharged by only the IC engine) and other technologies, the batteries in PHEVs can also be recharged by using an external

power source, such as a home electrical outlet.

Infineon offers a broad product portfolio to enable a smooth transition across all power classes, from mild HEV and full HEV, to high-power EV or BEVs. The portfolio includes hybrid power modules for mild HEV applications for a power range up to 20kW, or 20kW to 50kW (in HybridPACK 1 or HybridPACK 1 Pin-Fin packages). In addition, power modules for full HEV applications for a power range up to 100kW (HybridPACK 2) are offered. Easy modules cover applications like for auxiliaries and chargers with up to 10kW. This portfolio is mainly based on 600V/650V chip technology (IGBT and diode).

In mild hybrid cars, the battery voltage with typically 100V to 200V is lower than in a full hybrid. Therefore there is no need for 600V technologies. The challenge was to develop IGBTs with a lower breakdown voltage (such as 400V) and reduced losses. These goals can be achieved by a reduced chip (wafer) thickness as shown in Figure 2, as the thinner the wafer, the lower the power losses (quadratic proportionality). Infineon puts a lot of effort into the design of the related components and the sensitive wafer handling required to produce these ultra-thin components. The current product generation is produced with wafers as thin as 70µm, which is the same thickness as a sheet of paper. The new 400V IGBTs are a further milestone, with an overall wafer thickness of only 40µm, which is about half the thickness of a human hair, as Figure 3 showcases.

The handling of these ultra-thin wafers and devices is challenging. The Infineon 40µm thin wafer technology is based on a lot of innovations and process development, both in front and back end. After the thinning process (grinding and etching), the microchips are diced into individual units. Besides the advanced wafer thinning process, an improved chip separation was developed to avoid chipping, while a suitable delivery

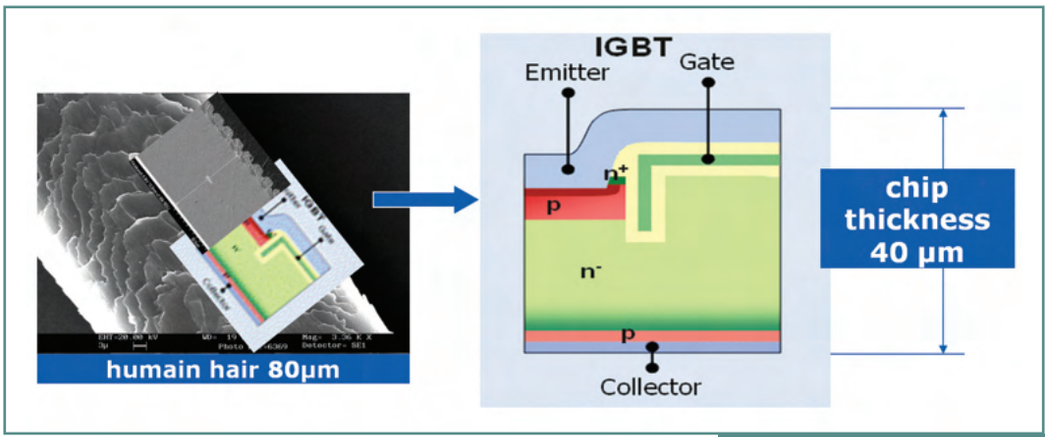


Figure 3: The extreme miniaturization and handling of 40µm wafers is a major engineering challenge, requesting sophisticated front- and back-end process technologies

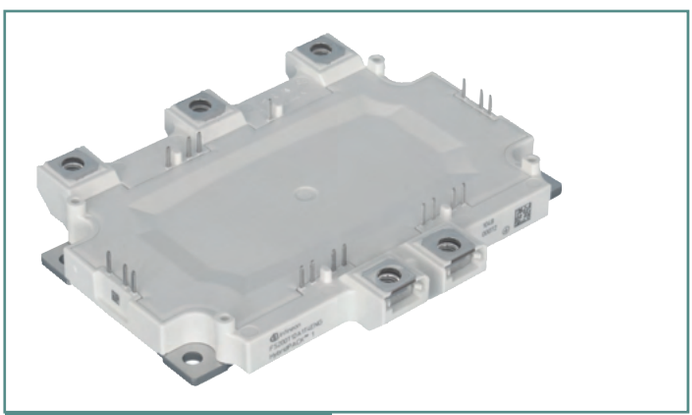


Figure 4: Product development of first 40µm 400V IGBT in trench field stop technology for drive applications was realized with a proven HybridPack1 systems package

concept through to assembly location has to be ensured. In addition to the pick-up process, the soldering and the bonding have to be suitable for the extremely small chips (1cm^2) at 40µm chip thickness.

The product development of first 40µm IGBT in trench field stop technology for drive applications will be realized with a HybridPACK1, as shown in Figure 4. HybridPACK 1 is a proven and well-established power module package, used in the 650V range and other platforms. It has been designed for mild HEV applications for a power range up to 30kW. Designed for a junction operation temperature at 150°C, the module accommodates a six-pack configuration of third generation Trench-Field-Stop IGBT and matching emitter controlled diodes, and is rated up to 400A/650V. HybridPACK 1 is suitable for air or low temperature liquid cooled inverter systems. The flat copper base plate, combined with high-performance ceramic substrate and Infineon's enhanced wire-bonding process, provides unparalleled thermal cycling and power cycling reliability for mild HEV inverter applications.

The target application for the new 400V IGBTs are mild hybrid cars with low DC-link voltages in the range of 100V to 200V. The reduced losses are mainly achieved by a reduced chip thickness of 40µm. A comparison with the state-of-the-art 650V IGBT/diode chipset shows that the new 400V power devices provide significant reduced losses at DC-link voltages < 250V. The output characteristic of the 400V IGBT shows a VCESAT reduced by about 200mV in comparison with standard 650V IGBT. Turn-off energy loss is decreased by more than 10% in comparison with a 650V reference for equal dV/dt values. The industry-first 400V IGBTs offer higher current density in comparison with 650V devices and reduced total losses of IGBT and diode during turn-off.

The reduced switching losses came along with a very fast switching characteristic. In addition, the new 40µm thin 400V IGBTs provide short circuit robustness equal to one in a 650V reference device.

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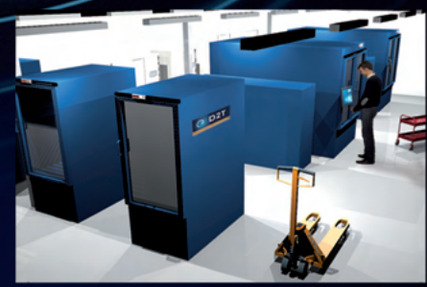

At its own testing centers, or on clients' sites, D2T Powertrain Engineering is testing tomorrow's powertrains. Validating batteries for electric and hybrid drives is its everyday work.

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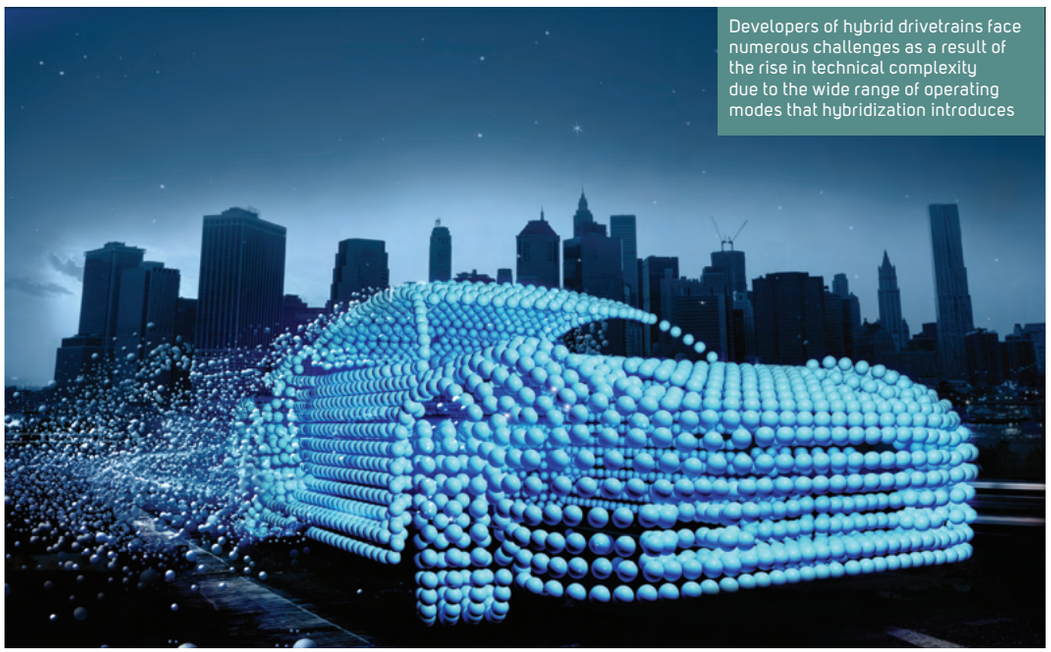
Optimal test conditions

There are many technical challenges in the variant calibration of hybrid vehicles – but these hurdles can also be opportunities if approached in the right way

The automotive industry is racing ahead to introduce some degree of hybridization into its product ranges. Because the term 'hybrid vehicle' can cover a wide range of differing technologies and drivetrain topologies, this has led to a plethora of vehicles that call themselves 'hybrid'. As a result, this situation poses an interesting challenge for marketers to differentiate these 'hybrid' vehicles from the incumbents.

However, it is not just the marketers who are faced with challenges; the developers of such hybrid drivetrains also have hurdles to overcome as they are faced with a rise in technical complexity due to the wide range of operating modes that hybridization introduces. As propulsive torque is being generated in more than one place in a hybrid vehicle, the transitions from conventional drive to electrically supported drive bring with them complex aspects of multi-dimensional system control.

Therefore the challenge is to be able to implement hybrid technology in an existing drivetrain, while adapting the existing components as required. The functional variability of hybrid technology, however, permits a range of possible implementations, with the control calibration tasks needing to be well structured concerning hand-over, traceability and robustness.



Developers of hybrid drivetrains face numerous challenges as a result of the rise in technical complexity due to the wide range of operating modes that hybridization introduces

An overview of the data chain with regards to hybrid calibration

The only way to manage this exploding complexity is to apply methodical approaches to the calibration task, and employ partial test automation when developing hybrid vehicles.

The advantage to handling the exploding complexity of hybrid drivetrains is to employ a systematic and methodical approach, which then eliminates repeated loops of calibration effort.

The first step is to define and determine the interface parameters between software modules; individual calibration tasks are typically carried out in a range of development environments using environment-specific methods; for example, in an offline environment using simulation techniques, or on a testbed using DoE tools, or in the vehicle itself. The interface between these environments and the format of data to be transferred needs to be closely coordinated and optimized.

The second step in this process would be the ability to evaluate driveability objectively across all test environments. One of the crucial input signals for the driveability evaluation is the longitudinal force, normally measured behind the vehicle on a chassis dyno. This signal is used to calculate the longitudinal acceleration of the vehicle body. When the tests are run on a drivetrain testbed, the signals from the electrical motors are used as inputs to the vehicle simulation model, which in turn is used to calculate the longitudinal acceleration of the vehicle body.

A third step would be the simulation of battery states, which affect the vehicle calibration strategy. This means monitoring the SOC or SOH in hybrid vehicles, allowing calibration strategies to be developed before the hybrid drivetrain is physically available.

The final step – the test-planning phase – needs to support the efficient use of climatic chassis dynos and battery simulator resources. Calibration tasks would therefore be structured according to the requirements of the measurement environment, planned appropriately, and then executed.

As a result, the common denominator across all these environments (including chassis dyno and drivetrain testbed) is consistent and seamless tool chains across all environments to eliminate the confusion that often occurs when calibrators are forced to use different tools, in different environments, for the same or similar calibration tasks. These tool chains need to include battery simulators for hybrid drivetrains.

The test sequence planning must also be independent of the test environment; model-based approaches and vehicle simulation allow the transfer of calibration tasks that are 'upstream' in the process. This front-loading approach can help reduce time and effort in the calibration process.

Crucial in all this is the ability to be able to measure and evaluate objective driveability, even if the vehicle configuration that is being calibrated does not yet physically exist and is being simulated. All driveability results must be consistent across all the test environments.

Finally, the application of the automation software to plan and execute the test permits the system to be run unmanned overnight.

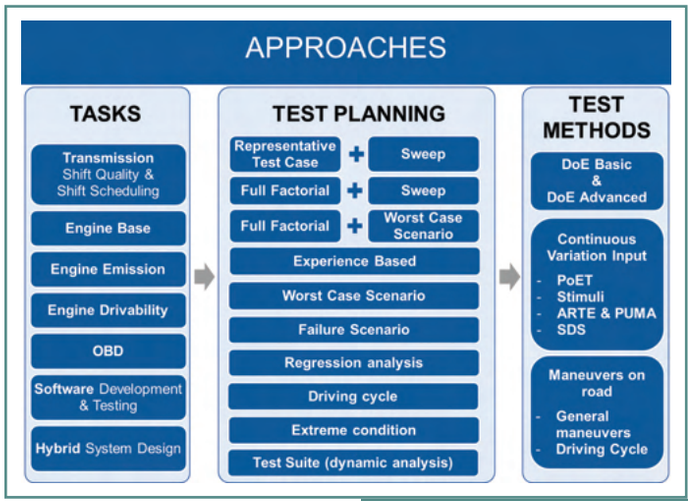
The handling of calibration data is a challenge, even for conventional drivetrains. The complex hybrid application projects require a new approach for the administration of calibration data. Some of the issues concern the handling of cross-controller functionality, where the conventional engine and transmission control units must now communicate with the new hybrid controllers and subsystems.

The question most often asked in calibration management meetings is "where are we and how close are we to completion?". These questions can only be answered if the team has implemented cross-functional project management and controlling, and if the calibration process contains statistical indicators of progress, indicators of maturity, references to interactions and the relevant affected functions. Another question concerns the re-usability of calibration experience and expert knowledge, which can only be addressed if the calibration process is embedded and mirrored in a software tool that integrates calibration guidelines into the documented process.

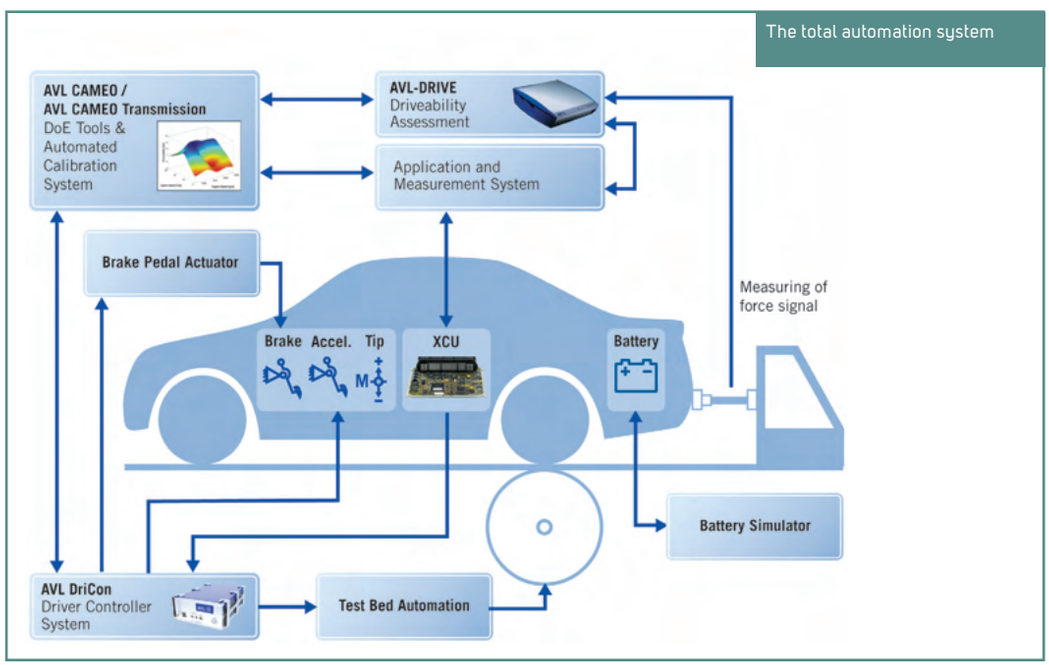
An important, fundamental approach to the reduction of calibration effort would be the structuring of calibration parameters and control unit functions according to variant-variable functions and system-bound parameters, and the allocation of variant-specific differences to function modules, parameters and calibration steps.

By transporting the calibration, validation and interface testing processes from the test track to the chassis dyno or drivetrain testbed, it is possible to guarantee constant environmental conditions across the project. This, in turn, guarantees the repeatability of the measurement results.

Gerhard Kokalj, AVL's head of transmission and hybrid calibration, is convinced that this process reaps benefits: "In order to achieve client calibration targets of driveability, CO_2 reduction, maximum battery lifetime and safety in hybrid vehicles, it is crucial to be able to utilize the experience and know-how of calibration experts in a structured and documented fashion, using all testing resources that are available".



Various approaches to a new development project, covering tasks, test planning and the test methods



The total automation system

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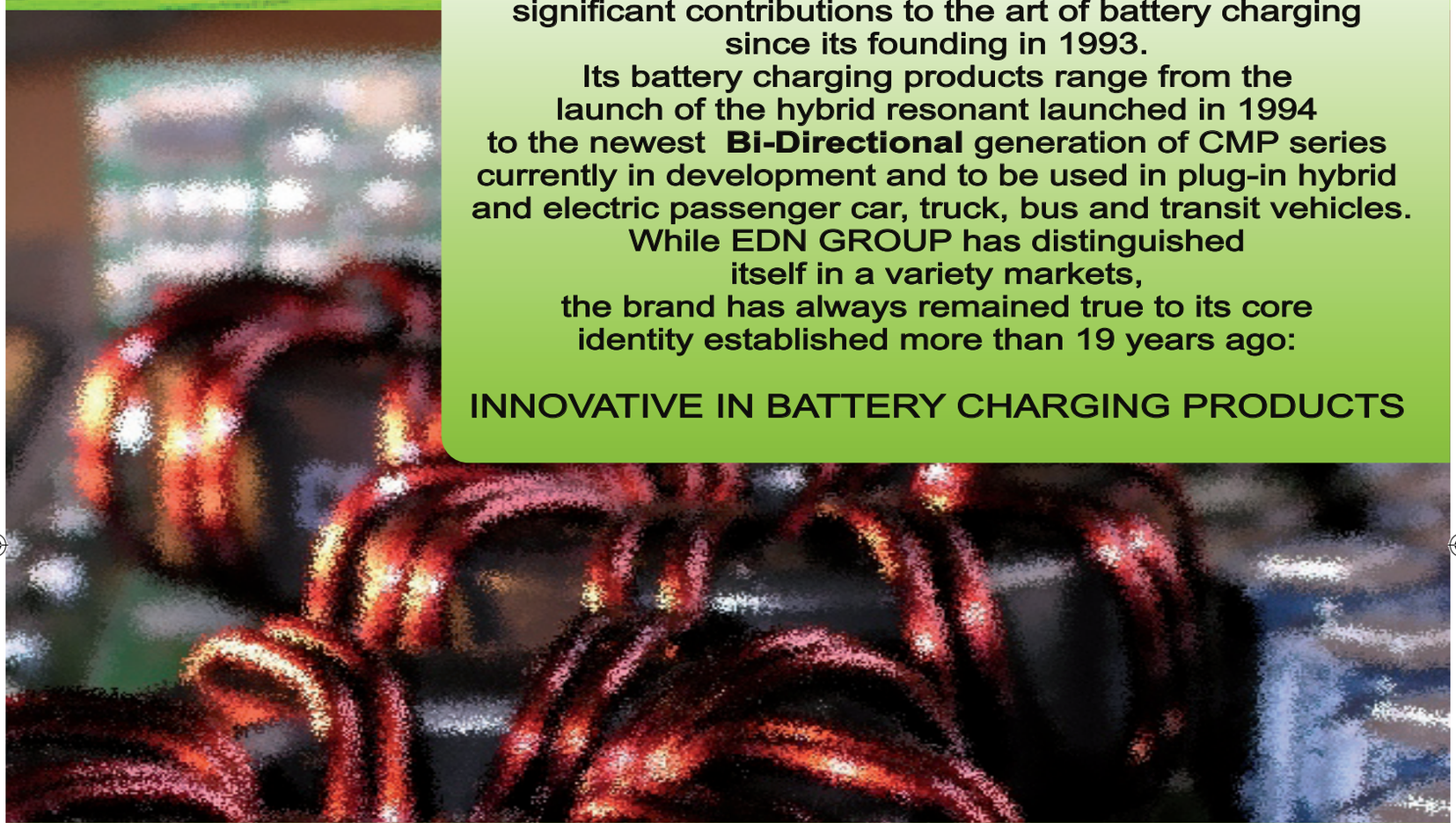

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Electric and hybrid vehicle interconnection challenges

The need to support automotive OEMs in their drive to create more affordable low-emissions vehicles that will appeal to mainstream consumers has never been so great

Car makers are under increasing pressure to bring to market low-emissions vehicles in a much smaller time period

In taking EVs and HEVs from the drawing board to the public highways in such a short space of time, automotive car makers and their suppliers have already negotiated an array of technical challenges. As far as interconnection is concerned, these have included issues such as safety, interference, and durability in applications that feature voltages and operating currents many times higher than in conventional vehicles.

Furthermore, in developing EVs and HEVs that are capable of attracting mass-market support, OEMs have naturally placed a high priority on ensuring that these vehicles live up to expectations in terms of reliability and performance. Equally, it has never been possible to lose sight of the need for affordability. With the first generation of mass-produced EVs and HEVs now on the streets, there is little doubt that the focus on reducing total build costs is intensifying. Only by reducing the price differential between EV/HEVs and conventional models will manufacturers be able to extend their appeal beyond environmentally conscious 'early adopters'.

FCI Motorized Vehicles is determined to play its part in this drive for affordability. As one of the leading automotive connector manufacturers, the company has built an excellent reputation for working with OEMs from the earliest stages of new developments to create effective solutions. This was certainly the case with the EV/HEV market, and the results are demonstrated in the Power.S3 family. Designed specifically for EV/HEV applications, this portfolio of terminals, connectors, and charge plugs combines intensive research into the requirements of EV/HEV design with long-standing experience of the automotive environment.

For powertrain applications, key features of the Power.S3 family include RCS-800 terminals with an 8mm round pin that makes more efficient use of space than equivalent square designs, and boasts higher like-for-like current-carrying capacity. The RCS-800 and right angle RCS-890 connectors target high current applications such as the battery, junction box and inverter. They incorporate innovative housings, with features such as slide-assist function for fast and easy connection, unique electric interlocks, and connector position assurance that ensures 100% safe mating. In addition, these parts benefit from a unique two-step unmating process, incorporating a time delay between the interlock opening and power disconnection. Disconnection is impossible when the connection is live, eliminating the risk of accidental electrocution or arcing. A combination of IP2xB finger-touch protection and IPx9K, IP67 external sealing is employed.

For peripheral equipment such as high-voltage air conditioning,

heating and onboard chargers, the Power.S3 family is complemented by the Apex280 two-way connector, incorporating similar mechanical and sealing features.

Alongside issues such as safety and durability, the high power characteristics of EV/HEV interconnection also demand effective protection against the threat of interference. In basic terms, there are two options: individual shielding or peripheral shielding. As the name suggests, individual shielding involves applying shielding continuity to each cable, as well as to each individual connector line. So, for a three-way connector, three individual shielding operations are required. Peripheral shielding, in contrast, uses a single shielding braid around the cable and connector.

In developing the Power.S3 family, FCI has been committed to peripheral shielding from the outset. This reflects the fact that, in terms of total applied costs, the benefits are clear. For the harness maker, individual shielding is a time-consuming process. Each individual cable must be prepared, introduced to the connector, and individual shielding applied. For a three-way connector, these operations are multiplied threefold, including shielding continuity controls. Furthermore, higher levels of rework are required. Peripheral shielding, however, is a simple process, requiring a single link between the braid and connector using a standard metal collar.

With an increasing number of EVs and HEVs on the market, important lessons are now being learnt. Not just in terms of how these vehicles perform, but also how they can be manufactured more efficiently. FCI is very much part of this learning process, and continues to work alongside OEMs to enhance its connector offering. The latest addition to the Power.S3 family, the RCS-890, reflects this approach. As a 90° version of the existing RCS-800, the 230A/750V RCS-890 is designed to alleviate the high mechanical stresses placed on connectors by the bulky, 35-50mm^2 power cables required in EV engine bays.

Real-life experience is also confirming the advantages of peripheral shielding on the production line. Harness makers using the Power.S3 range have reported excellent results in serial production, with speed of assembly and minimal rework requirements delivering obvious cost benefits. Further savings are made by the elimination of the need for more expensive, shielded cables.

The intelligent RCS-800 and right angle RCS-890 connectors target high-current applications such as the battery, junction box and inverter by incorporating innovative housings, with features such as slide-assist function for fast and easy connection

But FCI is committed to proving not only the commercial benefits of peripheral shielding, but also its ability to meet the most demanding technical specifications. This commitment has encompassed in-house salt spray aging tests, and vibration testing up to 15G, made in conjunction with FCI's R&D center, as well as close collaboration with OEMs, and in-depth study of the real-life performance of peripheral shielding in consumer EVs and HEVs. To date, all have demonstrated the ability of peripheral shielding solutions to provide the necessary levels of corrosion resistance and maintain excellent standards of noise suppression.

For car makers looking to reduce the total applied costs of interconnection in EV and HEV applications, FCI already offers a range of proven, purpose-designed products. However, the EV/HEV market is developing fast, and FCI is evolving with it. This includes recognizing that some automotive OEMs retain a preference for solutions based on individual shielding. Alongside further research and testing of peripheral shielding, the development work being undertaken by FCI at the moment also includes investigation of the potential to achieve competitive total applied costs of individual shielding.

At this stage, it is still not clear exactly how fast the EV/HEV market will grow, and in what precise direction it will travel. But with R&D teams working in all of the major automotive manufacturing centers worldwide, FCI Motorized Vehicles remains ideally positioned to respond to the demands of this market, delivering solutions that meet both the commercial and technical challenges of EV/HEV interconnection.

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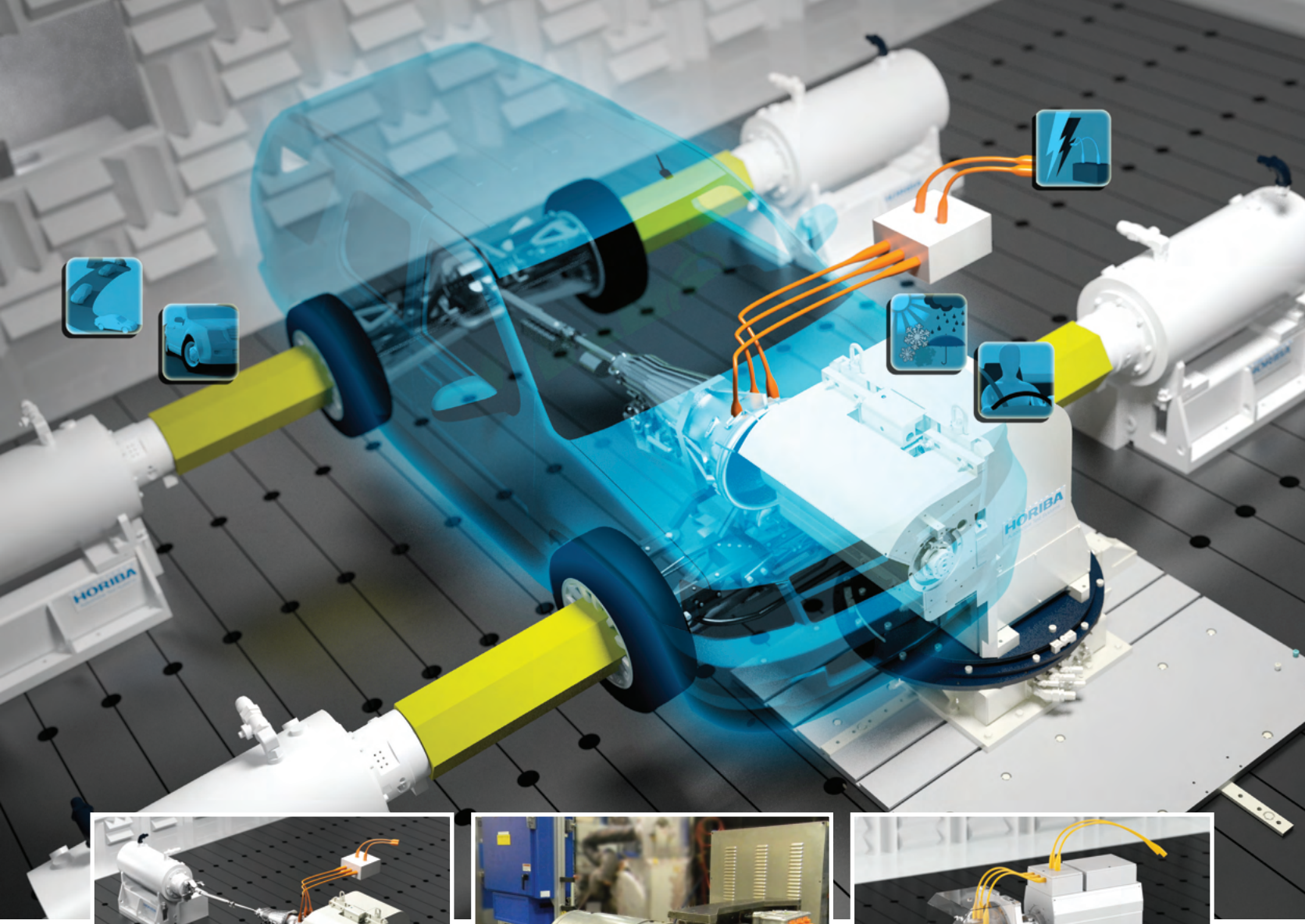

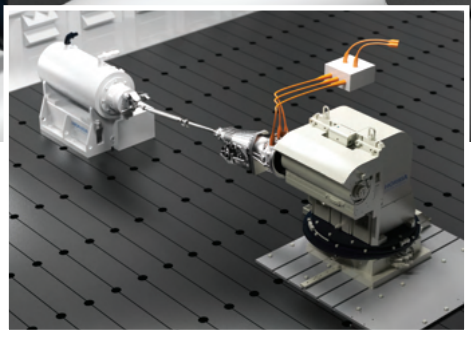

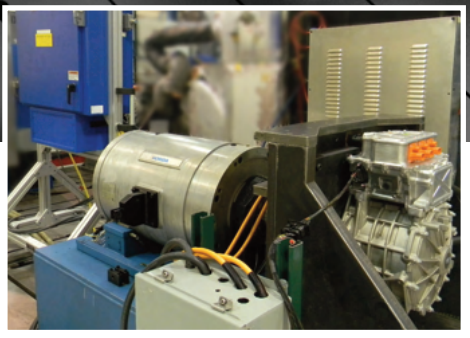

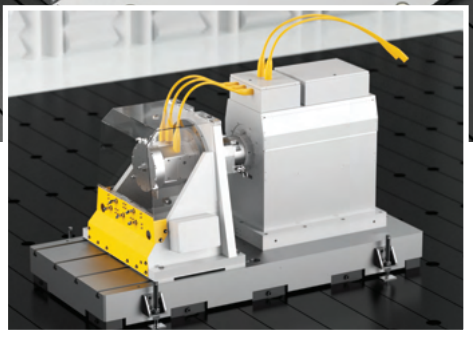

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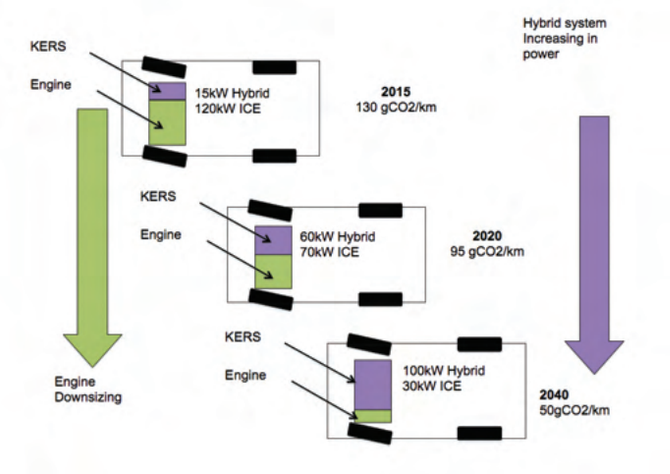
Flywheel hybrid roadmap

A flywheel hybrid specialist reveals technology development plans to meet long-term emissions targets of the automotive industry with an innovative but low-cost solution

Long-term future CO_2 emission targets can be met with a simple downsized IC engine combined with a low-cost performance-boosting flywheel hybrid system. This is the outcome of a future-casting study conducted by mechanical flywheel hybrid specialist Flybrid Systems. The result of the study is a specification for a performance-orientated B-segment car that can sprint from 0-100km/h in seven seconds while returning CO_2 emissions of just 56g/km on the US FTP75 test cycle.

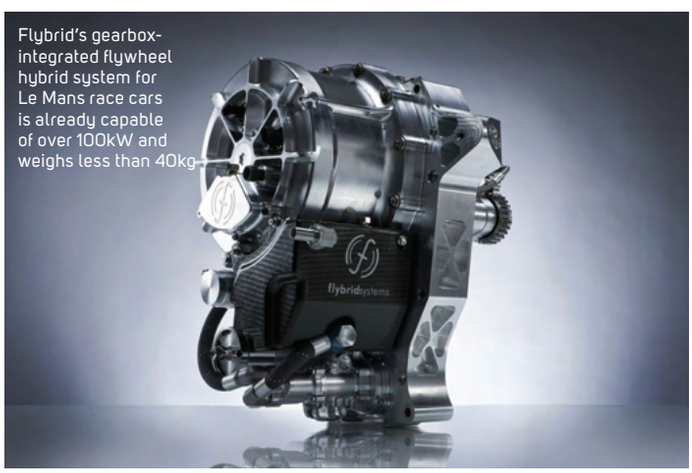
Starting with a validated MATLAB/Simulink base model for an existing B car platform, Flybrid engineers applied simple and fully realistic improvements to each of the key vehicle characteristics, such that it displayed an aero drag similar to today's class leader combined with known low rolling resistance tires and readily achievable weight reductions. The engineering team then determined the minimum IC engine performance required to drive the common regulatory cycles, allowing some excess for gradeability considerations, and selected a specification of flywheel hybrid system that would ensure excellent on-road performance. The final specification was for a 47bhp IC engine and a 134bhp flywheel hybrid system.



Flybrid's roadmap shows hybrid power increasing with time as the engine is progressively downsized

The principle of operation is that the flywheel is used to boost the vehicle up to its cruising speed, whereupon the IC engine takes over to cover the longer-term power requirements of the cruising condition. When the car slows down the flywheel is used to store kinetic energy, partially replenishing energy levels. Any deficit between the energy stored during braking and the energy required to re-accelerate the vehicle is taken from the engine while it is at a low load condition and fed directly to the flywheel with a very high storage efficiency of over 90%.

Depending on how aggressively the car is being driven and what the car knows about its environment (taking into account such factors as speed limits and topography) the vehicle will choose when to make boost energy from the flywheel available and in what quantity, with the aim to only store enough energy to meet the expected driver requirements. If the driver demands more or less power than expected, there is the opportunity to turn up or down the IC engine from a mid-power condition to compensate. Using a mixture of well-developed predictive software and a driver interface that will allow manual override of operation modes, the driver requirement can reliably be met even with an extreme downsized engine.



Flybrid's gearbox-integrated flywheel hybrid system for Le Mans race cars is already capable of over 100kW and weighs less than 40kg

The vehicle as modeled is light at 1,000kg, which means that the amount of energy required to achieve 100km/h is relatively small at around 500kJ. Some of this energy can come from the IC engine, so even allowing for aggressive acceleration to motorway speeds, the flywheel does not need to be any bigger than the types of systems that Flybrid is already using in a number of hybrid vehicle applications.

Properly integrated into the gearbox of a front-wheel drive B car, a Flybrid system of the required specification would weigh around 50kg and would roughly double the cost of the vehicle gearbox. This cost and weight increase would be substantially offset by the downsized engine, so the overall powertrain would not be significantly heavier or more expensive than for a similar performance car of today.

Commenting on the output of the study Flybrid managing partner, Jon Hilton, says, "We believe that this study shows a genuinely achievable route to the low-emissions car of the future that we would all be happy to drive."

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Current sensing designs

Recent advances in Hall-effect current sensor technology are helping to realize further critical inroads in the development of hybrid and electric vehicles

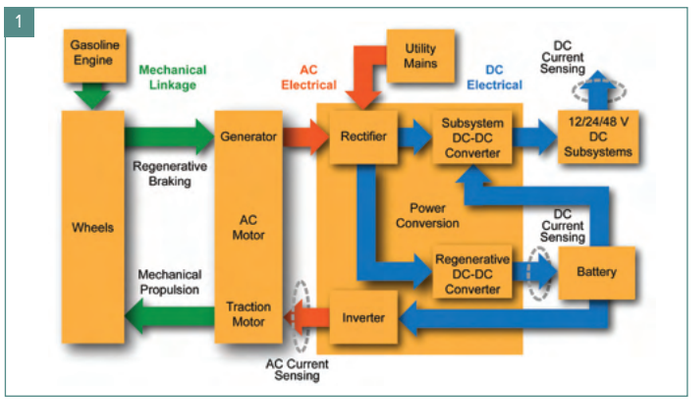
HEVs, which are quickly becoming the most popular green car, employ complex power electronic circuitry to control the flow of electric energy through the vehicle. In a single motor HEV (see Figure 1), the motor acts as a drive motor in parallel with the IC engine, or as a generator to charge the battery during regenerative braking.

A typical HEV has systems that require electrical current sensors for the efficient control of the AC motor and DC-DC converter applications.

While there are many HEV configurations, typically in the HEV power cycle the main battery voltage is inverted and the resulting AC voltage is applied to the motor that in turn drives the wheels. This is highlighted in Figure 1, where during regenerative braking, the AC motor also serves as a generator. During regenerative braking, the output of the motor/generator is rectified and converted to a DC voltage necessary to charge the HEV battery cells, completing the power cycle. If the HEV is a plug-in vehicle, then the line voltage can also be rectified and used to charge the battery.

To power the low voltage subsystems in the car, a DC-DC converter is used to reduce the hybrid battery voltage (typically 300-500V) to a lower level DC voltage.

Classic Hall-effect current sensors have suffered from a limitation in both accuracy and output signal bandwidth. However, Allegro MicroSystems has developed a family of Hall-effect current sensor ICs that are ideally suited for HEV applications with the following features and benefits: signal processing and package design innovations that enable >120kHz output bandwidth; the highest current resolution and the lowest noise spectral density Hall sensors in the marketplace; proprietary, small footprint sensor packages with galvanic isolation; reduced power loss through hole compliant and low-resistance integrated conductor packages; and precise factory programming of sensor gain and offset.



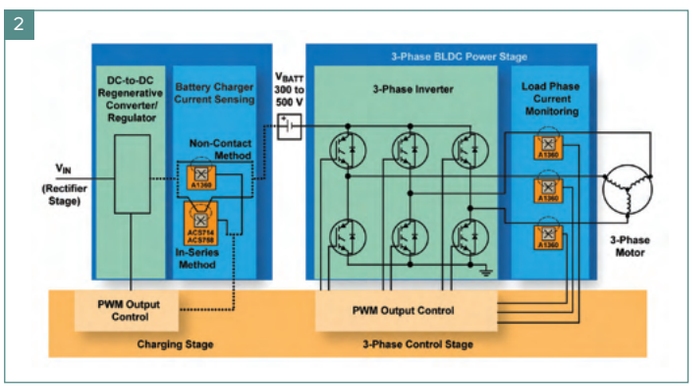


Figure 3 depicts the wide range of proprietary configurations in the Allegro current sensor family and displays the current magnitude that can be sensed using each type.

The typical three-phase motor inverter converts high-voltage DC battery voltage to a three-phase AC voltage used to control the AC drive motor (see Figure 2b). The inverter phase currents are measured and used to control the inverter switches (typically IGBTs). The control loop requires high-bandwidth current sensors to improve accuracy, and to maximize both the torque and the efficiency levels.

The A1360 Hall transducer provides an output voltage proportional to current and has a typical output bandwidth as high as 120KHz. This sensor offers high-resolution and high-accuracy performance for higher speed control of the PWM switches in an inverter system.

A simplified regenerative DC-DC converter is shown in Figure 1 and 2a. This converter uses a current sensor that can operate at high-voltage battery levels. Accurately sensing the converter output current is a critical function to maximize HEV battery life by limiting the charge current.

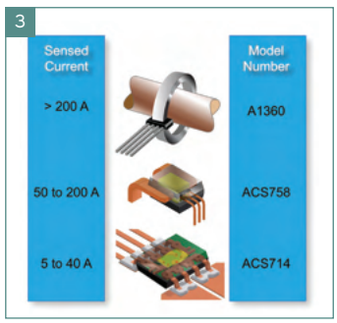


Figure 1: Showcasing the typical HEV system block diagram

Figure 2a and 2b: The DC-DC converter charger; and the three-phase DC-AC inverter

Figure 3: The intelligent Allegro Current sensor IC packages

The ACS714 current sensor is ideal for many lower current, subsystem DC-DC converter applications. The ACS714 is a factory trimmed, galvanically isolated sensor available in a small form factor SOIC8 package with an integrated 1.2 mΩ conductor for low power loss. The Allegro ACS758 device incorporates both a 100 µΩ conductor and a ferromagnetic core into a small galvanically isolated package capable of sensing 50 through 200A.

Allegro's Hall-effect current sensor technology offers significant advantages in sensing both AC and DC currents in HEVs. With galvanic isolation for high side current sensing, and low power loss, they are easy to use in high efficiency HEVs.

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Battery validation labs

Global automotive manufacturers are equipping themselves with costly test facilities in anticipation of battery validation methods that are currently being defined

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Zeus is a multistage, high-tech battery test facility solution that takes into account the need for benches that offer engineers a variety of assessments, from endurance tests through to research testing. The application of Zeus can be adapted to all testbed equipment, present and future, and this includes power drives, climatic chambers, and cooling systems. Its flexibility and performance allow it to change with future methodologies, thus covering more complex testing procedures, robust databases, and the integration of models in real time on the testbed.

Such is its flexibility that Zeus is offered in three different packages: Zeus Easy for durability tests done on an autonomous testbed without a database; Zeus Data Base for durability tests done on testbeds linked to a common database; and Zeus Advanced for more complex tuning of the BMS, coupled with simulation on a testbed in real time.

Julien Faedda, D2T's head of battery solutions, further explains the setup: "Zeus Data Base is Zeus Easy with the database application added. And Zeus Advanced is Zeus Data Base with the simulation application added. In this way, you expand your bench as your needs expand. You're no longer stuck with a fixed system. Your applications benefit from the performance of a Morphee automation platform. For simulation in real time, Morphee is unique – it has high performance but unrivaled simplicity for integrating models. Today, our clients equipped with this function – which is already more than 150 beds – are unanimous about it: once they have tried simulation D2T style, they can't operate without it!"

For hardware, D2T offers an array of proven solutions ranging from 2-5V for individual cells, and up to 600V for complete packs.

At its development center in Trappes, France, D2T Powertrain Engineering has established a battery testing facility with its own solutions. It has two testbeds for battery packs, and three testbeds for modules or cells. Each of these beds has the capacity to test up to four cells per testbed at the same time, and in total up to 12 tests can run in parallel. Each cell is run by Morphee, in conjunction with CAN. The temperature of the climate chambers is regulated in a range from -30°C to +70°C. For the pack benches, the supply voltage is 500V for power of 120KW. The module and cell benches carry 20V per channel for 50KW of power.

It's important to note that obtaining testbeds from a company that also validates batteries has a number of advantages. First of all, there are security issues in installing new testbeds. For example, setting up a new electrical infrastructure is a major operation that can take time, but with D2T Powertrain Engineering on board as a partner, customers can commence work with D2T before their own testbeds are in place.

Over time, there is also the security of having a product that evolves at the same pace as the field does: D2T interacts constantly with manufacturers for implementing and progressing tuning tests. At the same time, these solutions are enriched as skills develop, which means that everyone benefits.

With D2T Powertrain Engineering, customers have the option of taking advantage of a professional exchange that takes place between D2T specialists at their development centers, and this scenario represents a considerable advantage to the manufacturer as it ensures that the results from their testbeds can be correlated with results from D2T.

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Interconnect challenges

Facing new engineering hurdles for future electric and hybrid vehicle platforms has led to several technological interconnect innovations being realized

According to Strategy Analytics, a predicted 6.5 million all-electric and hybrid vehicles will be manufactured by 2018. From an interconnect perspective, manufacturers do not need to worry too much about the platform of these vehicles because the future interconnect performance requirements, regardless of the platform, will essentially be the same.

There is already dialogue within the automotive industry about how the interconnect product should handle a current in-rush or spike. In typical battery powertrains, interconnects have been developed to accommodate amperage spikes for periods lasting milliseconds; now OEMs are looking for a 200A product that may have to handle 250 to 300A spikes – but for minutes not milliseconds.

From industry feedback, it is estimated that the industry requirement will be for a minimum of 250A, although it is more likely going to be closer to a continuous rating of 300A. As the interconnect industry defines new test programs for these >200A contact systems, it has to consider this new duty cycle. As a result, the all-important question is: how do interconnect companies and developers put together a test profile that will accurately predict the future performance for such a requirement?

One thing that's already apparent is that the concept of rating these proposed harness products for temperature and T-rise is largely dependent on the application, whether the connector is in open air or an enclosure, and so the scenario in this respect is anything but clear. Industry bodies, such as USCAR, have assigned committees to define a T-rise rating but, at the moment, there is no real timeframe for the final specification. Again, from industry feedback, it is believed that the operating temperature specification will be from -40°C to +125°C, with a T-rise of 45° at ambient.

New designs from Molex are expected to exceed the requirements set out by CisPR 12 and 25

On top of the high current rating, the industry is also requesting interconnects that can accommodate various voltages. As harness ratings will be heavily influenced by application and cable voltage ratings, the future for voltage limits remains unclear, although a connector that has the capacity for somewhere in the region of 1,000-plus volts is highly probable.

Other important challenges to address with these high-current, high-voltage connectors are the sealing and shielding properties. For example, it is anticipated that finger-proof sealing to IP20 per IEC60529 would be necessary for future connector designs and, as an additional safety net, a first mate, last break technique would be implemented with a specific arrangement that will extend the typical pull-apart period into the millisecond arena.

Generally, the vehicle is a hostile environment in terms of electro magnetic interference and radio frequency interference, therefore shielding from and to the rest of the electronics within the system is also very important. Being at the forefront of shielding, Molex has a technological edge on the rest of the global interconnection industry in terms of shielding design innovation and experience with new designs expected to exceed the requirements set out by CisPR 12 and 25.

This is a new and exciting market to be in, and much more research and development is needed to answer questions about end-of-life performance for separable interfaces in high current applications.

CONTACT

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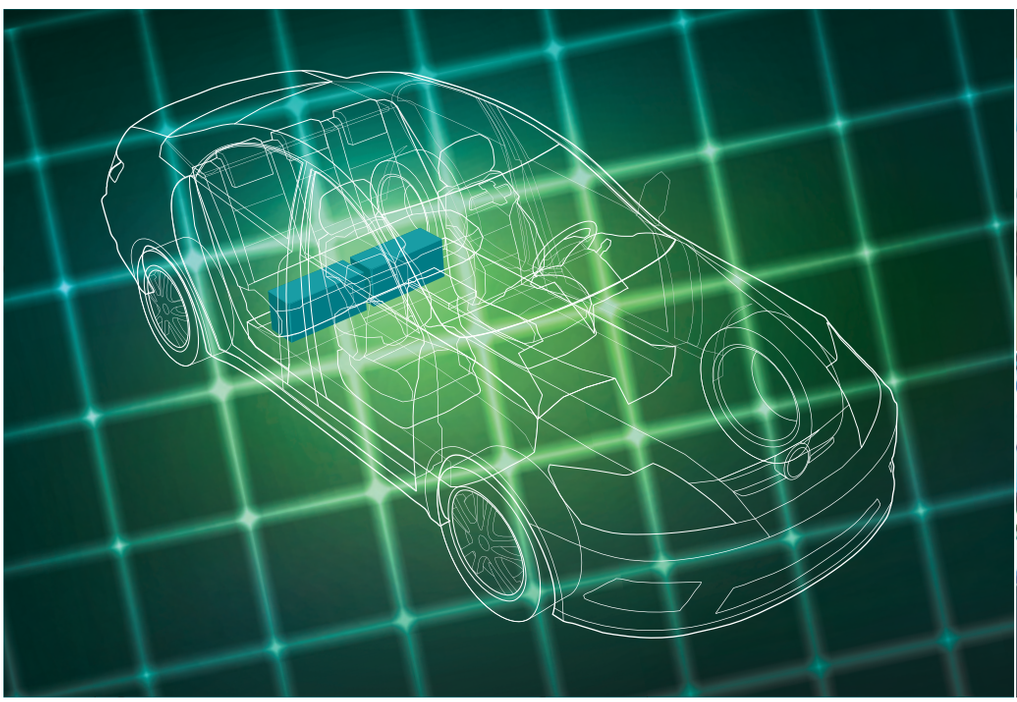

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E-powertrain creations

New developments in ball bearing technology are helping to enable significant increases in the efficiency of next-generation electric traction motors

As environmental regulations tighten and consumers demand more sustainable options, the manufacturers of vehicles and automotive components are constantly seeking new, energy-efficient solutions. With the growth of hybrid and fully electric vehicles as a popular and sustainable transport option, one area that has seen strong technical development is in the field of e-powertrain solutions.

Key to the success of electric and hybrid vehicles is the capacity to deliver longer mileage (and, in the case of the latter, lower CO_2 emissions and fuel consumption) while maintaining stable performance. This can be assisted by maximizing powertrain efficiency. Therefore electric motors for these applications are today engineered to run at very high speed to increase efficiency and power density. This means that bearing manufacturers must supply the designers of electric motors with bearings that can enable these higher rotational speeds while resisting the increased temperatures that these high speeds generate.

E-powertrain applications require innovative solutions to meet the targets for efficiency and robustness. These areas must be met in order to strengthen and build the market with an appealing profile of electric and hybrid vehicles. Therefore it is important that bearing manufacturers are involved early in the system design development in order to avoid issues arising that may limit the effectiveness of the powertrain and, ultimately, the vehicle itself. The power and efficiency of the electric motor are key to the brand image of the car, which is why motor components such as bearings and sensors are so important.

SKF eDrive Ball Bearings (left) benefit from a number of innovative design features that help ensure EVs (below) realize increased efficiency levels

SKF eDrive Ball Bearings benefit from a number of innovative bearing design features, including an optimized internal geometry, an ultra-low friction seal, and a patented polymer cage that is extremely robust and energy efficient at high speeds. The use of long-life grease enables optimum performance in high-speed applications and within a wide operational temperature range of -40° to 150°C. Together, these design features enable the higher operating speeds, with low heat and low-friction torque, that are demanded to support the performance of the motors in electric and hybrid vehicles.

By lowering levels of friction and heat generation, the designers of bearings can enable electric motor and e-powertrain manufacturers to improve the efficiency, power density, and robustness of motors, as well as increasing battery lifetime. As a result, the manufacturers of electric and hybrid vehicles can offer their customers increased mileage and overall improved robustness of the powertrain's key components.

The SKF Vehicle Environmental Performance Simulator (VEPS) has been used to predict efficiency improvements and mileage increase of typical electric vehicle applications when using the SKF eDrive Ball Bearing with a set of other SKF energy-efficient bearings and seals in the e-powertrain. For example, in a typical electric vehicle an extra 1% of mileage could be gained by using SKF solutions in the electric traction motor and gearbox, compared with conventional alternatives.

SKF eDrive Ball Bearings can also be integrated into the SKF Rotor Positioning Sensor-Bearing Unit to further enhance synchronous electric motor efficiency. The SKF Rotor Positioning Sensor-Bearing Unit provides high-precision analog signals to determine rotor angular position. This helps to further improve efficiency and reduce torque ripple and electric noise. The SKF Rotor Positioning Sensor-Bearing Unit also offers high resistance to vibrations, severe magnetic field disturbances, and continuous high temperatures up to 150°C.

Efforts to reduce CO_2 in the automotive industry with sustainable solutions are resulting in some fascinating innovations and developments in the e-powertrain area. In addition to this, the continued optimization of existing technology plays a major part in this development, and a good example of this is the SKF eDrive Ball Bearing.

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The HybriDrive Accessory Power System 2 provides both DC and AC power in support of the full electrification of bus/truck accessory systems such as air conditioning, engine cooling, power steering and compressed air, to further enhance both efficiency and performance

As the importance of lowering emissions and increasing fuel and energy savings continues to grow within the vocational truck market, green technologies are continually developing to address the needs of the market. CNG, hydraulic, and hybrid-electric technologies, to name just a few, are capturing the attention of fleets and truck OEMS across the world in order to help solve their issues. Each technology claims specific benefits to the market while some technology forecasters provide criticisms to their validity.

BAE Systems accepts the challenge to reduce fuel consumption, emissions and the cost of brake service with its family of HybriDrive products, which includes HybriDrive Series and its latest hybrid-electric propulsion system, HybriDrive Parallel.

The HybriDrive Parallel technology is a scalable system designed to meet a range of heavy-duty platforms

Currently, more than 3,500 hybrid-electric transit buses have transported over three billion passengers around the globe and this is making a significant impact on the environment. Over 460,000 tons of CO^2 have been saved along with diesel fuel usage reduced by 33 million gallons.

BAE Systems is committed to providing solutions to help the environment and offer a path to a full-electric vehicle. The HybriDrive Series' design is the only system that puts transit agencies on that road. With series technology, it is possible to replace a diesel engine with alternative fuels or run purely on regenerative battery power once that technology has advanced.

BAE Systems has taken the lead along with its partners to build a fuel cell bus that blends energy from the fuel cell and the batteries, providing a zero-emissions vehicle powered by hydrogen fuel. This fuel cell bus utilizes the HybriDrive Series transit bus propulsion system, further demonstrating its flexibility and the future significance of the series hybrid architecture.

Based on its experience in the transit bus market, BAE Systems' HybriDrive Solutions business developed a heavy-duty hybrid-electric propulsion system for the heavy-duty vocational truck market. HybriDrive Parallel is a scalable system designed to meet a wide range of heavy-duty platforms, vocations, and duty cycles, allowing the company to equip construction, refuse and delivery vehicles with a hybrid solution for this extremely cost sensitive market.

HybriDrive Parallel uses simplified, proven components and controls to integrate with big-bore engines to provide the highest power and torque in the hybrid market to date. The system is based on a single electric machine integrated with the engine and transmission and can be installed with minimal impact to the vehicle. Propulsion is enhanced through an optimized blending of power from a conventional power source and the electrical hybrid machine.

HybriDrive Parallel uses simplified and proven components and controls in order to integrate with big-bore engines to provide the highest power and torque in the commercial vehicle hybrid electric market

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Test investment continues

The challenge of applying conventional and hybrid powertrains in future, eco-friendly vehicles means that test facilities must evolve very fast to keep up with the latest developments

Tickford Powertrain Test was formed six years ago by its established management buyout team. The company's operational roots date back 30 years to Tickford Engineering. Based in Milton Keynes, the privately owned business is one of the last truly independent test facilities in the UK. Employing 60 personnel with a turnover in excess of US$7.5 million, the business has continued to grow during the past three years despite the difficult economic conditions.

Tickford operates from a 30,000ft^2 facility that has 22 engine and rig test cells. Facilities include a fully absorbing tilting engine rig, a three-axis hybrid driveline rig, transmission durability capability, an engine build area, and a chassis dynamometer with vehicle emissions capability. Current engine dynamometer capacity ranges from 25kW to 900kW, with supporting combustion and emission measurement, engine auxiliary loadings rigs, and a bulk supply cold fluid capability down to -30ºC for a number of the test cells. A comprehensive range of eddy current, motoring, and transient dynamometers ensures Tickford can support projects from simple engine durability cycles to the most complex vehicle derived road, track, and emissions-based simulation cycles.

To support the test facilities there is bulk fuel storage for all standard gasoline and diesel products, and specialized biodiesel products and alcohol-based fuels. Clients' fuels can also be used directly from smaller industry standard barrels, enabling efficient usage of specially formulated test specific fuels.

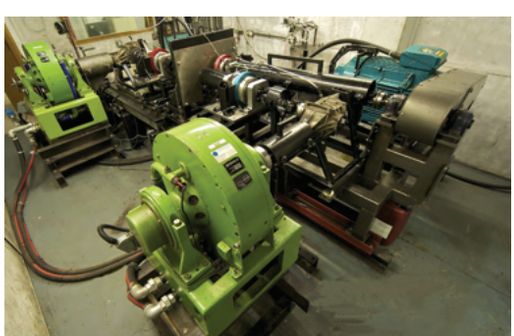
All the projects run at Tickford are covered by ISO 9001 quality standards. In addition, Tickford conducts a range of CEC fuel testing procedures that are conducted to ISO 17025 accredited quality standards.

As the global automotive industry faces increasing legislative and environmental challenges, the pressure to optimize conventional gasoline or diesel powertrains is ever-present. How these powertrains develop to complement a wide array of hybrid technologies is a parallel challenge. These industry challenges have dictated that Tickford has had to respond with investment in its own test facilities over the past three years, and this investment has secured the ongoing and future growth of the business, while supporting the test challenges faced by the company's OEM customers.

Tickford's state-of-the-art facility boasts 22 engine and rig test cells. Other features include an absorbing tilting engine rig and a three-axis hybrid driveline rig

Future investment will be key to Tickford remaining at the forefront of powertrain testing, with an ongoing investment strategy that sees the company committed to spending in excess of US$1.7 million during 2012, and similar amounts in 2013 and 2014. Advanced facilities and highly trained staff will evolve to mirror the technical challenges faced by the company's clients, therefore ensuring Tickford has a world-class test facility able to meet their demands.

Tickford has many multinational blue chip customers, including engine and vehicle manufacturers; fuel, lubricant, and additive companies; and Tier 1 and 2 suppliers. The continuing development of the facilities will enable Tickford to offer complete driveline and hybrid development, calibration, and validation services to these established customers. A further extension of the existing powertrain capability will encompass heavy-duty diesel engines with up to 16-liter capacity; this sees Tickford moving into a new area of opportunity away from its mainstream automotive roots into heavy-duty powertrains.



The current engine dynamometer capacity ranges from 25kW to 900kW, with supporting emission measurements

The advanced facilities at Tickford are helping international car makers to meet current and future stringent legislation

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ONLINE READER ENQUIRY NO. 511

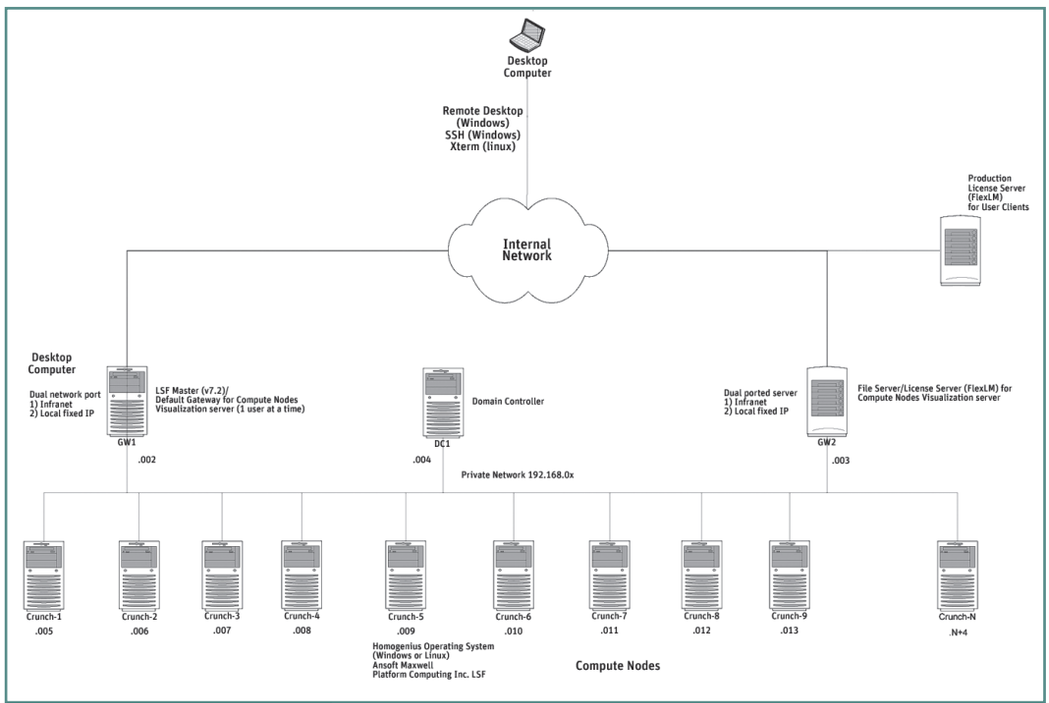
Electromagnetic simulation

A significant speed-up in Maxwell DSO on a 32-core high-performance compute farm has doubled traction motor design productivity at Detroit's largest car maker

Car makers have little experience in designing the traction motors used to drive EVs and HEVs and, as a result, engineers must consider a very wide range of design alternatives in order to optimize their design. Electromagnetic simulation plays a critical role by evaluating the performance of design concepts, such as by computing the torque profile of the machine. As with many global HEV and EV OEMs, General Motors uses Ansys Maxwell electromagnetic field simulation software to compute the torque profile of the motor; how the torque ramps up over time in motor mode; and the electrical resistance in stopping the vehicle in regenerative brake mode. In the past, it took hundreds of hours to perform electromagnetic simulation on a single design iteration, which negatively impacted productivity by leaving engineers waiting for results.

GM developed a high-performance computing (HPC) environment HPC platform using surplus hardware to create a 16-computer, 32-core compute farm that served as a stepping-stone to the current and more sophisticated approach. The actual details of the current approach are confidential, but it's possible to provide information on the stepping-stone approach that can be used to enter the HPC supercomputing arena in a cost-effective manner.

The stepping-stone configuration that's shown above uses 16 compute nodes in addition to an LSF master gateway, domain controller, and license server. LSF by Platform Computer (now IBM) was used as the parallel task manager and queuing software. The domain controller served as the file server and had 2TB disk storage for all the user files. It also served as the server for the Maxwell files so that it was not necessary to install Maxwell independently on each box. The stepping stone system required 32DSO, six Maxwell 2D, six Optimetrics, and 16 LSF Server licenses.



The stepping-stone configuration uses 16 compute nodes in addition to an LSF master gateway, domain controller, and the license server

Performing simulations running on 16 computers with 32 cores reduced the solution time by a factor of 16 to 4.5 hours. Assuming that a fully trained engineer costs about US$100,000 per year, to perform the same work as two engineers in the stepping-stone environment in a non-HPC environment would require at least four engineers. As a result, the stepping stone environment saves about US$200,000 per year in personnel costs. The total cost of the HPC software is roughly US$30,000 per year. So with software costs factored in, the stepping stone system saved US$170,000 per year with virtually zero upfront investment. In addition to this, the ability to evaluate more design alternatives reduced time-to-market, decreased manufacturing costs, and improved the quality of traction motors.

What's more, further improvements are on the way. When Ansys Maxwell supports graphic processor unit (GPU) computing by offloading highly parallel number-crunching algorithms from the central processor unit cores onto GPUs, it will result in a substantial increase in speed. In addition to this upcoming benefit, a GPU such as the NVIDIA M2070 Tesla Accelerator offers immense floating point speed and array manipulation features, typically providing a two times speed-up compared with an HPC system without GPUs.

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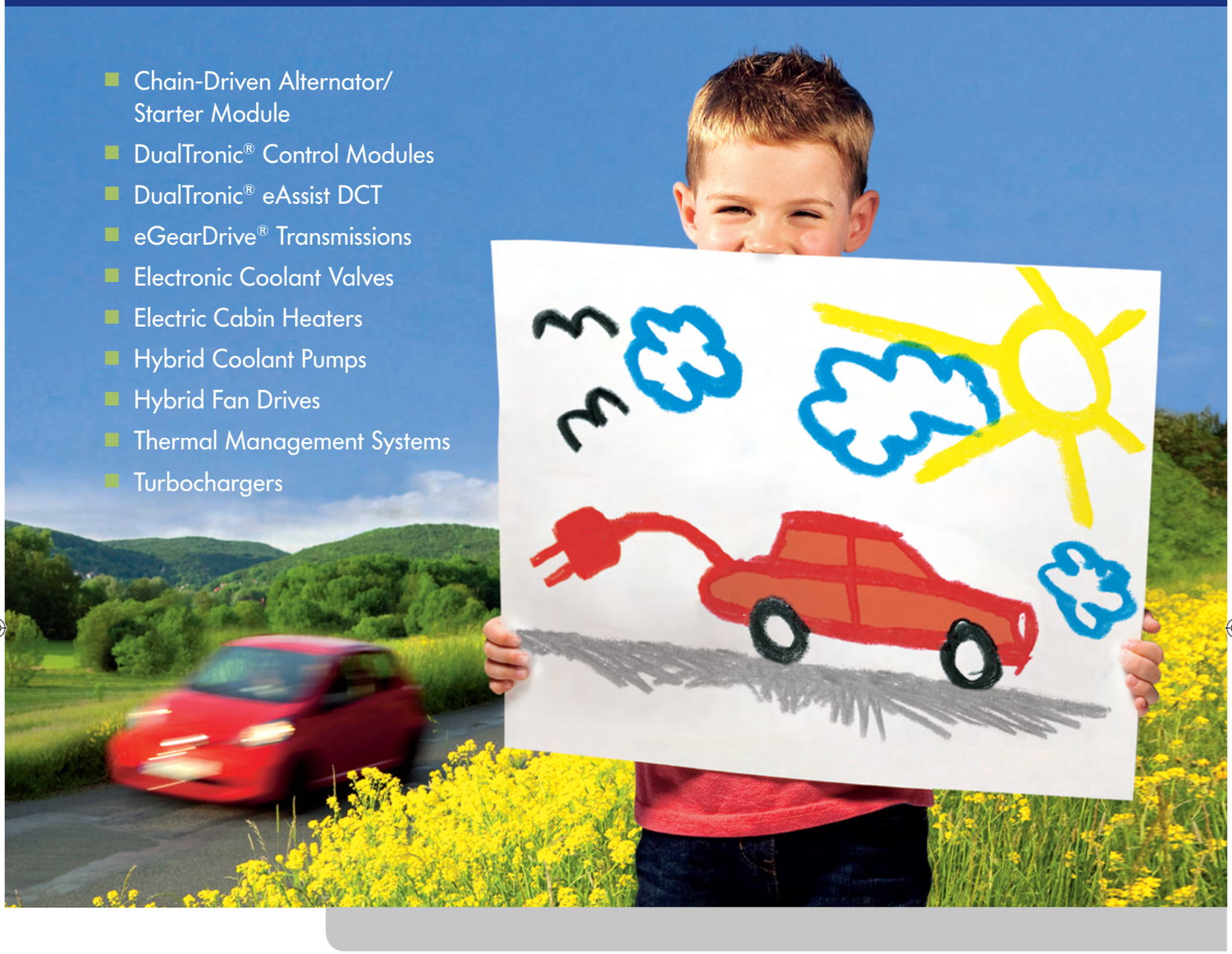
Driving toward a greener future.



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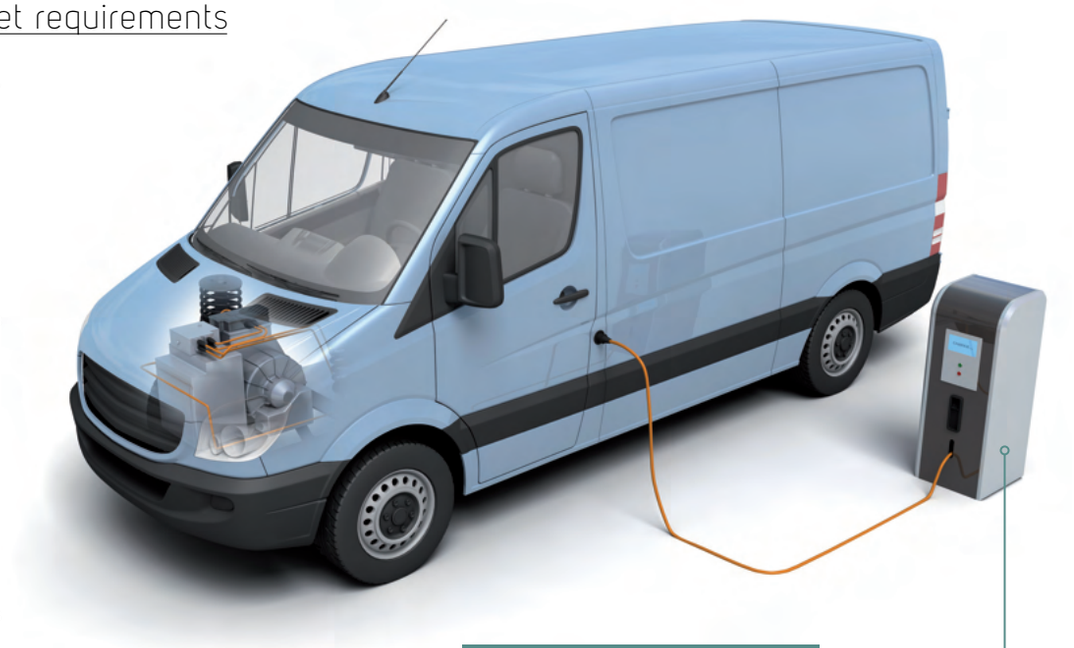
HEV electrical systems

Even before the introduction of unified standards, a leading supplier has developed a high-voltage electrical system for the Mercedes E-Vito that meets new market requirements



Huber+Suhner delivers integrated connectivity solutions for electric vehicles

The shortage of raw materials, an increasing CO_2 burden, and changes in consumer behavior are important drivers for the continuation of R&D in the automotive industry. Alternative drives such as fuel cells and hybrid or electric drives are having an increasing impact on the market.

Whereas today, the first standards are already in place, the development of the Mercedes E-Vito in late 2009 was carried out in the absence of any technical specifications. High voltages inside the vehicle posed new demands with regard to the design of the electrical system. Huber+Suhner, a manufacturer of components and systems for electrical and optical connectivity, was able to draw on its experience in high-voltage connections for the railway sector.

In 2009, the company was commissioned by Daimler to carry out the R&D of high-voltage electrical systems and succeeded in bringing a functioning system onto the market. In cooperation with Magna Steyr, Huber+Suhner was awarded the contract for the development of the high-voltage electrical system to be fitted to the Mercedes E-Vito – one of the very first electric vehicles to appear on the German roads.

With an order volume of more than 2,000 units, Huber+Suhner now produces a high-voltage electrical system comprising a high-voltage distribution unit (HVDU), single cores, as well as shielded and unshielded multicore cables with diameters between 2.5 and 35mm^2. Furthermore, the scope of delivery includes a number of unshielded low-voltage cables with diameters between 0.5 and 16mm^2 for connecting the low-voltage electrical system to the powertrain.

The particular challenge with this project was the extremely short development time on the one hand, and the many changes during product ramp-up on the other. "There was only just half a year between the start of the project and PPAP approval," recalls Norbert Schaller, Huber+Suhner's market segment manager for automotive. "At the time, no long-term experience was available in the design of high-voltage electrical systems, and no industry-specific standards were defined."

Due to the extremely high voltages, the customer defined a variety of requirements with regard to the high-voltage distribution unit. In particular, EMC protection, leak-tightness with regard to fluids such as water and oils, electrical resistance below 10 mOhm, and absolute safety for the user, had to be ensured. The industry standard connectors at the time were unable to meet these specifications. The RADOX Automotive Connection System (RACS) from Huber+Suhner enables an extremely space-saving and efficient connection to be realized between the HVDU and high-voltage units through the direct routing of the cables in the distribution unit. The shielded high-voltage connection features an extremely high current-carrying capacity and complies with the IP 69K protection class.

The EMC trap integrated in the HVDU box was a further element for increasing electromagnetic compatibility. The HVDU also had to be equipped with an interlock system, which stops the flow of current in the event of a crash. An active charge circuit, fuses, and capacitors are also a permanent feature of the distribution unit.

The development, design, and configuration of the entire high-voltage electrical system, as well as the project management and process design of the first prototypes, was performed by the team of engineers in Germany. Owing to the absence of a market standard at the time, Huber+Suhner also agreed on the scope of the validation testing in detail with Magna. Release sample production was then carried out in Switzerland, followed by production of the small-volume series in Poland. The Huber+Suhner team is now putting the experience gained in the design of the high-voltage electrical system for the E-Vito into practice at established manufacturers of electric and hybrid vehicles.

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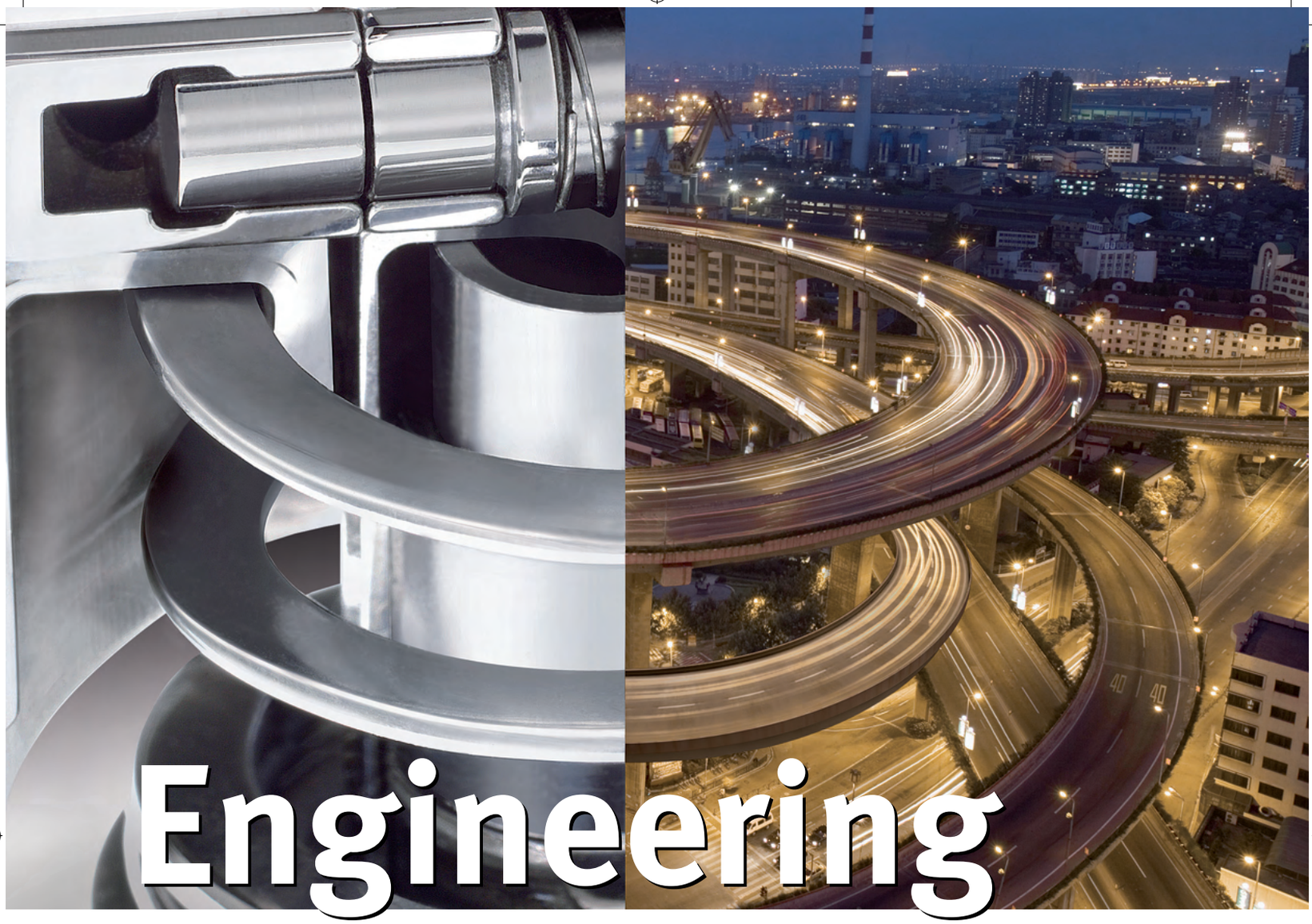
ONLINE READER ENQUIRY NO. 513



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Future e-powertrain designs

An all-new range of compact, flexible and cost-effective systems are set to play a very important role in the development of a new generation of EVs and HEVs

Efficiency without compromise: the watchwords for vehicle manufacturers are also the fundamental principles for a new generation of electric powertrains being designed and engineered by GKN Driveline. Not only do these meet the priorities for packaging, weight saving, and performance, but as integrated solutions from a single supplier, they guarantee maximized efficiency and cost-effectiveness for the customer.

The new Integrated eDrive System is an early demonstration of how GKN's joint venture with EVO Electric is already delivering new opportunities. This system combines EVO Electric's AF-130 three-phase motor with GKN Driveline's Family 2 two-speed eTransmission to create a single unit, optimized for weight, packaging, and performance. With the benefit of EVO Electric's proprietary axial flux electric motor technology – the system delivers high torque and power density in a compact and lightweight package that can be easily integrated in a wide variety of vehicles.

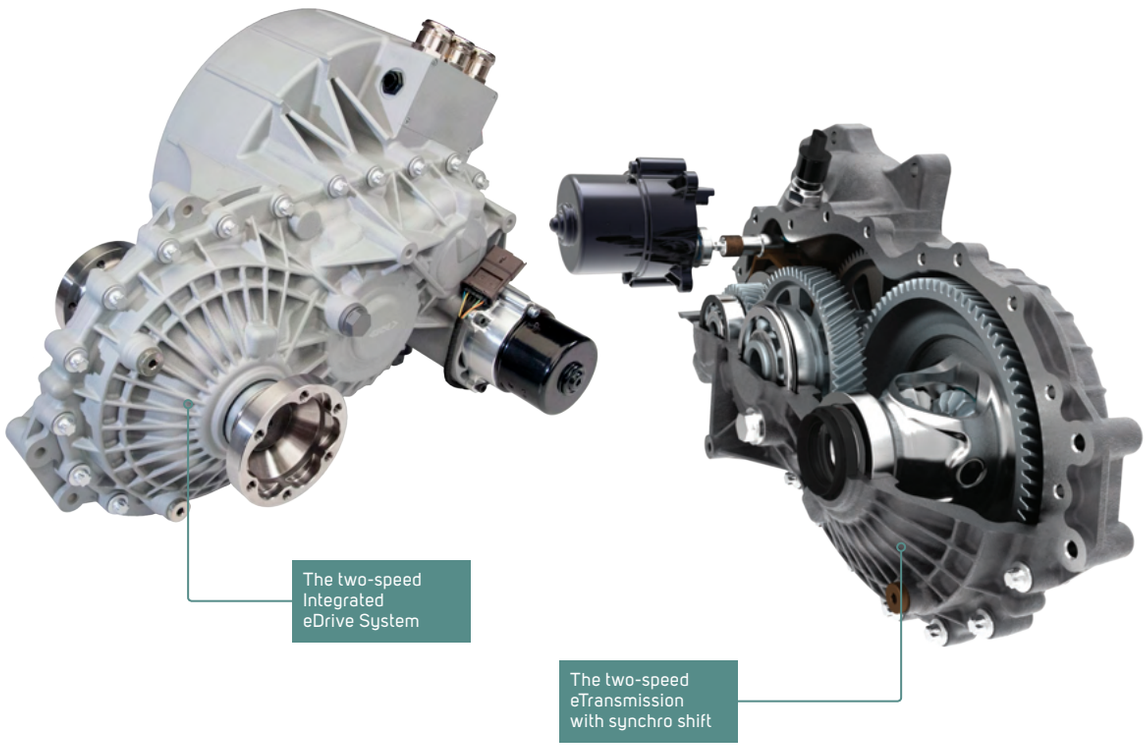
The complete unit weighs only 58kg and offers more than 92% peak efficiency. Its design also allows for simple, optional integration of a parking brake function. System peak output torque is 4,000Nm with a maximum speed of 150km/h; the motor itself develops 140kW and a peak torque of 350Nm.

John McLuskie, business development director eDrive Systems for GKN Driveline, says, "This system offers great benefits to manufacturers in that we are able to provide all the e-drivetrain elements apart from the battery. As a result, our customers are dealing with just one supplier instead of three and can be assured that each element of the system is perfectly integrated and optimized for efficiency and performance, even before it is fitted to the actual vehicle. This complete solution is compact, flexible, and cost-effective.

GKN Driveline is also designing new shift systems for electric powertrains, with two-speed operation that allows the electric motor to be kept running at peak efficiency. Compared with a single-speed transmission, a 10% increase in overall powertrain efficiency can be achieved. This opens up possibilities for vehicle range to be extended, or for battery size to be reduced by a similar proportion, according to the vehicle manufacturer's priorities.

Developing both electric motor-actuated synchromesh shifting and hydraulic seamless clutch-shift technology, GKN Driveline aims to meet a wide range of customer priorities for both EVs and HEVs, whether for the smooth, uninterrupted shift performance of the hydraulic system, or the simpler electric synchro shift proposition. Its work in this area has gained valuable technical insight and market reach through acquisition.

Theo Gassmann, director of advanced engineering and eDrive development, says, "The new products will play an important role in improving the performance, efficiency, and viability of a new generation of electric and hybrid electric vehicles. We are confident, that we have the resources and skills to take these technologies further, supported by our new business developments, to achieve even more efficient, intelligent and cost-effective eDrive Systems solutions that will drive the cars of the future."



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ARENS POWERPAC Power Electronics

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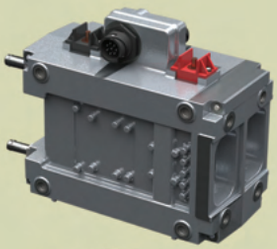
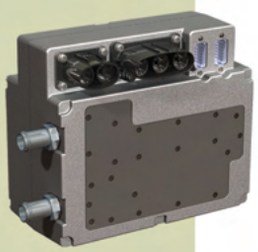
- Air or liquid cooled
- CAN communication
- Fully protected
- EMC compliant
- Group 31 size



DC/DC Converters

- 4KW continuous
- Bi-directional
- Air or liquid cooled
- CAN Communication
- Fully protected
- EMC compliant
- Group 31 size



Traction Inverters

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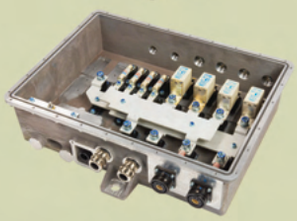
- 260-900VDC input
- Compact design
- IGBT based design
- Group 31 size



Power Distribution Modules

- High voltage version 750V, 750A
- Medium voltage version 360V, 300A

- 100KW Traction Inverter, 360VDC Nominal
- 6KW DCAC Inverter, 360VDC In (Nominal) / 115VAC Out
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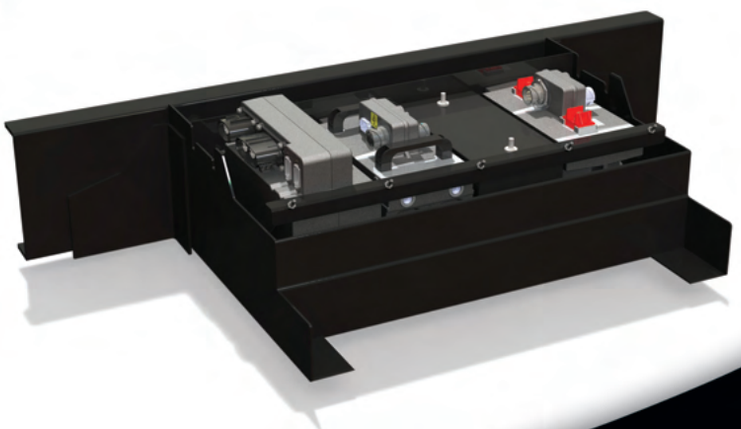

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Battery systems tester

A new flexible product, built on an open platform, aims to take battery testing to a whole new level

D&V Electronics has unveiled a brand new product that's been designed to specifically serve the battery systems testing market. In the emerging competitive environment of battery pack and power electronics, the BST-240 comes in as a high-value product designed to cycle, test, and measure for full battery operational conditions.

The BST-240 is built on an open platform, which is perfect for integrating with cutting-edge, real-time simulation and testing. This test system can also be used for long term, heavy-duty cycling, prevalent with endurance testing. Regardless of A-hr capacity, the BST-240 is available for any type of programmed testing. It is built as an intelligent bi-directional DC power system, and any power discharged from the battery pack system is regenerated onto the main grid in a safe and efficient manner.

OEMs and battery pack makers will find this product line interesting because of the full capability offered in the platform. The flexibility of the BST-240 enables the simulation of almost any high-voltage system in the fuel cell, Li-ion, lead-acid, capacitors, and power electronics environment. Specifically, an operational voltage range of 40V to 1,000V is suited for the battery packs integrated into heavy trucks, buses, and passenger cars, as well as scooters and recreational vehicles. Vehicle power systems can be simulated within the tester's programming environment, or controlled through a third-party controller module. The tester's software is based on an open architecture that allows for more capability to integrate with customer-driven software and hardware.

The BST-240 has the ability to charge the battery pack system, as well as to discharge for full pack capability testing. Furthermore, the proprietary BMS systems built on CAN communications or other network schemes can be integrated to the tester communication channels. Comprehensive testing of these products can then include tuning for built-in BMS diagnostics and control strategies.

The BST-240 is built on an open platform, which is ideal for integrating with real-time simulation and testing

D&V Electronics prides itself on producing innovative devices to serve a new environment. The company's engineers have developed a fast-switching feature specifically for emulating extremely fast voltage spikes and atypical tail-end conditions that can occur within inverter and electrical power systems. This serves as a valuable tool for R&D purposes to fully test battery pack systems for rare yet high-risk fail conditions. The BST-240 also boasts the highest current slew rate on the market for driving high current conditions in very short periods of time.

The tester is built with high-quality intelligent safety systems, DC-DC converters, measurement instrumentation, internal transformer, and load bank systems that are built on a PC control platform. The measurement instrumentation links with the BST-240 data-acquisition system, allowing for more than six channels of high-speed sampling. Additional options also offer thermal measuring unit modules that contain the capability for eight channels of thermocouple inputs. Multiple modules can be added to scale-up temperature measurement capability. Boards for further discrete input/output options are available to integrate with PLC systems or other control networks.

The BST-240 offers the industry the highest current slew rate on the market

Charging algorithms can be modified according to different charger standards, as well as customized scripts. Cycle testing can be performed according to any standard drive-cycle such as UDDS or US06. User-generated scripts can be developed in a visual basics or C++ environment if the application requires full programmability functions. However, the software user interface allows for easy-to-use flow-chart programming features. Step changes can be performed at a 10Hz rate for higher resolution control profiles, while voltage changes and current changes can be switched at an incredibly fast slew rate.

D&V Electronics' BST-240 aims to take battery testing to a whole new level with its fast current and voltage changing capability, as well as its high level of software flexibility.

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Meeting market needs

Standardized, off-the-shelf products, as well as bespoke systems, are helping the key players in North America to push ahead with new EV and HEV designs

Maccor started operations in Tulsa, Oklahoma, in 1986, as a company dedicated to the development of high-performance battery test systems. With a nucleus of engineers experienced in emerging battery technologies and computer control systems, the company has experienced continued and rapid growth.

In the past, the only commercial products available to evaluate battery performance had been designed and built specifically for lead acid vehicle battery applications. These were relatively high power units, without any high degree of accuracy, had limited test programming capabilities, and collected data relatively slowly. In the mid-1980s, when there was resurgence in new battery technologies, it became obvious that the available battery test systems were inadequate.

As a consequence, the founders of Maccor conceived of an entirely different design for battery testing. The result was a system that provided extremely accurate results, collected test data at high speed, would test large numbers of batteries at the same time, and could be programmed to perform virtually any test sequence required.

Over the past 25 years, Maccor's innovative technology has enabled the developer to become the standard for most companies involved in the further research, development, and quality control of cells and batteries for a wide range of products and cell chemistries. This solid foundation provides the company with the knowledge, experience and resources for the future. Today, Maccor has earned a greater than 80% share of US-based business in its product area, and has a major share of the European market, as well as an expanding portfolio in Asia. The company has nearly 1,500 systems in regular operation in more than 45 countries – including the first system ever built.

Maccor designs all of its own hardware and software, and this is an ongoing process. Most of the systems are customized to meet a customer's specific requirements, and from time to time, customers also request customized features within the software. Over the years, this has provided Maccor engineers with a wealth of knowledge and experience in the design and performance of these systems, and this experience is being used to develop systems for the future, with even higher levels of performance, additional features and capabilities, all using new computer technology.

Maccor is confident that it offers the widest range of features and capabilities of any manufacturer for this type of equipment, and if its standard equipment doesn't meet the exact needs of the customer, the company will customize its equipment to specific requirements.

In 2009, Maccor moved to a newer and larger facility due to the increased demand in sales volumes, and this new facility has the capability to handle the present manufacturing demand, as well as having room for expansion to handle any future increase in demand.

Unlike other developers, Maccor designs all of its own hardware and software, meaning that the company has extensive expertise in the battery test arena

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Cooling expertise

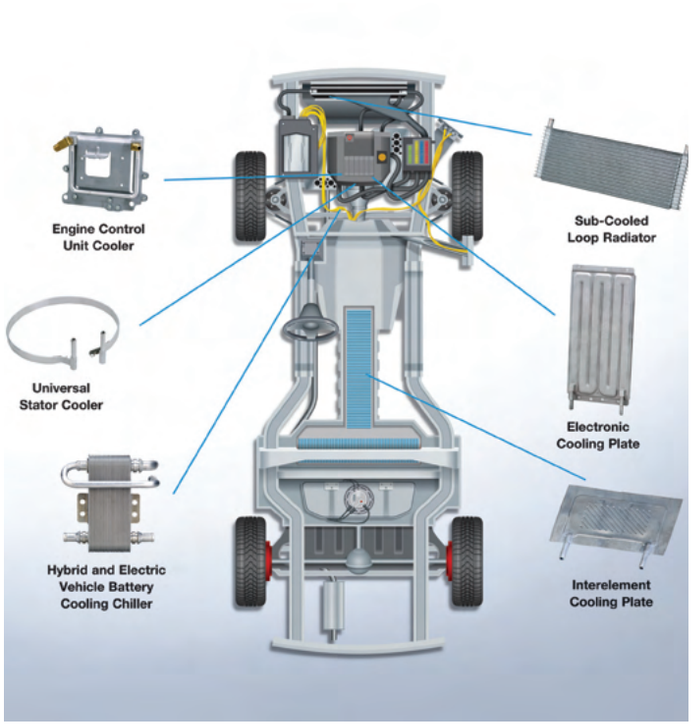
Custom heat-transfer solutions for hybrid vehicles are helping to improve efficiency

Megatrends are one way that companies plan research and development initiatives for the future, and a megatrend that is gaining significant traction is sustainability. By making vehicles more sustainable and increasing the number of hybrid vehicles on the road, the industry can reduce the use of fossil fuels, save money, and help protect the environment.

Hybrid vehicles, by definition, have two or more distinct power sources, including any combination of the following: IC engines, fuel-cell electric engines, or various types of batteries. However, one problem associated with these vehicles is the battery, as it generates heat that can damage the vehicle's electrical components.

Dana is addressing sustainability by developing technologies that assist with custom heat-transfer solutions for hybrid vehicle cooling systems. The company's extensive range of Long hybrid-engine cooling options sets the industry standard for innovation and quality. "These products are designed to be flexible and give the engineer options to transfer the heat generated by the battery, various parts of the engine, and the vehicle itself. Transferring the heat allows the systems to be more durable and the heat generated can be used for vehicle climate control," says Ted Zielinski, technical director for Dana's Power Technologies Group.

Every product in the system does its part to increase efficiency, starting with Dana's electronic cooling plates, which are manufactured using a cost-effective, proprietary clean nickel-brazing process. This highly conductive brazed-aluminum construction provides a consistent, uniform temperature across the base plate, while the brazed mounting simplifies installation.



Dana's hybrid cooling technology is manufactured with various types of lightweight aluminum and provides a multitude of benefits to the vehicle

The hybrid and electric battery cooling chiller offers packaging flexibility with a compact design that keeps climate control and battery coolant fluids clean and allows the use of long-life coolants. The chiller also transfers heat to the climate control system, extending the overall battery life.

Dana's engineers have created high-precision stamped integral battery cooling plates that enable less than one millimeter cooler assembly height, and are interleaved with prismatic lithium-ion cells. Heat is transferred from the surface of these cells to a sub-cooled coolant circuit.

The stator cooler is compact and lightweight, with all-aluminum construction. It provides direct cooling to the stator coils and prevents starter-alternator modules from overheating, even with frequent engine starts. Unique internal surfaces maximize heat transfer at low coolant flow rates.

To ensure that electronics do not overheat, an ECU cooler is attached directly to the ECU. The cooler accommodates a variety of cooling fluids, including long-life coolant and diesel fuel.

Finally, a sub-cooled loop radiator provides cooling to a lower temperature than is possible with the main radiator. It is designed for flow rates typical of electric pumps, but can fit any vehicle.

Dana's products can have a significant impact on vehicle efficiency and the environment. That's why it's the company's mission to develop efficient, effective power conveyance and energy management solutions. Through a focus on concerns such as cooling technology, the supplier can make a difference and create advances that address market demands to increase the sustainability of future vehicles. "Additionally, our cooling technology is easily recyclable, which contributes to the overall environmental benefits of electric and hybrid-electric vehicles," Zielinski adds.

Dana is a leading supplier of driveline, sealing, and thermal-management technologies that improve the efficiency and performance of passenger, commercial, and off-highway vehicles with both conventional and alternative-energy powertrains. The company's global network of engineering, manufacturing, and distribution facilities provides original-equipment and aftermarket customers with local product and service support. Based in Maumee, Ohio, Dana employs approximately 25,500 people in 26 countries and reported 2011 sales of US$7.6 billion.

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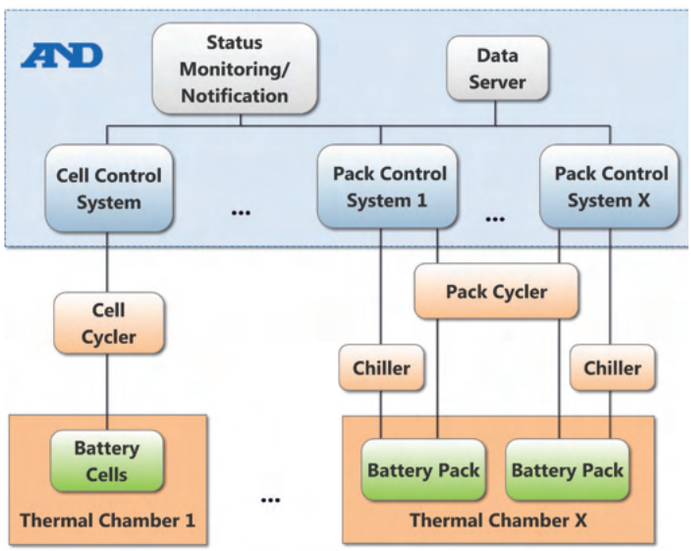
Total testing facility

The key to ensuring that a next-generation EV system is of the highest quality is a testing lab that is flexible, boasts intelligent solutions and features an array of advanced equipment

A modern testing laboratory must perform a full range of assessments, from simple lifecycling of cells to complex performance tests on modules and packs, as well as abuse testing on all subsystems. The laboratory may also have to accommodate all sizes, from cells as small as a coin to full battery packs of 25kWh or more, and system voltages ranging from 3V right up to 650V.

This disparity of requirements means that a full-featured facility must have a broad range of equipment to effectively accommodate all the testing that is required. The equipment would typically include cycling hardware, such as that from Bitrode, environmental chambers like those offered by Cincinnati Sub Zero, and a variety of other instruments for performing mechanical excitation, such as compression or vibration. In total, instruments from as many as a half-dozen different manufacturers might be involved in performing a single test.

Historically, all this equipment has been controlled manually, or with only simplistic site control systems such as non-integrated device controllers. This makes the duties of the test engineer overly burdensome, requiring many hours of setting up, programming, and monitoring a multitude of different systems. Lab managers face even worse problems: a test completes unnoticed late on a Friday, or even stops because of an error. The unfortunate result is a system with a per-channel cost of as much as US$500,000 sitting idle for hours or possibly days, with a consequent effect of increased testing costs and reduced ROI.



Left and below: A&D offers the automotive industry a holistic approach to developing the ideal modern testing laboratory that performs a full range of assessments

To succeed in the modern world of testing requires a system to adequately control all aspects of the process, from test management and data collection to machine control and laboratory safety. Some labs have elected to design packages in-house; it's important to congratulate the few that succeed, as well as sympathize with the rest that attempt and fail! Just as the typical test laboratories are not in the business of building cyclers or environmental chambers, neither are they in the business of designing, assembling and programming laboratory management systems. It is not, nor should it be, their core competency.

Building complete full-featured laboratory management and testing control systems is, however, a core competency of A&D Technology. A properly designed, fully integrated system should provide comprehensive test control, including control of multiple cycling systems, environmental chambers, data acquisition systems, and, if required, electrodynamic shakers and chiller systems. This system should be programmed to provide failsafe limiting of voltages and currents, as well as simplified test setup and operation, at the same time allowing the most intricate operational modes if needed.

In addition to a proper test control system, the fully integrated laboratory should include the capability to continually monitor all the systems in the lab, and notify the designated person upon test completion, or fault status, thus ensuring a much more efficient use of machinery and manpower, and even providing safe unattended three-shift operation if desired.

Finally, all the data generated from these test systems must be available to the requesting parties, while being secure from those without proper clearance. This is accomplished by means of a centralized data-management system that uploads information automatically and periodically to a secure data server, for use by all authorized personnel.

Applying the above-listed principles can transform the average battery testing laboratory into a world-class testing laboratory within a matter of months. This will improve the processes and reduce operating costs sufficiently that the upgrade typically returns its value in a very short period of time.

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Real EV consumption

Being able to measure the total energy balance of an electric car during real driving conditions provides development engineers with valuable and interesting data

Figure 1: In order to determine the overall energy balance of a vehicle in real driving conditions, the use of a mobile measuring system is needed

With its high efficiency and ultra-clean advantages, electric mobility offers great potential for the future of mobility as a whole, and this is something that has been underlined many times by the media. However, it's important to note that the energy demand specification from the manufacturers of electric vehicles is not directly comparable to the consumption data from conventional IC engine passenger cars. This article contrasts the gained energy demand figures for electric vehicles in comparison to official fuel consumption data from conventional IC engine cars.

For the purpose of this study, the test vehicle is a Mitsubishi i-MiEV. In order to determine the energy balance of a vehicle in real driving conditions, the use of a mobile measuring system is needed, and this is shown in Figure 1. The electric car has been equipped with a DEWE-510-E-Mobile measuring system. This system simultaneously measures the DC power of the battery and the power of the inverter-fed synchronous motor. This setup allows for immediate energy consumption, meaning that efficiency can be determined during the trip.

To gain measurements on energy consumption under different conditions (such as speeds or inclines), the position (including altitude), velocity, and acceleration of the electric car has been recorded using a GPS sensor. Test engineers made sure that they used the same measurement system throughout the tests and that the process was completely in sync with official energy consumption data. Furthermore, test engineers also filmed the entire process with a synchronized video camera that was connected to the measuring system. Figure 1 shows a screenshot of the measured data in DEWESoft.

The results of the tests point to the high efficiency potential of electric vehicles, with the energy demand values being well below the energy consumption of current passenger cars powered by an IC engine. However, despite the relatively high-energy efficiency of the test vehicle, room for improvement was found as a result of the measurements that were taken. There's no denying that electrical mobility is still only at the beginning in an automotive sense, but it is likely that the identified improvements in this field trial will soon be recognized by the industry and taken into account during the development of the next-generation electric vehicles.

The triple mix-road test allows for the fuel consumption figure of passenger cars to be determined. For the study, the test vehicle performed this combined cycle under real driving conditions, with the test track consisting of three sections: highway, country road, and city driving. The energy demand specification is determined separately for all three sections.

The standby power consumption of the electric vehicle varies between 500W and 1,000W, depending on whether the liquid cooling of the battery is in operation. In this case, the cooling system of the battery is automatically controlled by the BMS. As a result, it can be assumed that the average standby power consumption of 750W results for city driving and an energy requirement of 0.34kWh. The total energy requirement of city driving is 0.76kWh. As a result, this eliminates a little less than half the converted energy for city driving to the standby energy demand of the test vehicle.

These results means that vehicle manufacturers are challenged to optimize the standby power consumption further, so that higher efficiency can be achieved, even in low-load regions.

Table 1 shows the main results from the combined cycle driving test

	Highway	Country road	City	Total
Energy battery (kWh/100km)	15.16	12.55	7.27	12.60
fuel equivalents (l Diesel/100km)	1.52	1.26	0.73	1.26

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ONLINE READER ENQUIRY NO. 519

Bi-directional charger

The time required to offset the initial investment that's needed to purchase a PEV now looks much shorter thanks to a critical breakthrough

EDN Group has announced the development of a novel series of bi-directional converters that enhances PEVs with innovative vehicle-to-grid (V2G) services and exportable power, including vehicle-to-load (V2L) and vehicle-to-vehicle capabilities.

It is generally accepted that PEVs have become capital assets that provide a brand such as a car maker with the correct image and mobility values because of their low operational costs and green operating capabilities. However, it is also accepted that the adoption of PEVs is characterized by the high initial investment (incremental purchase cost) that's associated with a relative long payback time. In some cases, the time to offset the incremental cost makes the PEV unattractive as a capital investment from a consumer perspective.

What's less known about PEVs is that they have the potential to provide reverse energy flow, such as V2G, V2L and V2V, or as defined in SAE J2836-3.

To provide reverse energy flow, an inverter (DC/AC), or better still a unique bi-directional charger/inverter that reduces overall system components, must be present on the vehicle. This allows the PEV application to return energy to a home, business, service vehicle or charge station, that is actively connected to the grid.

Fundamentally, the cost savings achieved by combining a versatile mobile system, grid power services, and reverse flow capability, creates a new revenue stream that reduces the time taken to offset the incremental cost of the PEV when compared with traditional mobile power generation systems.

Features such as frequency regulation, Volt/VAR optimization, spinning reserve, installation peak shaving, and receptacles for tools, can help the adoption of PEVs as a capital investment for a cleaner and greener future.

New bi-directional converters that combine both inverter and charger benefits in one component will be launched by EDN Group later this year

EDN Group's bi-directional converters will be available for customer evaluation towards the end of 2012 and they will combine the inverter and charger benefits in a unique component, in place of the traditional onboard chargers.

The technology will be compliant with the emerging SAE standards, mainly with regard to safety and communication. The liquid and air-cooled converters will be scalable, with power ranges from 3.5kW to 20kW, single and three-phase line-voltages, with HVDC output voltages up to 850Vdc, providing compatibility with all US and EU electric passenger car and truck applications. The converter modules can also be connected in parallel to efficiently increase on- and offboard power capability.

Talking about the new charger range, EDN Group's sales engineering manager, Marco Cereda, says, "The new bi-directional series will be well suited to high-volume manufacturing, power density, and product price, and it will be very cost-effective and attractive with respect to standard onboard battery charger solutions."

EDN Group, a power converter manufacturer of reliable and technologically advanced high-frequency power converters, has extensive experience as a market driven organization and focuses its efforts to meet and exceed its customers' needs.

Its core strength in innovation allows the company to serve the automotive, military, industrial, medical, and laser markets. EDN's know-how and core competency provide its customers with high-end, high-quality products, and efficient problem-solving solutions.

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ONLINE READER ENQUIRY NO. 520

Testing upgrades

New features such as high-tech CANbus communication for electric vehicle testing systems are raising the bar in product development

One of the challenges for today's scientists and engineers is to find better solutions to make EVs and HEVs an attainable reality for future generations. For the past 20 years, Arbin has designed and manufactured testing systems for the battery, supercapacitor, and fuel cell industries around the world. The company's electric vehicle testing solution (EVTS) is specially designed for testing high-power EV and HEV batteries, packs, and modules. There has been an improvement in the systems' ability to efficiently return power to the grid that provides lower operational cost for long-term testing of high power EV battery packs. Arbin's engineers have redesigned the EVTS, including new features such as CANbus communication and multiple channel operational modes.

CANbus communication was originally intended to be used in passenger cars, but that was only the start; it has also helped many industrial users to provide internal networking to multiple devices by monitoring and filtering messages. Arbin provides CANbus 2.0B communication for its EVTS products that are used to test battery packs in conjunction with the BMS. The BMS works with a CANbus device by monitoring and protecting rechargeable batteries. For example, if over-voltage occurs, the BMS system protects the battery from operating outside its safety limits; the CANbus communicates this information to Arbin's MITS Pro Software and the EVTS tester before any damage is done to the battery. The MITS Pro Software provides flexible control types and streamlined testing. The system's software allows the EVTS equipment to be programmed to both receive messages from and transmit messages to customers' CAN devices. The CANbus device supports reading, writing, and sending CAN messages, logging, monitoring, setting, controlling, and protecting the battery pack. The device complies with standard CANbus specification such as SAE J1939 protocol, CANopen, or other user-defined protocols. When using CANbus, there is no additional third-party equipment, third-party DLL package, or third-party license needed.

Arbin's redesigned EVTS provides two test channels with flexible controls, enabling the user to perform a wide variety of tests. The test channels can be configured for multiple operational modes, including independent, parallel, series, and dynamic booster that can be used to meet user-testing demands. Independent channels allow the user to run multiple tests simultaneously, while parallel channel operational mode increases the current capacity. The EVTS's ability to put two channels in series is a unique feature that allows the voltage range to double, creating a more flexible testing solution. Arbin's dynamic booster reverses the polarity of the voltage to include a negative and positive range, providing the user with more flexibility for testing the safety of batteries. With all of these different operational modes, time and money is saved by working within one EV testing system.

Arbin's philosophy is to continue developing the most responsive, highest quality, and most technically advanced products with superior customer service and technical support, and with CANbus communication and the multiple operational modes, the company's engineers have raised the standard for quality EV testing solutions.

Arbin's electric vehicle testing system is equipped with two channels, each of which are capable of a maximum of 400V, 300A, with 90kW of power

EVTS-180 One system with two channels; each channel with 400V;300A			
Independent	Parallel	Series	Dynamic Booster
Two Channels	One Channel	One Channel	One Channel
400V;300A	400V; 600A	800V;300A	-400V to 400V; 300A

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ONLINE READER ENQUIRY NO. 521

Safer batteries

An exciting collaboration between two British companies is opening the door to a new era of lightweight, highly efficient and safer electric bicycles

With the electric bike rapidly replacing the traditional bike and motorcycle, one of the UK's leading electric bicycle manufacturers and distributors has been working closely with a UK-based manufacturer of a sulphur polymer rechargeable battery.

Both companies have been at the forefront of innovation since 2004, with Oxis Energy building next-generation battery systems and Wisper Bikes engineering cutting-edge electric bikes. Together, the two partners are now further improving the technology and system that will power the new Wisper-Oxis electric bike. At the start of this year, they successfully demonstrated an Oxis 36 volt system powering the vehicle.

According to Huw Hampson-Jones, CEO of Oxis Energy, "This is a very insightful decision made by Wisper. The international team at Oxis has the opportunity to demonstrate the significant advantages of the new design of the polymer lithium sulphur battery system. Let's be very clear about this – the breakthrough is profound. Beyond 2015 there will be no need for European public sector bodies to purchase petrol-driven vehicles for public use. In this, as a European company, we are ahead of the USA and Asia."

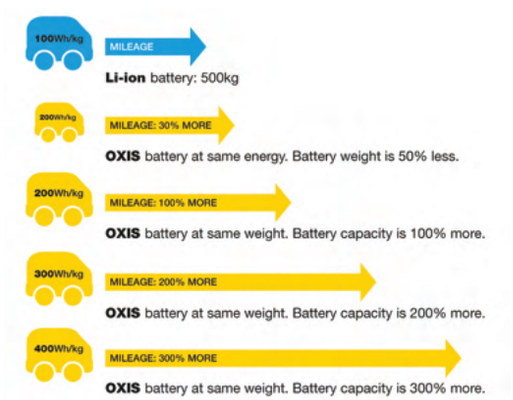
With its superior energy density levels, lithium sulphur has the potential to store five times as much energy as lithium-ion. As a result, this provides cyclists with the advantage of greater travelling distance per each charge. Further more, its chemistry is ultimately biodegradable, as it does not contain heavy metals or toxic components and subsystems.

Another direct consequence of the superior energy density level is an overall lighter bike. In addition to this, the Oxis system promises to be far more reliable than current battery systems – another important factor for cyclists.

Good design is important to Wisper. The company uses the very highest quality materials, such as magnesium and strong aviation alloys. David Miall, director of Wisper Bikes, believes that by combining the latest battery technology with a unique design, Oxis and Wisper aspire to give consumers a different offering. "We have been actively monitoring the developments of Oxis chemistry and technology systems for the past 15 months and we're now moving to a stage of commercializing the technology for use in consumer electric bikes," he says. "This means that our customers will be able to travel longer distances, more safely, and we can also add more features and services for them to use."

Choosing an electric bike can be a confusing decision for the consumer, with cost being a major consideration, but Oxis is confident that its polymer lithium sulphur battery systems will be significantly lower priced than those of lithium-ion packs.

Oxis Energy and Wisper Bikes are working together to develop a revolutionary electric bike that's powered by a polymer lithium sulphur battery system



The intelligent polymer lithium sulphur battery technology, which is being pioneered by Oxis Energy R&D engineers, offers multiple benefits when compared with the likes of lithium-ion systems. Advantages include overall cost and far superior energy density that ultimately realizes a much longer driving range and enables a lightweight design

However, it's in electric bike safety that the greatest breakthrough has been realized. Wisper is renowned for its robust and resilient products, and the Oxis technology compliments this by using a lithium metal anode, a sulphur-based cathode, and a lithium sulphide electrolyte, all of which allow the Oxis battery system to be inherently safer. Its prototypes have demonstrated safe performance in room temperatures to 140°C, albeit with reduced capacity at the top end of this range. Nail penetration tests, both on freshly assembled and cycled pouch cells, did not result in any noticeable increase in temperature.

With development work continuing, cyclists may not have to wait too long for the dream electric bicycle as the Wisper-Oxis electric bike is targeted for launch into the world market in late 2013.

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ONLINE READER ENQUIRY NO. 522

Electric mobility at sea

The solar yacht MS Tûranor PlanetSolar has finished its voyage around the globe, and with it some extensive endurance and reliability testing of its inverter systems in harsh environments

Electric mobility has become a widely used buzzword, especially in the field of individual mobility solutions for the replacement of traditional IC engine vehicles. The PlanetSolar organization has taken this expression one step further and accomplished the first ever fully electric journey around the globe with solar power. In this case, the vehicle was not a road vehicle but a solar-powered yacht, a catamaran to be more precise.

The idea sounds simple, but from the first project plan to the finished journey a myriad of technical challenges had to be solved. One of the many hurdles was the electrical powertrain of the ship. Drivetek AG, a Swiss electric drivetrain specialist, was given the task of leading the powertrain development project.

Given the tight schedule of the development project, Drivetek decided to rely on Semikron's off-the-shelf automotive graded high-voltage SKAI2 inverter hardware platform for integration into the powertrain powering the ship. SKAItek, a joint-venture company between Semikron and Drivetek, provided the motor control software – called QUASAR – for the control of the two ship propellers. The liquid-cooled permanent-magnet synchronous motors as well as the complete powertrain system were designed and integrated into the catamaran by Drivetek.

The technical specification of the ship is impressive: installed photovoltaic power of 93.5kW; 537m^2 of solar panels; and a total weight of 95 tons. With this setup, the catamaran survived 584 days at sea, and during this time it circumnavigated the globe and returned to Monaco on May 4, 2012. During the voyage the ship navigated in all the different climatic regions of the planet, and the powertrain system accumulated a total operating time of more than 12,000 hours. This endurance testing of the SKAI2 inverter system under real-life conditions in harsh environments provided conclusive proof of the performance and reliability of these systems. Extensive in-house test results have also been confirmed with the field data.

1

2

1: The SKAI2 high-voltage inverter system 800VDC/250kVA has proven its reliability in extreme harsh conditions for more than 12,000 hours

2: MS Tûranor PlanetSolar SKAI2-powered solar yacht at sea

The QUASAR motor control software and the SKAI2 inverter hardware platform are an established team, and due to their robust design they are perfectly suited for tough vehicle applications. The successful solar yacht powertrain project is a good working example of the cooperation between Semikron as the inverter manufacturer and Drivetek acting as the engineering service provider toward the end customer. This network of partners offers additional benefits to customers, such as Drivetek also providing the energy management and solar-power tracker system of the catamaran.

Built into an IP67 enclosure, the compact SKAI2 inverters withstand high vibration amplitudes up to 10G$_{rms}$. The QUASAR motor control software functionally complements the system and completes this tried-and-tested package.

The QUASAR motor control software is based on a modern, field-orientated control system. It guarantees stable control of the electrical machine up to the strong field weakening range, thus enabling the development of dynamic and efficient traction drives or generator solutions. The QUASAR system receives input from a central controller via CANbus and converts this precisely into a speed or torque.

The SKAI2 platform comprises highly integrated inverter electronics systems. These inverters provide the ideal powertrain solution for many applications such as electrical and hybrid vehicles, agricultural and utility motors, communal vehicles, buses, motorbikes, and boats, to name just a few examples.

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ONLINE READER ENQUIRY NO. 523

Eco-friendly exhibition

The fourth Macao International Environmental Co-operation Forum and Exhibition proved to be a resounding success, with both exhibitor and visitor numbers at a record high

Hosted by the government of the Macao Special Administrative Region, the 2012 Macao International Environmental Co-operation Forum and Exhibition (2012MIECF) featured the theme 'Green Economy – New Engine, New Growth'. Held on March 29–31, 2012, the forum was a massive success, having been attended by more than 8,500 participants, of which 6,400 were professional visitors.

There were some 703 environmental projects from more than 20 countries and regions received at the exhibition, a number that's 13% up from last year. A total of 702 business matching sessions were held, which represents a 22.3% increase from last year. These included 362 sessions relating to green hotel procurement; 92 business matching sessions attended by government agencies; and nine local government departments participating in procurement matching. Some 35 cooperation documents were signed, which represented a 13% increase on last year. Furthermore, 62% of the signing parties were from Macau, while the rest were from mainland China, Hong Kong, the Netherlands, Brazil, and other key markets. These exciting statistics from 2012MIECF further establishes the forum and exhibition as a cooperative platform for international companies in the environmental arena.

The 2012MIECF trade fair saw 398 organizations from 28 countries and regions exhibiting – a 20% increase on last year, among which enterprises from Thailand, Cambodia, and Nigeria participated in MIECF for the first time. The 2012MIECF Green Forum, which featured 55 invited speakers from 14 countries and regions, saw an attendance of 1,200 participants across its six conference sessions.

The 2012 Macao International Environmental Co-operation Forum and Exhibition was attended by 6,400 professional visitors

On the last day, four exciting ecological cars were offered to the public for test drives, and this attracted both local residents and tourists hoping to experience for themselves the characteristics of the electric vehicles. The feedback from these potential consumers was that this was a rare but vital opportunity to experience an innovative new technology. The four ecological cars offered for test drive were Mitsubishi's MiEV and Minicab MiEV, two of Segway's two-wheel electric cars, and a pure aerodynamic experimental car.

Mitsubishi's Minicab MiEV was exhibiting for the first time outside Japan. Both the Minicab MiEV and MiEV use the same technology – engine and battery – but with different designs in the form of commercial truck and passenger car styles respectively. Their maximum speed is 128km/h (80mph), and both can use domestic power supply for charging, needing around seven hours to complete a full charge. If combined with a fast charge system, only half an hour will be required to fill 80% of the required power.

The other ecological vehicle on show was Segway's one-passenger standing EV, which has the benefit of being able to save parking spaces, as well as reducing emissions. Segway is also suitable for disabled people needing prostheses to walk.

The final car available for the public to sample was a pure aerodynamic experimental car, which uses compressed air as its power source, meaning that it requires no fuel or battery to operate. After compression, the air is stored in a compressed air tank, and through compressed air power, the cylinder of the engine pushes the piston-driven engine to run.

The executive director of host coordinator for the Macao Trade and Investment Promotion Institute, Irene Lau, hailed the show as a great success. She said, "In view of the world's current focus on environmental issues, after five years of continuous development MIECF has reached a new level, both in scale and influence. The international participation this year is an affirmation of Macao's position in the field of environmental protection. Moreover, exhibitors have recognized MIECF's improvements in business matching with the right parties, and in efficiency and quality."

Since its launch in 2008, MIECF has continued to get better in terms of quality, and has shown itself to be an important platform for the development of green industries in the Pan-Pearl River Delta Region and Southern China. The next edition of MIECF is scheduled for March 21-23, 2013.

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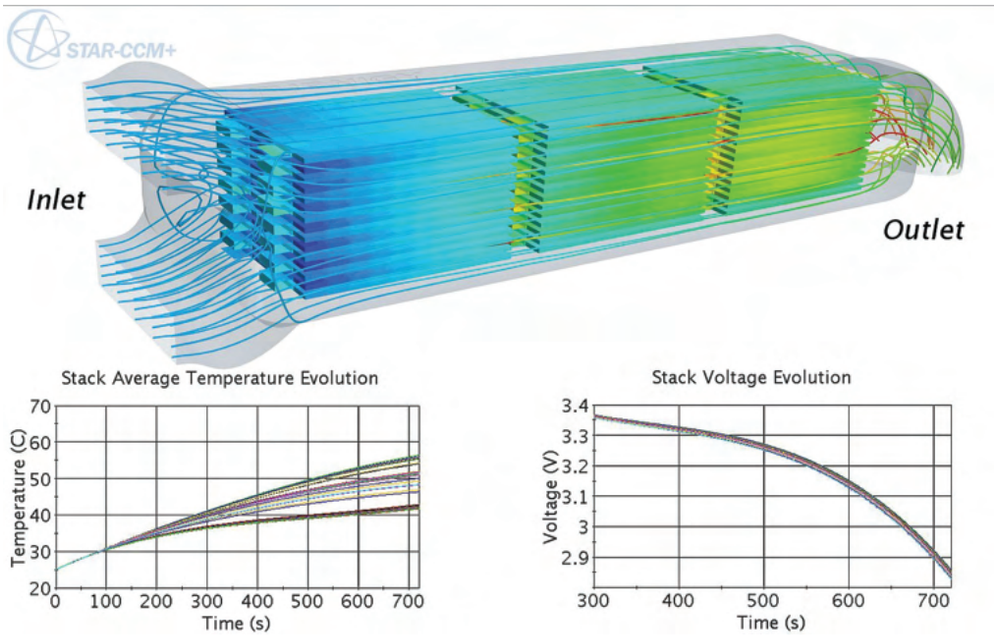
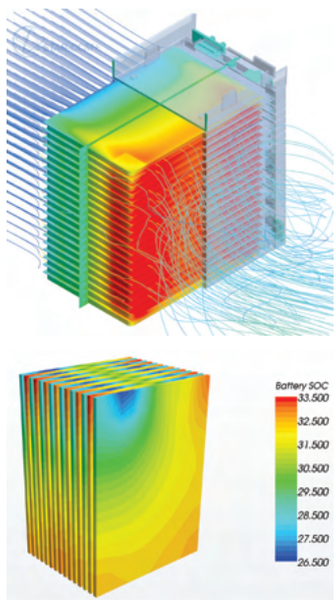
ONLINE READER ENQUIRY NO. 524

Battery modeling

A new and unique technology is helping engineers to simulate flow, thermal and electrochemistry of lithium-ion batteries in a reduced timeframe and with lower costs





The above detailed graphics showcase a screen representation of a battery pack within the STAR-CCM+ technology. The top right-hand image illustrates the streamlines of cooling air flow around the discharging battery cells. The in-depth analysis on battery cells taking place inside the STAR-CCM+ package are illustrated in the image to the right

The rise of hybrid and electric vehicles as a viable transportation mode in the past decade has given rise to organizations constantly pushing the envelope toward designing better, more efficient, and long-lasting battery cells – the very heart and soul of such vehicles. A new, unique tool from CD-adapco helps engineers to simulate flow, thermal and electrochemistry of lithium-ion batteries. This new battery technology is a combination of Battery Design Studio (BDS) from Battery Design LLC; and Battery Simulation Module (BSM), a capability of CD-adapco's multidisciplinary simulation software, STAR-CCM+. BDS offers a simulation environment for analysis and design of the electrochemistry of a single battery cell, while BSM combines the electrochemical solution from BDS with the flow and thermal solver of STAR-CCM+ to calculate the 3D thermal, flow, and electrochemical properties of Li-ion battery cells.

This new technology allows engineers to move from short-length scale simulations, such as analysis on a single cell, to complex battery modules, packs, or complete installations, including multiple hundreds of battery cells and their surrounding structure and cooling system. This high fidelity, coupled solution removes the need for duplicating engineering tasks, by enabling the same battery performance model, in a range of three, to be used in any of the different-length scale models.

The complete battery definition, including all geometric details of the cells, details of the collector technology, number of electrodes, and a relevant numerical model of the performance under load, is built in BDS. The battery model is then tested in BDS under appropriate discharge and thermal conditions. Studies such as response to load, parametric studies, and form factor studies are also possible in BDS.

The cell design from BDS is imported into STAR-CCM+ BSM, where an equivalent 3D CAD model is automatically generated and discretized with finite volumes. This single cell can be used to create modules, which can then be added together with surrounding CAD geometry to build a 3D CAD model of the complete battery pack. Then, a closely-coupled solver computes the electrical/flow/thermal properties of the design. In addition, a 3D microscopic electrochemistry solver also exists for micro-scale analyses. This technology enables cell designers to optimize active material packing ratio, particle shape and size distribution, electrolyte properties, and other aspects, under charge and discharge conditions.

This technology will enable OEMs to deliver batteries for new EV designs in a reduced timeframe and lower cost, adding real value to the design of Li-ion batteries and their installations.

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ONLINE READER ENQUIRY NO. 525

High-tech BMS

A radically improved second-generation battery management system is helping the lithium-ion battery industry to satisfy the wide-ranging demands of its customers

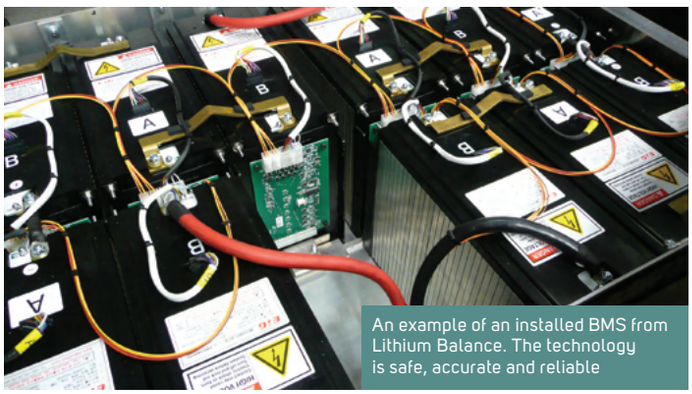
After a busy few years with close to 150 projects completed, the conclusion from a leading battery management supplier, Lithium Balance, is clear: all customers want the same thing, but with differences. This was true for commercial vehicle fleet projects, 12.5 ton truck conversions, boats, submarines, and even the odd manned helicopter.

All customers wanted something off-the-shelf that they could integrate into their system with a minimum of fuss and investment. Some were happy to do a proper integration project, while others just wanted to drop the BMS into the application.

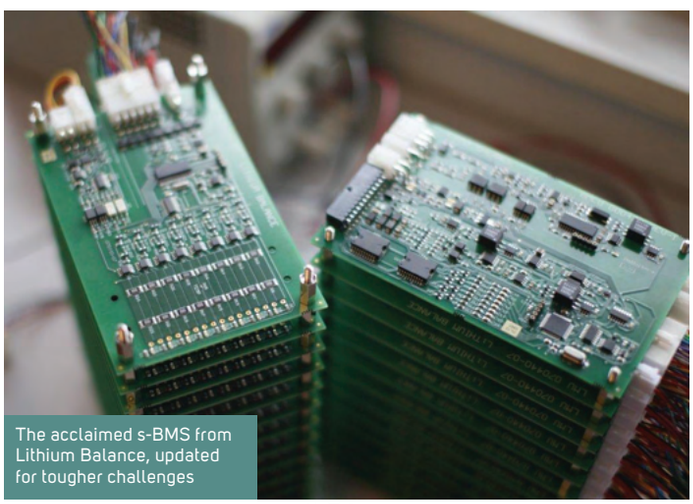
On the other hand, every customer had their own specific demands, whether it was to do with CAN interfacing, diagnostics, critical error responses or packaging.

Such a variety of needs means there's a difficult balancing act to be struck; the key to success was to develop a flexible BMS that had solid fundamentals – meaning the system needed to be safe, accurate, and reliable at all times, under all conditions, ensuring a safe response when something did go wrong.

Delivering the required flexibility was not too difficult as Denmark is a center of excellence for micro electronics and embedded systems. Lithium Balance was able to call upon the expertise of test instrumentation and cell phone developers, automotive engineers, and a range of related disciplines, to produce a flexible and expandable platform that allowed the easy incorporation of custom features.



An example of an installed BMS from Lithium Balance. The technology is safe, accurate and reliable



The acclaimed s-BMS from Lithium Balance, updated for tougher challenges

On the fundamentals side, as the operating environments grew tougher, Lithium Balance felt that change was needed to keep the company ahead of the demands of the customers. A 600V pack voltage seemed adequate, but now 700V applications are commonplace, driven by the ready availability of 450V AC drive systems and controllers. Furthermore, power storage clients are demanding 1MWh packs.

The response from Lithium Balance was to give the s-BMS a complete makeover, replacing the existing communications bus with an RS485 bus, optimized for low power consumption and superior EMI characteristics, moving the voltage limit up to 1,000V, thus ensuring all interfaces were galvanic isolated to at least twice that voltage. The onboard balancing current from 0.5A to 1A and reworked the PC interface to make it more responsive.

The acclaimed s-BMS from Lithium Balance is universal, safe, and affordable – and able to meet the demands of industry, regardless of the application.

The BMS has an easy-to-use software interface (1). Data on cell voltages are charted (2)

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ONLINE READER ENQUIRY NO. 526

Electric expertise

The need to meet goals relating to price, durability and performance has seen one niche OEM bring component development in-house

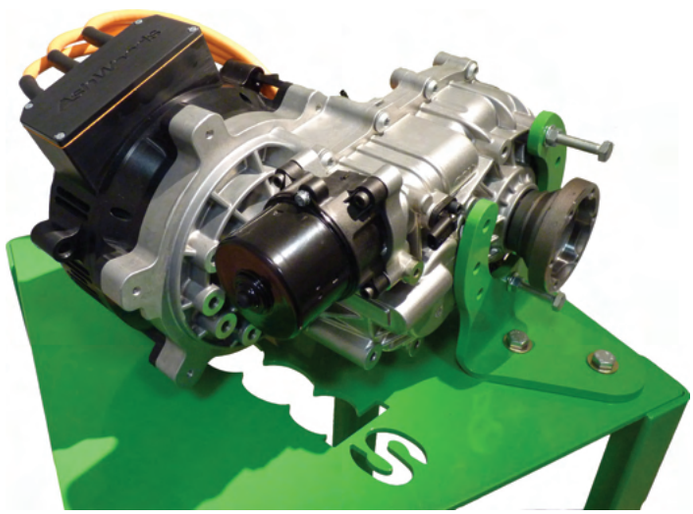
It's often said that necessity is the mother of invention – and for Ashwoods Automotive, innovation is also the cornerstone of the company's success.

The clean-tech SME, based in Exeter, has grown rapidly to become one of the UK's leading suppliers of hybrid light commercial vehicles (LCVs). And this year it has further expanded by launching its own range of component parts for electric and hybrid vehicles.

The company is a UK market leader in hybrid LCV technology, supplying hundreds of its upfitted Ford Transits to a range of public and private-sector fleets. However, while developing the second generation of its award-winning hybrid drivetrain, engineers at Ashwoods became increasingly frustrated with the quality, cost, and capabilities of key components. So the company's talented R&D and engineering teams began to develop their own technology.

"We believe that technology has to provide value for money," says Mark Roberts, Ashwoods' managing director. "This should be a balance between price, durability, and performance. We often found one or two of these key elements in a supplier's component, but very rarely all three. Ultimately we decided to do it ourselves, rather than compromise.

"After deploying these new technologies in our own hybrid vehicles, we can now leverage our unique experience to develop high-quality, cost-competitive parts for other manufacturers."



Ashwoods integrated battery module incorporates the supplier's BMS and inherently safe lithium ferrous phosphate power cells. The company's axial, radial flux and permanent magnet motors are a low cost, compact, efficient and powerful modular drive system that have been applied to the Ford Transit

Ashwoods has launched a range of modular-based axial-flux permanent-magnet motors. Their innovative design means one motor can be assembled within one hour, making them highly cost-effective to produce. In fact Ashwoods believes it now offers the UK's lowest cost-per-kilowatt axial-flux permanent-magnet motors suitable for automotive applications.

The company has also developed an integrated lithium battery module management system called Battery On Board (BOB), which provides a scalable plug-and-play power cell; along with a BMS that can support a growing range of cell chemistries.

In the design and development of these products, Ashwoods could draw on more than 2.5 million miles of real-world hybrid drive data from its own LCVs.

"We are only standing here today as an electric motor manufacturer because as a niche vehicle OEM we couldn't find any suitable motors available in the marketplace," adds Roberts. "Our vehicles operate in some of the most demanding fleets in the UK, which is the ideal environment to perfect robust and reliable technologies."

The new parts range is set to help Ashwoods double its turnover this year, after an exciting 2011. Last year the company set records by winning three coveted Institute of Technology & Engineering Awards. And it became the sole supplier into Phase 2 of the Department for Transport's Low Carbon Vehicle Procurement Programme, which will see Ashwoods deliver a further 500 hybrid LCVs into public-sector fleets across the mainland UK this year.

Roberts adds, "Innovation and development are at the core of our business. We feel there is a role for innovative SMEs like Ashwoods in producing quality, cost-effective hybrid and electric technologies that will ultimately help accelerate the adoption of low-carbon vehicles."

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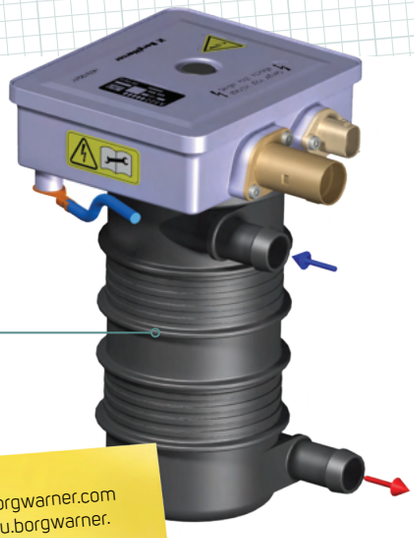
ONLINE READER ENQUIRY NO. 527

New high-voltage PTC heater for electric vehicles

The minimum waste heat on electric and hybrid vehicles provides the heaters with a key role in defrosting fogged and iced screens and heating the interior cabin. BorgWarner's latest positive temperature coefficient (PTC) cabin heater technology offers drivers a comfortable ride and supports the demands of next-generation technologies for further increasing vehicle electrification.

The newly-developed high-voltage PTC liquid heater for water-based heating features a small electrically heated water circuit. Controlled via an electronic bus interface, the PTC heater with a power of 5.5kW heats up the passenger compartment comfortably within a few seconds. Besides its compact design and light aluminum case, the new PTC liquid heater can be easily installed at different locations. The liquid heater is connected to the 400V onboard power network, making it suitable for various onboard voltages ranging 200V to 420V, while almost providing the full power output from 250V onwards. The electronically controlled system fulfills high safety standards with its insulated design, using galvanic isolation between high-voltage and low-voltage side, and is equipped with a hardware overcurrent protection. The technology is based on more than 10 years of Beru Systems' experience in series production, in reference to both heat production and control electronics. With this new high-voltage PTC liquid cabin heater technology, BorgWarner offers advanced solutions for the electrification of the drivetrain.



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ONLINE READER ENQUIRY NO. 528

Extending the ISOPLUS-DILTM range

IXYS has announced the extension of the ISOPLUS-DILTM package range using latest-generation TrenchMVTM Power MOSFET arranged as three identical, but electrically separated, half bridges in one package – therefore replacing standard six-pack configurations.

Improvements in the non-planar MOSFET technology, namely trench MOSFETs, resulted in attractive technical advantages to the TrenchMVTM Power MOSFET family. These include Lower RDS(on), lower gate charge, increased ruggedness, and faster switching speed, representing a major efficiency improvement.

The appeal of the new GMM 3x series is its excellent switching performance; it uses three identical and optimized halves bridges with minimized stray inductance, and dispenses with the internal coupling effects of the traditional six-pack. The Kelvin source contacts directly connected to the MOSFET die enable optimum control during the high-speed operation of the TrenchMVTM MOSFET family. The construction, which uses direct copper bonded ceramic isolation in concert with optimized molding technology, creates a best-in-class reliability, with extended power cycling capability and excellent thermal performance products.

IXYS provides the GMM 3x series in the voltage range of 40-150V. The devices can be surface-mounted with standard pick-and-place machines, and are suitable for re-flow automated soldering processes for low-cost production to customers worldwide. Further more, the GMM series offers the market lower weight, high power density, and electrical isolation, to a higher degree than other power modules.

IXYS
W: www.ixys.com

ONLINE READER ENQUIRY NO. 529

External sound simulation

A suite of software and hardware tools from Brüel & Kjær assists with the design and evaluation of external vehicle sounds.

These systems can work either together or individually to help sound engineers and designers at every stage of development, from initial design, through validation processes and sign-off, to final production solutions.

The exterior sound simulator is an interactive audio-visual simulator that is used to design and evaluate the sound experienced by the driver and pedestrians as the vehicle is driven around a user-defined scenario. It enables real-time modification of the sounds, and controlled evaluation of many different sound designs in a wide variety of scenarios.

Once a final set of sound designs has been selected for real-world testing, they are downloaded directly onto QVSound. This is a compact and powerful eight-channel sound generator that can be mounted in the prototype to produce user-definable sounds, using parameters from the vehicle's CANbus. This system can simultaneously produce different interior and exterior sounds, making it ideal for demonstrating, fine-tuning, and obtaining sign-off of sound designs.

An adaptive sound algorithm in QVSound enables the system to adjust the sound content and level according to the background noise environment around the vehicle. It can be used manually by the development engineer or allowed to run automatically, and can be tailored for use as a production system.

Brüel & Kjær
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ONLINE READER ENQUIRY NO. 530

Real-world testing

One of the biggest challenges for engineers developing new EVs is trying to replicate real-world realistic lifetime drive cycles. A helping hand, then, from independent test and development facility, Millbrook, which boasts a range of laboratories and tracks that can replicate any road topography and surface, and together with dedicated EV charging points and rapid chargers, enables engineers to accurately simulate real-world conditions in a secure and safe environment. What's more, Millbrook's expertise is not just limited to creating real-world EV conditions: for those involved in battery development, Millbrook offers the industry a full vehicle crash laboratory and HyGe sled.

Millbrook
W: www.millbrook.co.uk
ONLINE READER ENQUIRY NO. 531

Safe and reliable lithium battery

Sinopoly Battery engages in production, sales, and research and development of safe and reliable lithium-ion power batteries. With a product range of 10Ah to 1,000Ah, Sinopoly batteries are capable of meeting customers' power supply and energy storage needs.

It is commonly known that energy density is vital to achieve a reasonable driving range; and it is one of the most important factors in choosing batteries for HEVs and EVs. The high-energy-density Sinopoly batteries enable the vehicles to have longer run-time and more reliable performance. Another factor EV manufacturers are concerned with is safety. The batteries have passed various safety tests, such as fire endurance tests and high temperature tests. They have also received certifications including CE and UN38.3.

Sinopoly's lithium-ion battery cells and packs are applicable in various types of electric vehicles, such as pure electric cars, electric buses, and electric motorcycles. Sinopoly has jointly developed a 12m electric coach, which can travel 270km on a single charge, with FAW Bus and Coach Company. The bus started operating for the public in Jilin, PRC, on November 2011, after a satisfactory two-month trial run. The formulation of anode and cathode materials inside the battery delivers high power, excellent lifecycles, extreme temperature tolerance, and a short recharging time.

With applications in many different fields, the battery cells and packs are sold to different customers all over the whole world. Sinopoly Battery continues to be the safe, reliable way to maximize the performance of EVs.

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ONLINE READER ENQUIRY NO. 532

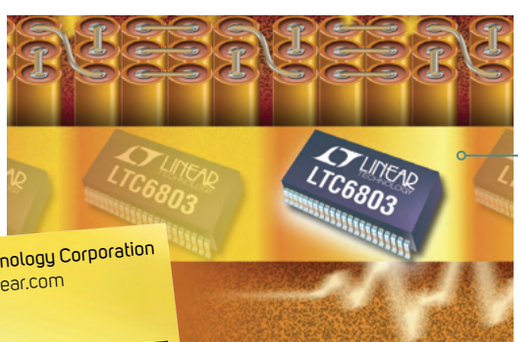
Fundamentals in battery management

Operating large lithium-ion battery packs safely and reliably, with the energy, power, and environmental requirements of an automobile, is no simple task. The electronics of the electric and hybrid-electric vehicle must bridge the gap between a demanding automotive environment and sensitive battery technologies. To meet the 15-year, 5,000 charge-cycle goal of a battery pack, each battery cell in a long, high-voltage battery string must be constrained to a specific SOC range.

Battery monitoring devices, such as Linear Technology's LTC6803, provide the precision cell voltage measurement levels that are required for this task. To understand the challenge, consider that a typical automotive battery pack may have several hundred cells with charge and discharge currents exceeding 200A, and voltage transients exceeding 100V.

An LTC6803 can monitor up to 12 cells, and an entire battery stack can be monitored with many LTC6803 devices connected in series. Further more, a daisy-chainable serial interface allows these LTC6803s to communicate to a host processor without isolation.

This interface was designed to operate with >20V of AC noise and 30V of fast switching spikes, and packet error detection is included in all commands and data. As a second-generation technology device, the robust features of the LTC6803 are enabling high performance battery technology on the road today.



Linear Technology Corporation
W: www.linear.com
ONLINE READER ENQUIRY NO. 533

Innovative technologies for the electric drive of tomorrow

The era of electric vehicles is not too far away – that's something that most experts agree upon. The latest technologies to increase the efficiency and output of the electric motor are under the spotlight, and this is an area that Kienle + Spiess is focusing on.

Kienle + Spiess is one of the biggest independent stamping works in Europe, and the company has developed a production process to manufacture laminated cores, which it claims is the first innovation in this sector for 25 years. Compared with most other production methods for stator and rotor cores, this new gluing/stacking process – called glulock – has proven to be precise but less expensive, and with appropriate production tolerances.

The glulock stack is a laminated core, available in almost any size, with nearly optimal contours, and a positive influence on the geometrical properties of the cores. The omission of interlocking elements reduces, for example, eddy-current losses when compared with cores stacked the conventional way. As a result, it is possible to produce laminated cores with high electrical efficiency and positive influence, particularly in high frequency ranges.

Another innovation from Kienle + Spiess that could become interesting for the industry is its copper die-casting to produce copper rotors. Although the production technology of such components is more expensive and the weight is higher than that of conventional aluminum rotors, the excellent efficiency levels open up new possibilities for drives of EVs.

Kienle + Spiess
W: www.kienle-spiess.com

ONLINE READER ENQUIRY NO. 534

New opportunities for innovative vehicle concepts

Lenze Schmidhauser has been developing and producing energy-efficient and environmentally friendly solutions in the field of electromobility for 25 years.

All of this knowledge and experience has now been incorporated into the new, compact product platform of high-performance double inverters (DCU), DC/DC converters (PSU), as well as the potential combinations of these units. The scalability on offer allows a large power range to be covered. The products in the new platform are available in various versions and, thanks to their reliable and rugged design, are ideally suited to flexible deployments in commercial vehicles. Not only do they make safe handling extremely easy, they also fulfill the strictest efficiency requirements in every respect and guarantee consistently high quality for a long service life.

Lenze Schmidhauser
W: www.Lenze.com

ONLINE READER ENQUIRY NO. 535

Simple but effective charging

Emobility will not happen without an adequate charging infrastructure that offers users the possibility of a ubiquitous charging. EV users will charge mainly at home and at the office, but there is also a significant percentage that will make use of 'opportunist' charging and fast charging. Ingeteam's vision for the charging infrastructure is that all these scenarios will be integrated into one control center, which will take care of users' administration, billing and reservations, as well as cover the demand response.

With this aim in mind, Ingeteam has launched a specific product line for Emobility infrastructure – called IngeREV. The IngeREV Garage offers a simple solution to charging EVs in a domestic or private environment in modes one, two, and three, where simplicity is most demanded. However, upon demand, it can incorporate advanced new features such as RFID authentication, connector retention system, local and remote communication (via OCPP protocol), and demand response.

The IngeREV City has been specifically designed and developed to operate in a public environment, so it offers vandal-resistant and weatherproof properties (IK10 & IP55), yet offers an appealing design. It is equipped with a cable-retention and locking system for modes one, two, and three, and a battery to provide one hour of autonomy in blackout situations.

The IngeREV Road is Ingeteam's product line for fast DC charging according mode four of norm IEC 61851. It is compatible with CHAdeMO standard and it can supply up to 125A or 500V to a maximum output of 50kW.

Ingeteam Power Technology
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ONLINE READER ENQUIRY NO. 536

Supplying batteries for the first Hiriko prototype electric vehicles

Axeon has supplied lithium-ion batteries for Spanish organization Hiriko, and its prototype electric vehicles, which feature a unique folding design.

The urban electric two-seaters, which will be built in Vitoria-Gasteiz, have an innovative folding design that allows them to park in a very limited space, with a single access door at the front of the vehicle and an advanced steer-by-wire system, which removes all mechanical steering components.

The solution to the challenge of fitting a powertrain within a folding design has been achieved with two Axeon lithium-ion batteries mounted in parallel – one in each half of the car – to allow four-wheel steering and four-wheel drive through the in-wheel motors.

The capacity of each battery pack, made up of five modules of lithium nickel cobalt manganese pouch cells, is 7.5kWh and they weigh in at 88kg. The batteries, each with their own BMS and service disconnect for safety, are connected in parallel through an Axeon high-voltage interface to allow for system redundancy.

The batteries supplied to the Hiriko vehicles demonstrate the flexibility of Axeon's solutions, which have been used in a diverse range of vehicles, including light CVs, e-bikes, and the electric Rolls-Royce Phantom prototype.

The production model for Hiriko will involve franchised local and sustainable manufacturing in different markets. Hiriko's electric vehicles will be targeted at large cities, where they will be available for rental from 2013.

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ONLINE READER ENQUIRY NO. 537

European Electric Vehicle Congress

After the success of its first show, where more than 300 delegates from 31 countries and 120 presentations were made, the European Electric Vehicle Congress strengthens its position as a global platform to foster an exchange of views between researchers, industry, authorities, end users, and NGO's representatives in the field of eMobility.

As motivations and constraints are different for each of the groups mentioned above, EEVC-2012, which will be held in Brussels from November 19-22, 2012, will aim to help define and select the most promising solutions, taking into account the research and development progresses, as well as the environmental and economical constraints.

Once again, the venue is Brussels, which helps to ensure optimal connection with the representatives of the European institutions that are considering battery, hybrid, and fuel cell electric vehicles to play an important role in lowering atmospheric pollution and reducing oil dependency. New mobility concepts, noise, and health factors will also be discussed.

EEVC-2012 will be held in the middle of the next EU Commission's call for projects on clean transportation and, therefore, can be used as a platform to start consortia and project proposals.

Electri-City.mobi
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ONLINE READER ENQUIRY NO. 538

Multichannel protection sleeve

IPROTEX produces a wide range of technical textiles that are used in the automotive industry, as well as railed vehicles, aerospace, and military engineering. IPROTEX is a specialist in textile component protection and has developed its own product line for electric and hybrid vehicles.

Wireway is a textile cable conduit that allows a contactless installation of parallel lying wires and harnesses. It offers excellent mechanical protection properties, resistance against chemical and physical conditions in the automotive environment, and low weight. The numbers of channels and the individual diameters can be produced to customers' specifications.

According to regulation ECE/TRANS/WP.29/GRSP/2009/16, the outer covering of high-voltage-cables can be identified by its orange color, and each individual channel of Wireway can be marked in a different color.

IPROTEX
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ONLINE READER ENQUIRY NO. 539

Wiring harness assembly

Wire harness routing challenges and smaller packaging spaces are common in high-voltage systems. Mass is added and packaging space is consumed by the energy-storage system and auxiliary devices. Further more, vehicle size is not growing; every gram counts in the power-to-weight ratio.

The TE Connectivity AMP+ high voltage, low-to-medium current header and connector family is designed with this in mind. With more than 3,000 HVA 280 combinations, TE offers safe, reliable solutions that enable flexibility in system design.

In addition to this, options are not limited by the device header – the same interface is used for 2-4mm2 individually shielded wires and multicore wire. Reduced size and mass is achieved through a combination of optimized packaging, an integrated HVIL, and floating two-stage latch.

TE Connectivity
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ONLINE READER ENQUIRY NO. 540

Positioned for the Future

Candiac LFP Production Unit

Süd-Chemie is stepping forward in the battery materials business! The new 2500-ton production unit for our high quality Life Power® P2 Lithium Iron Phosphate (LFP) material is the largest of its kind in the world. Lithium Iron Phosphate is the ideal material for large format rechargeable batteries due to its inherent safety, high power capabilities and long operating lifetime.

Contact us at www.Clariant.com

Süd-Chemie is a member of the Clariant Group of Muttenz, Switzerland.
Life Power® is a registered trademark of Süd-Chemie AG

SÜD-CHEMIE
CREATING PERFORMANCE TECHNOLOGY

Clariant
Süd-Chemie AG
a Clariant Group Company

State-of-the-art battery materials manufacturing plant

Süd-Chemie celebrated the opening of its new battery materials manufacturing plant in Candiac, Canada, earlier this year, marking an important step in its commitment to developing alternative energy technologies. The new plant, operated by subsidiary Phostech Lithium, produces carbon-coated lithium iron phosphate (C-LiFePO4), a high-performance cathode material for rechargeable batteries.

"This new plant is a cornerstone for the continuing growth of our capabilities in energy storage systems," says Christian Knobloch, sales and marketing manager for the battery business of Süd-Chemie. He continues: "It represents a critical step in ensuring more effective use of clean renewable energies for hybrid and electric vehicles and stationary applications."

The facility produces Life Power P2 C-LiFePO4, a safe, high-power cathode material for rechargeable lithium-ion batteries used in hybrid and electric vehicles; stationary energy storage systems, in combination with renewable energy generation; and consumer applications, such as power tools. To meet the sharply increasing worldwide demand for Life Power P2, Süd-Chemie – which acquired Phostech Lithium in 2008 – invested more than US$75 million in the Candiac facility, boosting overall global capacity by 2,500 metric tons per year. The development project also received financial support from the Canadian and Quebec governments.

It is the inherent safety of lithium-iron-phosphate in particular that makes it one of the dominant cathode materials for electromobility, so cell producers can meet all safety requirements defined by the automobile industry. Life Power P2 eliminates the risk of fire or explosion from thermal runaway and does not contain hazardous materials such as cobalt, which is harmful to both the environment and human health.

Life Power P2 is also superior to conventional cathode materials in terms of cycle life. Other specific benefits of the material are high performance at low temperature levels, very high discharge power, and fast recharge.

Süd-Chemie
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ONLINE READER ENQUIRY NO. 541

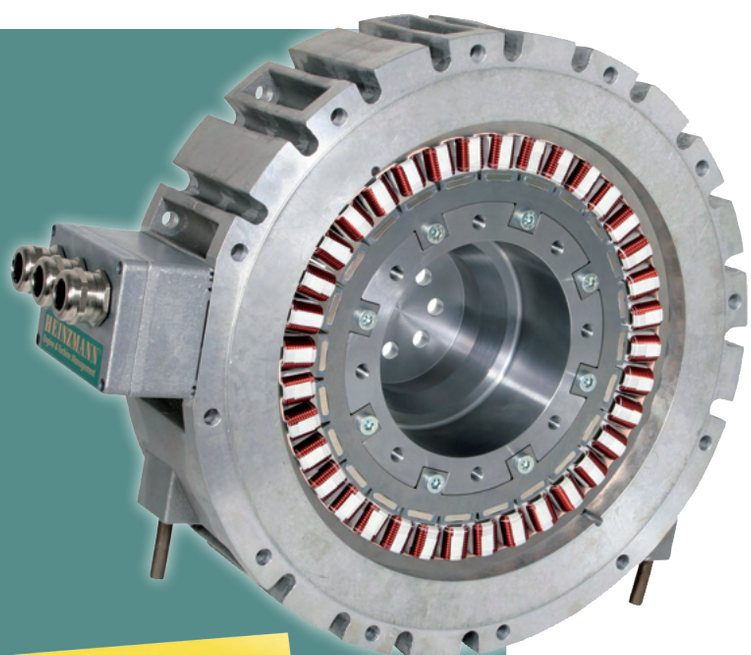
Next-generation hybrid drive

Heinzmann has unveiled a further developed hybrid drive concept with concentrated single tooth winding. This third-generation system is ideally suited for low-speed and high-torque applications, optimized copper losses, and optimized use of active material, and features a robust design that's suited for heavy-duty applications.

Heinzmann develops and manufactures innovative components and systems for modern hybrid drives for industrial and construction vehicles driven by diesel, gas, and petrol engines. With these products, the following systems can be achieved: parallel hybrid, serial hybrid, range extender, and integrated variable speed generators.

Designed for use in the rough environments surrounding construction machinery, Heinzmann's hybrid technology represents the high-end of compact electric drives. The company offers hybrid drives for a broad range of electric motors for traction, and also to operate auxiliary units. This range of electric drives permits the partial (hybrid) and full electrification of mobile machinery.

A substantial reduction in emissions (gaseous and noise) and fuel consumption is realized by using this technology, while both dynamics and productivity are also increased.



Heinzmann
W: www.heinzmann.com

ONLINE READER ENQUIRY NO. 542

The best gateway to your success in the Asia's automotive industry

Held inside AUTOMOTIVE WORLD 2013

EV JAPAN 4th EV & HEV Drive System Technology Expo

EV JAPAN

Concurrent Shows inside AUTOMOTIVE WORLD 2013:

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CAR-ELE JAPAN

3rd Automotive **Weight Reduction Expo**

Dates: Jan. 16 [Wed] – **18** [Fri], **2013**

Venue: Tokyo Big Sight, Japan

Organised by: Reed Exhibitions Japan Ltd.

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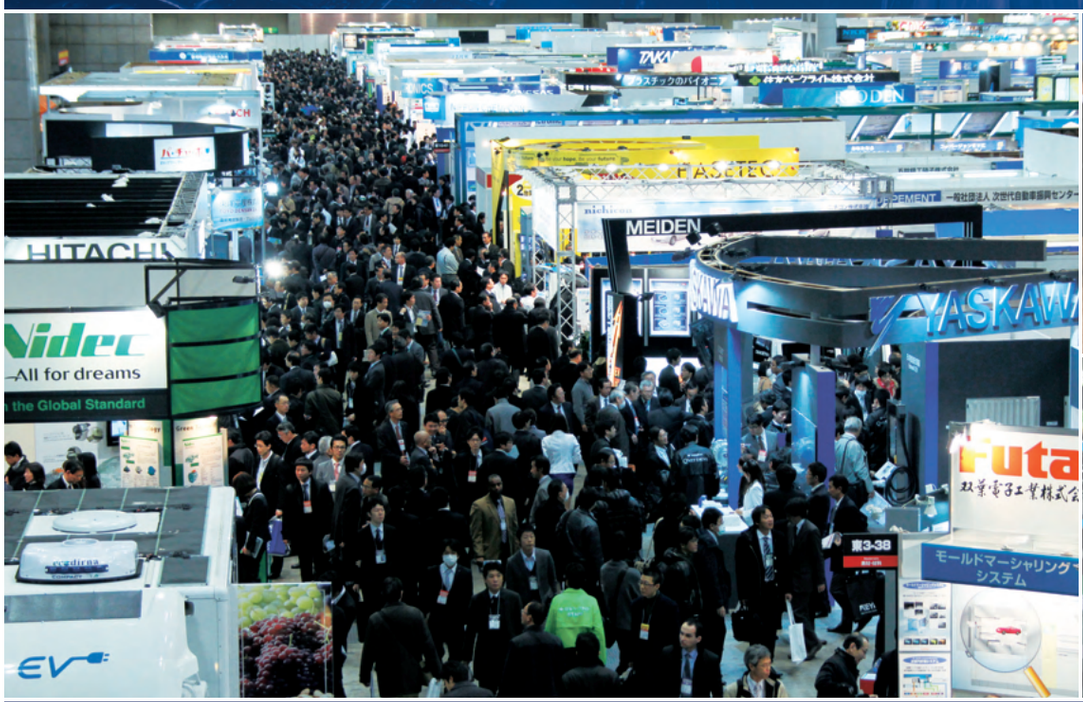

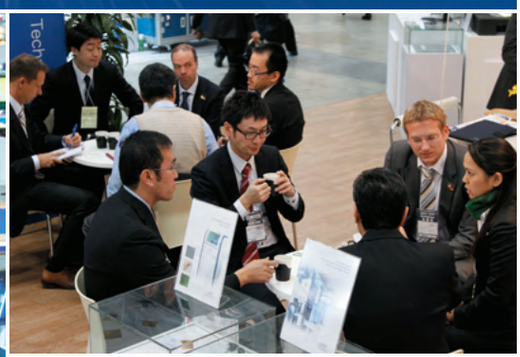

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Passing the charging tests

Tests at the University of Tennessee at Chattanooga have proven that the concept of opportunity charging will significantly increase the range of electric buses. Tests under the lead of Prof. J. Ronald Bailey, director of the Center for Energy, Transportation and the Environment, have shown that using opportunity charging while passengers are boarding can increase the range from less than 80km (50 miles) to more than 193km (120) miles without any other changes on the bus. Overall efficiency was found to be more than 90%. Electromagnetic field strengths inside and around the bus have been found to be well below the international standards for exposure. The test results were presented recently at the EVS26 in Los Angeles by Bailey.

Another surprising fact is that the tests were performed with technology originally designed by Conductix-Wampfler in 2001 and 2002, and with components originally delivered to the USA in 2004. After the original project in the USA was cancelled for reasons not related to technology, the charging equipment was stored for an extended period on an outdoor loading dock without protection other than the original wooden shipping cradles. The robustness of the design and technology was clearly demonstrated when the system was unpacked and started without any problems due to the long delay or exposure to the weather.

After more than 10 years of experience in practical operations of wireless charging of e-buses, such as in Genoa and Turin, Italy, Conductix-Wampfler has recently launched the second generation products with improved performance, integration possibilities, and remote diagnosis and control interfaces.

Conductix-Wampfler
W: www.wampfler.com

ONLINE READER ENQUIRY NO. 543

Essential EV and HEV show in Japan

EV Japan – the fourth EV and HEV Drive System Technology Expo – will take place from January 16-18, 2013, in Tokyo, and will be held inside Automotive World 2013, an annual event featuring three crucial fields for automotive technologies – EV and HEV, automotive electronics, and weight reduction. EV Japan showcases a variety of crucial technologies for EV and HEV applications such as motors, inverters, and secondary batteries. The 2013 show is expected to be attended by more exhibitors and visitors than ever before, and EV Japan is now one of the most important business platforms for EV and HEV technologies, with market leaders from around the world gathering.

Fully supported by top industry executives from major OEM and Tier 1 companies such as Toyota, VW, GM, Nissan, Ford, Honda, Mitsubishi, Daimler, Mazda, Audi, Tesla, Robert Bosch, Denso, Hitachi Automotive Systems, and Dana Holdings, EV Japan attracts a vast number of professionals from all the key automotive manufacturers and parts suppliers, including the companies mentioned above.

In order to promote EV and HEV technology in Asia, it is essential for a company to participate in EV Japan, as it a vital gateway to success in the Asian automotive industry.

EV Japan
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ONLINE READER ENQUIRY NO. 544

Ultracapacitor developments

The US military currently spends an estimated US$400 per gallon on diesel fuel because of the costs associated with remote locations, supply chain, and security issues. In an effort to reduce dependence on fuel, decrease weight, and increase reliability, department of defense OEMs are evaluating ultracapacitor technology to supplement and replace batteries in various military vehicles and applications.

Because ultracapacitors charge and discharge much more quickly than batteries, weigh much less, and require no maintenance, several branches of the US military are evaluating them for hybridization of special weapons, heavy-duty trucks, and mobile-weapons platforms. One major defense contractor has already designed in and deployed Maxwell Technologies' ultracapacitors in hybrid diesel-electric transport trucks to provide peak-power assist and reliable cold cranking to increase fuel efficiency and decrease maintenance.

The US military isn't the only sector evaluating and integrating ultracapacitor technology. Maxwell Technologies recently introduced a 12V, ultracapacitor-based engine start module (ESM) that ensures reliable engine starting for commercial trucks and heavy vehicles. The product is sold as an easy-to-install retrofit that replaces one battery in the truck's battery array to avoid starting problems in cold weather, or when batteries are drained by repetitive starting or climate control and other driver comfort functions.

Freightliner, International, Kenworth, Mack Trucks, Peterbilt, Volvo, and Western Star Trucks are all evaluating the ESM as a design-in option and currently offering product retrofits through their service outlets. Both US and European auto manufacturers are also further evaluating and integrating Maxwell's TS 16949-qualified automotive ultracapacitor cells.

Maxwell Technologies
W: www.maxwell.com

ONLINE READER ENQUIRY NO. 545

Improved performance compact 35kW drivetrains

Zytek's 25kW/64N powertrain has been integrated into a number of high-profile European passenger vehicle and light-duty commercial vehicle applications. Learning from these highly successful applications, and responding to customer demand, an increased performance powertrain has been designed within the same package space with little or no increase in system weight.

The uprated, permanent magnet synchronous motor achieves 35kW of mechanical power and 75Nm of torque while maintaining the 13kg weight. The increased performance has been achieved within the same package envelope, maintaining the original compact design, which is simple to install in a wide variety of vehicle applications.

The accompanying compact transmission with integral differential weighs just 11kg, but the overall reduction ratio of 14:1 enables the powertrain to generate 1,050Nm of axle torque. The current transmission ratio can also be modified to suit customer-specific requirements.

In the knowledge that this market sector is extremely cost sensitive, the powertrain is driven by a high volume, low-cost power inverter, manufactured by Zytek's joint venture partner Continental AG. The water-cooled power inverter weighs just 7.5kg with an integrated 12V/DC-DC converter system.

In summary, the increased performance powertrain, comprising the three key components to effect a vehicle conversion to pure electric drive, can now be obtained from the same supplier, reducing integration and overall calibration costs.

The total powertrain weight of 30kg is class-leading in performance, packaging, weight, and, most importantly, cost. The increased performance levels will make this exciting development the choice of many urban electric vehicles.

Zytek Automotive
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ONLINE READER ENQUIRY NO. 546

Innovative eDifferential technology generates new opportunities for drives and driving dynamics

With four-wheel drive, a total of 286bhp, and the innovative option of wheel-selective electronic control of the drive torque, Schaeffler's ACTIVeDRIVE was one of the all-electric (so-called battery-electric) vehicles that came face to face with the public and the competition at the first Bodensee-Elektrik Rallye. This concept vehicle was also one of the most powerful vehicles among the teams made up of notable participants.

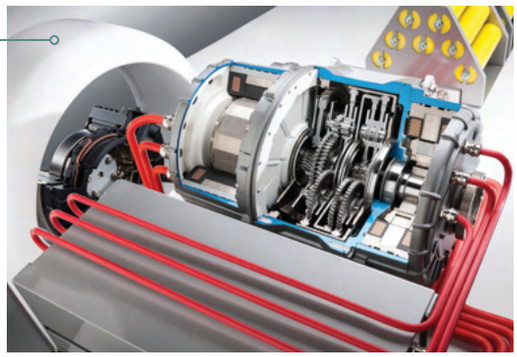
"The ACTIVeDRIVE is a test system, demonstrator for various technologies, and a laboratory on wheels," explains Peter Gutzmer, CTO at Schaeffler, who drove the ACTIVeDRIVE with project manager Christian Weyhersmüller on all five stages and 400km of the first rally for electric vehicles around Lake Constance on the Rhine.

The special feature of the Schaeffler ACTIVeDRIVE is the active electric differential mounted both on the front and rear axles (Schaeffler eDifferential). This component combines an electric drive with the option of controlling the drive power in each wheel individually. This facilitates torque vectoring (distribution of torque between the right and left wheels), which is beneficial for driving dynamics, safety, and comfort.

"The eDifferential permits intervention in driving dynamics through selective power supply instead of through braking intervention, and thus power reduction, as is the case with ESP. The active electric differential improves the transmission of force when driving on surfaces with varying frictional values. It also supports the steering system and has a positive effect on the driving dynamics, safety, and driving comfort. In addition, using two eDifferentials enables the longitudinal distribution of drive torques," says Gutzmer.

Actively distributing the drive torque makes the eDifferential an ideal platform for innovative driving dynamics control. The solution demonstrated in the ACTIVeDRIVE makes Schaeffler a pioneer of such electric concepts in one vehicle drive.

The eDifferential integrates two water-cooled permanent magnet synchronous motors (PMSM) of different dimensions, a planetary gear, a transmission for active torque distribution and, as a key element, a Schaeffler lightweight differential. The electric drives are manufactured by Schaeffler brand IDAM. The larger up to 105kW and 170Nm PMSM provides the drive. The second PMSM, which regulates the distribution of torque, must only supply 5kW of power in order to generate a difference in torque on the axle of up to 2,000Nm. The other innovations incorporated in the ACTIVeDRIVE are an integrated electromechanical parking lock, a new force-feed lubrication system without an oil pump for the transmission, planet carriers of sheet metal, and various high-speed bearing solutions with optimized friction characteristics. The electronic control system is manufactured by AFT and is also therefore a Schaeffler product.



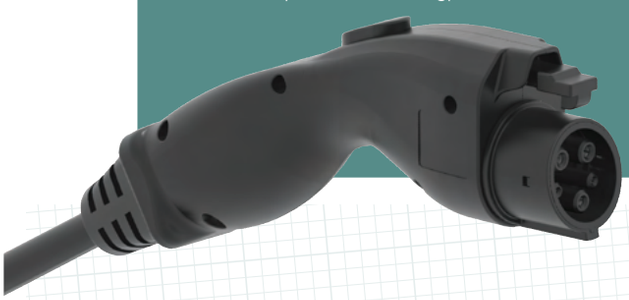
Schaeffler
W: www.schaeffler.com
ONLINE READER ENQUIRY NO. 547

Solutions for the mobility of tomorrow

For more than 50 years, Bals Elektrotechnik has been a partner for secure connections and now it is offering an extensive range of system components and solutions well-suited to electromobility, including both Type 1 and Type 2 systems. This enables the company to provide plugs and sockets according to IEC 62196-2 for both European e-vehicle models, as well as those from further afield. The company also supplies system components to numerous manufacturers of charging stations, energy supply companies, public utilities, and facility management companies.

With Bals connectors, a special design of the component housing ensures that water cannot penetrate the terminal compartment of the Type 1 plugs and sockets, while all Type 2 charging systems are also equipped with silver-plated contacts to ensure good conductivity and resistance to corrosion. Bals also simplifies the previously difficult plugging-in and unplugging of the plug with the exclusive contact technology called Easy Contact: with this, the plugs are able to handle even frequent use.

Bals also offers an EVCP2 controller, which, among other things, controls communication between the vehicle and the charging station. The component, measuring only 3 TE, has considerably more functions than a comparable standard module, including allowing currents to be freely set from 6A to 80A, meaning that just one component is needed for the various currents.



Bals Elektrotechnik
W: www.bals.com
ONLINE READER ENQUIRY NO. 548

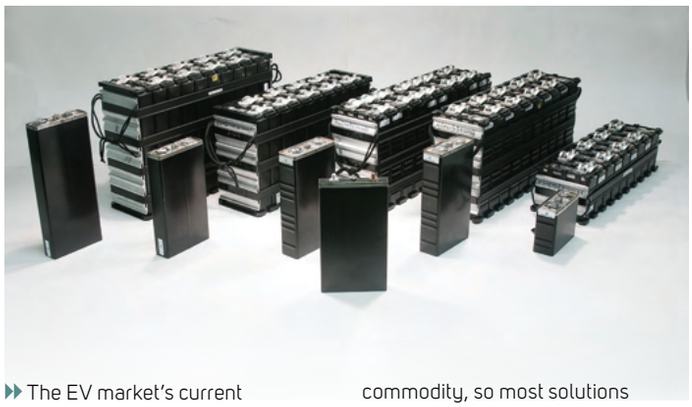
Low loss core materials for peak efficiency in EV/HEV designs

The design of onboard chargers, battery chargers, and infrastructure needed to propel the electric vehicle market, is at an all-time high. Engineers require low loss magnetic materials to deliver maximum power transfer. Stability across wide temperature and frequency ranges will improve performance. All Magnetics' powder cores offer high saturation and no thermal aging, with stability across a wide temperature range. Coated toroids offer a 1,250V minimum wire-to-wire guaranteed voltage breakdown point. Kool Mμ material offers low core loss without nickel content, a cost-effective solution for many designs. MPP material is a premium 80% Ni material offering the lowest possible core loss and maximum efficiency for designs requiring peak energy transfer. High flux and XFlux materials offer high (>1.5 Tesla) saturation for high DC current designs.

Magnetics has tooled-up several block sizes, up to 80 x 30mm, to accommodate larger-scale designs. XFlux and Kool Mμ blocks allow the magnetic designer to create a custom inductor, optimizing the size and effective permeability required. The advantage of a custom-built inductive structure is the ability to achieve the target inductance and performance in designs, where space is a key constraint. An easy-to-use spreadsheet is available to calculate the Ae, le, and Al of the block structure to determine which perm and size block is best for the high-current application.

Magnetics
W: www.mag-inc.com
ONLINE READER ENQUIRY NO. 549

Overcoming EV instability



The EV market's current instability is a reminder of how volatile the industry is. The current troubles among the leaders highlight the importance of having a strong automotive or battery background supported by a stable non-EV revenue stream to overcome the current and future associated financial difficulties in order to work towards sustainability.

However, sustainability in the near future is not possible as the most critical component – the battery system – is not a commodity, so most solutions are unique and non interoperable. Moreover, the development cycle is a long and drawn-out process, which will require vast amounts of investment from non-EV sources to prevent either the battery supplier or EV manufacturer from bankruptcy. Even after reaching production, there is no guarantee, currently, that the EV and battery manufacturer will be sustained financially solely on EV projects. A financial lifeline or an alternative profitable and non-EV product line is a must for survival.

Furthermore, if the discussions about battery leasing become a reality, EV manufacturers will need a battery partner with more than a few years of manufacturing experience and with other revenue streams to avoid the potential risk of the manufacturer collapsing at the first sign of trouble.

EVB Technology, a wholly owned subsidiary of GP Batteries, possesses both the EV battery manufacturing experience (18+ years) and the financial backing from mature product streams, to overcome these obstacles in the EV industry.

EVB Technology
W: www.evbtech.com

ONLINE READER ENQUIRY NO. 550

High-performance lithium-ion battery systems

German company Akasol is one of the leading developers and manufacturers of mobile and stationary high-performance battery systems. Fields of applications for the company's technology include the CV and automobile industry, wind energy, hydropower and solar industries.

Akasol was founded in 2008 by the Schulz Group and leading members of Akasol eV. The history of this university association dates back to 1989 and started with the development of solar race cars, winning several world championships in this field. Akasol is therefore one of the pioneers for high-performance batteries.

The lithium-ion storage solution developed by Akasol is called Akasystem and can be freely scaled, is certified for use in the automotive industry, is standardized, and – something which can't be taken for granted these days on the market – is also available for delivery. The battery system features a combination of high energy and high-performance density, with a compact design, and a flexible, modular setup.

In one application, Akasystem is equipped with a total of 45 Akamodules and 105kWh storage capacity, which supplies a hybrid electric drivetrain for a 40 ton garbage truck. Under the hood there are three 15m (50ft) Akasystems that are standardized for commercial vehicles, each with 35.25kWh storage capacity at a nominal voltage of 600V, peak performance of up to 270kW, and weighing in at 290kg.

For the planned limited edition of the fully electric super-sportscar LAMP03, Akasol has configured a liquid-cooled 42kWh 18M Akasystem with performance up to 420kW, and total weight of less than 350kg. Furthermore, rail and tram applications will soon be equipped with high performance Akasystem configurations, as the company has announced various cooperations in this field.

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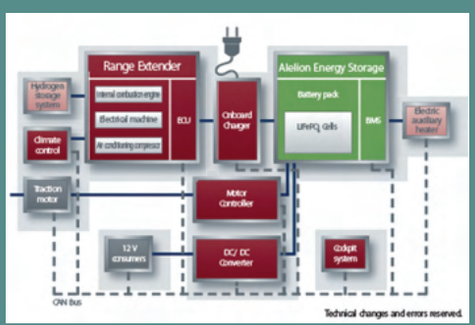
ONLINE READER ENQUIRY NO. 551

Energy storage for electrical drivelines



Alelion Batteries AB has unveiled its energy storage system for hybrid and battery electrical applications. The concept is to offer all required parts, through partner Paragon AG, for a complete driveline for PHEV, HEV, and EV applications for materials handling and off-highway segments.

The energy storage systems utilize the established and flexible energy storage modules from Alelion Batteries as building blocks that make it possible for OEMs and end users to have access to proven, durable, robust, and high performing energy storage, with a high level of configuration possibilities. This gives customers unique flexibility for intelligent, modern, climate friendly, and cost-efficient energy storage, with a short time to market.

Modularity of the energy storage is offered within the energy storage packages and also externally on a system level. This modularity gives energy storage solutions from 12V to 500V, starting from 200Wh up to 18kWh, but with the possibility for external modularity this capacity range can also be extended.

Besides the modularity of the energy storage system, other highlights are the Alelion Batteries-designed CAN-based battery monitoring system, which has all its features incorporated for safe, automatic, and intelligent operation of energy storage.

Alelion Batteries AB
W: www.alelion.com

ONLINE READER ENQUIRY NO. 552

New release of Motor-CAD

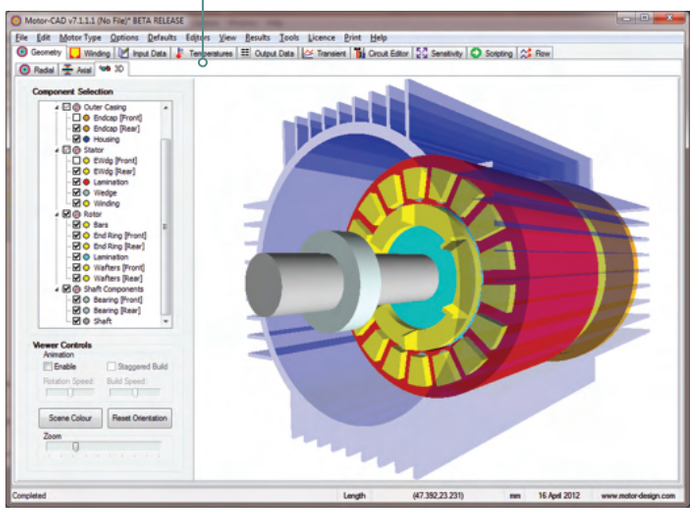
Motor Design supplies a comprehensive set of electric motor simulation software for electromagnetic and cooling system design.

Motor-CAD is one of the most sophisticated and easy-to-use software simulation programs for thermal analysis of electric motors. It is used by many of the leading automotive manufacturers and suppliers to optimize the cooling systems for electric motors used in hybrid and electric traction. Typically, Motor-CAD is used to predict the motor thermal performance with different duty cycles, so optimizing the cooling system for the expected load cycles.

Dr David Staton, director at Motor Design, says, "Motor-CAD v7.1 has just been released and has some exciting new features to make cooling system optimization even easier to carry out and produce more accurate results. It also has new visualization features to aid understanding of the cooling system performance."

One of the new visualization features is a 3D geometry viewer, which really makes it easy to visualize the cooling system. Another major new feature that improves accuracy in calculating the heat transfer through the conductors in a slot is the fully integrated thermal finite element analysis module. It only takes a few seconds to construct the mesh and calculate.

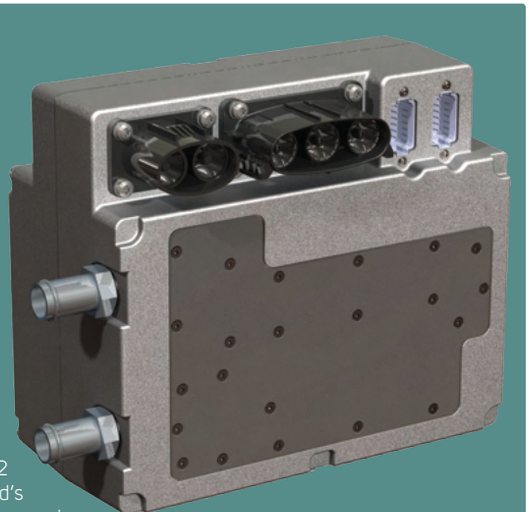
Staton concludes, "Not only does Motor Design provide software to motor designers, but we also provide extensive consultancy and training services, and our customers get expert motor design advice and full support."



Motor Design
T: +44 1691 623 305
E: info@motor-design.com
W: www.motor-design.com
ONLINE READER ENQUIRY NO. 553

Traction inverters

Arens produces a line of automotive hardened traction inverters with power ranges from 30kW to 500kW for applications ranging from hybrid passenger cars to medium-duty trucks and large transit buses. The Arens POWERPAC 100kW traction inverter features one of the industry's highest power density in a compact enclosure. It is ideal for truck, bus, agricultural, and various construction equipment applications.



Arens has been building heavy-duty traction inverters for 12 years, supplying many of the world's largest truck and bus manufacturers, and the company has the experience and skill to develop the right traction inverter for any hybrid automotive program. In addition, Arens manufactures a complementary line of high-voltage junction boxes, DC/DC, and DC/AC converters, to simplify the customer's hybrid vehicle design program.

Arens
W: www.arens.com
ONLINE READER ENQUIRY NO. 554

Electric motors experience

The Remy Electric Motors story started more than 100 years ago in automotive rotating electrics. In 2012, Remy is a global leader in the starter, alternator, and hybrid/electric motor segment. Remy's launch of its first automotive hybrid/electric motor began in North America 20 years ago. Today, volumes have grown to more than 100,000 electric motors traveling the roads of five continents around the world.

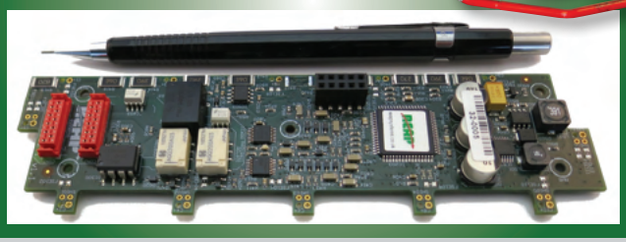
Remy's hybrid/electric motors can be found in almost any application, from space-sensitive motorcycles, to large metropolitan hybrid buses. Remy Electric Motors are under the hood of medium- and heavy-duty trucks, utility trucks, SUVs, passenger cars, electric vehicle conversions, and agricultural and construction equipment. Remy Electric Motors' portfolio includes custom motors and off-the-shelf products featuring patented HVH technology. The HVH product line offers unrivaled durability and value, plus excellent power and torque densities. Remy is proud to consistently deliver powerful, high-performance, compact, durable electric motor solutions.

Remy Electric Motors
W: www.remyinc.com
ONLINE READER ENQUIRY NO. 555

REAP systems

Renewable Energy and Advanced Propulsion

REAPsystems designs and manufactures Battery Management Systems (BMS) for large, high voltage lithium ion batteries which are used in electric vehicles and other markets.



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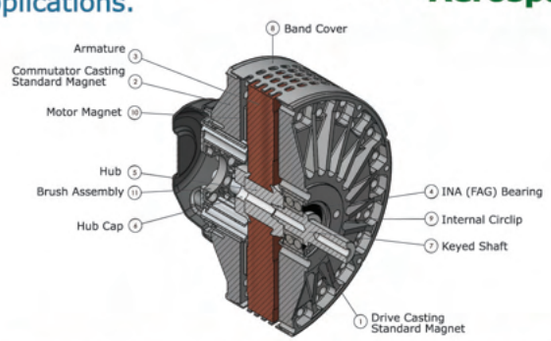

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New rotor-position sensor based on eddy-current technology

Rotor position is a key input parameter for the control of permanent magnet synchronous motors. To deliver this information and meet the constraints of electric and hybrid vehicles, Electricfil Automotive has developed a new rotor-position sensor based on eddy-current technology.

The EMPOS sensor is designed with planar primary and secondary windings integrated on the PCB in a water-and oil-tight package. An aluminum or steel trigger wheel is fixed on the rotor. The ratio of the two secondary voltages of the sensor then determines the target position.

The sensor is thin (<10mm) and lightweight (<100g without cable harness), containing no ferromagnetic parts that could disturb sensor operation. It is insensitive to pollution, EMI, vibrations, and positioning errors. The shape of the sensor wheel has been kept simple so that the wheel can be manufactured using standard fine blanking or punching processes.

Electricfil Automotive uses magnetic optimization software to customize product dimensions and winding patterns, providing +/-1° accuracy (electrical), in line with EV and HEV requirements, for all customer environments and speeds up to 20,000rpm.

An application-specific integrated circuit (ASIC) generates the excitation signal and handles the entire signal-treatment chain, including analog and digital processing. The ASIC also provides diagnostic functions to avoid false position information in case of any single failure.

The ASIC is integrated on the sensor PCB, ensuring short signal paths for high-frequency analog signals. The position signal and a diagnostic signal are transmitted to the motor controller via either a SIN/COS signal (modulated or not) or via an SSI-based digital serial interface, ensuring no loss of accuracy due to analog/digital conversion, noise, and EMI.

Standard prototypes are available for testing from Electricfil Automotive on request, with mass production scheduled to begin in early 2014.

Electricfil Automotive
W: www.electricfil.com

ONLINE READER ENQUIRY NO. 556

VisualCN updates

For more than 20 years, Bitrode's VisualCN has been the industry choice as a reliable, efficient data acquisition and user-interface to meet today's rapid fire-testing demands. The VisualCN's central components – modular architecture, a suite that optimizes each component for its unique purpose, independence from third-party codes, and vendor software that eliminates compatibility issues while enhancing speed, reliability, and data analysis – are well known.

More recently, however, Bitrode engineers have merged the tabular and graphical viewers that optimize program editing, test monitoring, formation processing, and data analysis, to achieve an even simpler, more complete – and thus efficient – interface. "We don't even have to consider interfering with the application or the server of the program editor – only the individual components," says Mike Kuznetsov, chief design project leader.

For Hal Hollingsworth, electrical engineer for Exide Technologies in Atlanta, the VisualCN has been a windfall for the Exide's engineering departments across the USA. "It's been instrumental in refining our test platform making it more efficient," he says, "providing a welcome departure from the redundancy of their prior DOS-based software."

Bitrode Corporation
W: www.bitrode.com

ONLINE READER ENQUIRY NO. 557

Fully integrated test solutions

Angelantoni Test Technologies (ATT), mainly composed of French company BIA, Italian organization ACS, and German company TIRA, has conceived and delivered extremely advanced and fully integrated solutions to safely carry out tests on electric vehicle batteries in all their forms – cells, modules, and batteries, as well as power electronics and ECUs. Tests on batteries can generate potentially dangerous situations, since they are carried out by simulating the limit conditions that may occur when there is a transfer of energy from the battery to the electric motor or during the battery's fast recharge phase. To avoid potential overheating or formation of dangerous atmospheres, ACS chambers are equipped with smoke sensors, dangerous gas sensors, a stabilization system, a flame extinguishing system, and an electrically isolated test enclosure. Tests can be conducted under climatic conditions, with vibrations, and can even simulate complete charge/discharge cycles.

As today's EVs are equipped with high-speed motors, BIA has introduced a new range of dynamometers to meet these new requirements. Up until now, no company except ATT has been able to provide such compact dynamometers with high performance: available torque up to 400Nm; available speed up to 20,000rpm; and available power up to 240kW. The hybrid hydraulic bearings technology in BIA's dynamometers has made it possible to combine high torque at medium speed, and constant power at high speed levels.

Angelantoni Test Technologies
W: www.angelantoni.it

ONLINE READER ENQUIRY NO. 558

Battery development and more

REAPsystems specializes in electronics for lithium-ion battery systems. One of the company's recent challenges was to develop a number of new products that are suitable for a wide range of applications, including electric performance motorbikes.

This application exhibits a number of technical challenges, such as space constraints, production cost targets, battery size variants, high power levels, maintaining safety, and long battery life.

The following technical elements are part of the REAPsystems solution: integrated isolation test and pre-charge; small and intelligent cell monitoring circuits integrated into the custom battery modules; a high degree of calibration, maximizing system performance and consistency, while keeping full control over all battery cells in order to provide long battery life; optional control of parallel battery strings; and additional system level controls in the REAPsystems battery control unit to maximize motor torque while preventing motor overheating.

In addition to successfully developing these products, REAPsystems managed a consortium of collaboration partners through to a finished prototype of the urban electric sports motorbike within very short timescales.

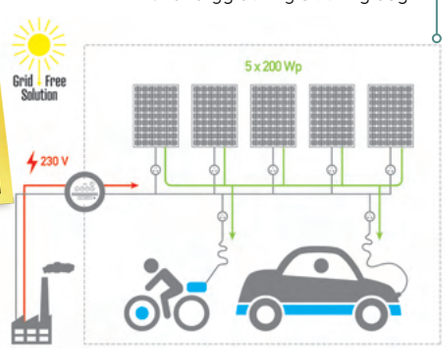
REAPsystems
W: www.reapsystems.co.uk
ONLINE READER ENQUIRY NO. 559

Harvesting power from the sun

Installing a grid-tied photovoltaic power plant is a demanding job. Making an off-grid system with a battery bank for energy storage is an even more complex project. The GridFree solution by GWL/Power allows harvesting of the energy from the sun directly without any costly installations. The GridFree solar panels are equipped with a micro-inverter technology that works simultaneously with the AC power grid. Just plugging the solar panel into the household 230V AC socket extension cord will turn the solar panel into a direct solar power generator.

GridFree products are a simple solution to reducing the power consumption for energy-hungry devices. Take the EV as an example: as long as the sun is shining, the charging power is taken from the solar panels. The more that is taken from the panels, the less that needs to be taken from the AC grid. When the sun moves behind the clouds, additional power starts to be taken from the AC grid. The shifting between the GridFree and the AC grid is smooth and transparent. Simply putting five or six 200Wp panels together will generate up to 1kW of energy during a sunny day.

GWL/Power
W: www.ev-power.eu
ONLINE READER ENQUIRY NO. 560



High-tech springs for EVs and HEVs

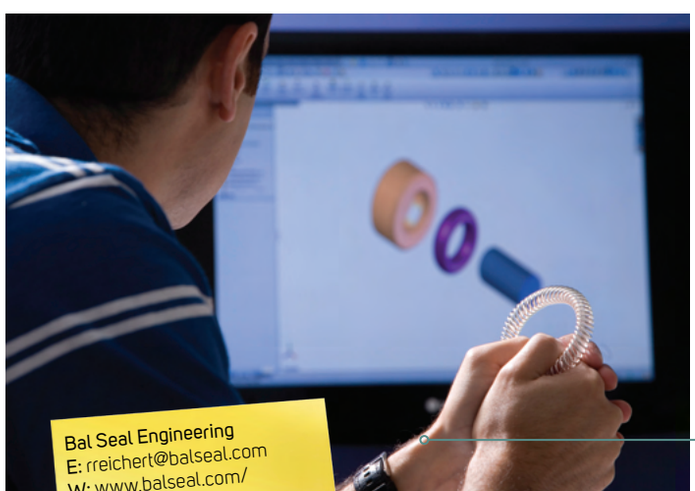
A proven performer in medical, aerospace, and other industries for decades, the spring continues to gain popularity as a versatile component for automotive equipment due to its unique ability to perform both mechanical and electrical functions. When engineered properly, it can latch a panel or plate while providing the electrical conductivity necessary to shield internal electronics against EMI. Paired with the right groove configuration, the spring can also simultaneously lock, while ensuring the consistent transmission of signals or current to motors and relays.

Bal Seal Engineering, a US-based manufacturer of the Bal Seal Canted-Coil Spring, and a supplier to the automotive industry for more than 50 years, says the key to the component's growing favor with equipment designers is its simplicity. By engineering the pitch and orientation (axial versus radial) of the individual coils and considering wire diameter, material, plating, and other factors, the company says it can build a great deal of control and functionality into a small package.

"We can precisely determine insertion and breakaway forces, conductivity, and other important properties," says Roland Reichert, Bal Seal automotive market manager. "This gives design engineers the ability to take one simple-looking component, which is actually highly engineered, and address a multitude of challenges with it."

According to Reichert, Bal Seal's springs have already found their way into many of today's hybrid vehicles, where they make and maintain critical connections to and from the lithium-ion battery pack, and other powered systems. The springs' individual coils provide multipoint contact, so they ensure consistent transmission of electricity and electrical signals to the motor during low-speed operation, as well as reliable recharging of the batteries from regenerative braking.

In external vehicle charging systems, adds Reichert, springs are being employed to conduct electric power and signals from wall or base units to battery packs. Capable of handling high current flow in tight spaces with minimal heat rise, the springs automatically compensate for misalignment and surface irregularities that may otherwise compromise charging efficiency.



Bal Seal Engineering
E: rreichert@balseal.com
W: www.balseal.com/automotive
ONLINE READER ENQUIRY NO. 561

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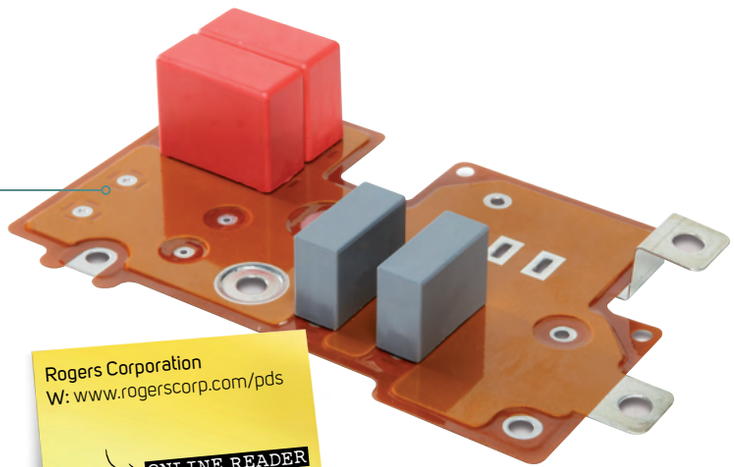
Power distribution solutions

The electrification of the powertrain in a car is rapidly increasing. Many OEMs plan to launch a whole range of hybrid or EV applications in the very near future. The trend for more electrified propulsion results in the need for more power. Higher current and higher voltage applications are required to drive all new electric functionalities within strict mechanical boundaries. Long-term reliability in harsh conditions and vibration resistance are essential.

Many applications in a HEV/EV require power distribution solutions for their power electronics. A laminated busbar construction typically fits the motor drive and the converter applications when high current capabilities, compactness and 3D design are required.

In energy storage applications, laminated busbars are used to interconnect the battery cells to provide compactness, rigidity and ease of installation. RO-LINX PowerCircuit busbar is a newly developed product in the RO-LINX family to meet the needs for the HEV market applications.

Rogers Power Distribution Systems division is in a leading position to deliver solutions for power distribution for the new and next-generation of HEV/EV products. Rogers has been developing and manufacturing laminated busbars for more than 40 years and can leverage its knowledge in electric propulsion drive technology for trains and off-road vehicles into HEV applications. Rogers has a worldwide presence with engineering capabilities in the three major regions. The company's manufacturing is ISO/TS 16949 certified for automotive projects.



Rogers Corporation
W: www.rogerscorp.com/pds

ONLINE READER ENQUIRY NO. 562

Wiring harness protection

Delfingen, a global leader in electrical wiring protection systems, fluid transfer, and assembly technologies, has developed a wide range of products to answer the new technical challenges of hybrid and electric vehicles.

A range of fiberglass sleeves has been developed for electrical and thermal insulation, coated with silicone resin for higher dielectric strength to provide safety and reliability. Delfingen also offers the industry a range of expandable braided and self-closing knitted sleeves for mechanical protection and easy installation.

Specially designed for electromagnetic insulation, the Nu-Guard EMI-HV sleeve is made from braided copper and PET monofilament to efficiently shield the electromagnetic radiations generated by currents between batteries, converter, and motor.

The Delfingen convoluted tubes protect from abrasion and other mechanical aggressions: tubes with oval shape for flatter bundles for cable management, dual channel tube for routing, and tapeless closeable tube for ease of assembly.

All Delfingen products (convoluted tubes, smooth tubes, textile sleeves, and specific parts) meet the requirements for hybrid and electric vehicles, and are available in an orange color for high-voltage identification.

Specific parts are custom-made and have been developed to fulfill customers' protection and fastening needs on the wiring harness.

The company's products are designed by Delfingen's advanced engineering teams and are tested to extreme conditions to ensure safety and reliability in the vehicle.

Delfingen
W: www.delfingen.com

ONLINE READER ENQUIRY NO. 563

Advanced performance and high-efficiency batteries

The new Hawker XFC batteries with 2V cells from EnerSys provide materials-handling equipment manufacturers and operators with greater flexibility to specify plug-and-play power sources that can be charged for as long and as often as required to support total operational autonomy. The battery systems combine advanced performance and high efficiency with low overall cost of ownership, and are suitable for a range of applications, including counterbalance, reach and pallet trucks, order pickers, and AGVs. Minimum gassing ensures they can be used in retail areas, public spaces, and sensitive manufacturing locations.

XFC batteries can be used when in a partial state of charge and they deliver superior and stable performance even at high discharge rates. Their thin plate, pure lead technology supports high energy density and allows rapid recharge in less than four hours from 60% depth of discharge, and opportunity charging as often as needed without damaging the battery system.

The batteries can be specified for power-on-demand applications where charging can be carried out whenever the operator requires, whatever time is available. Charging batteries in situ whenever the truck is not being used reduces the need for charge and change facilities, resulting in lower costs and smaller space requirements. The batteries are totally maintenance-free and no topping up with water is necessary.

EnerSys
W: www.enersys-hawker.com
W: www.enersys.com

ONLINE READER ENQUIRY NO. 564

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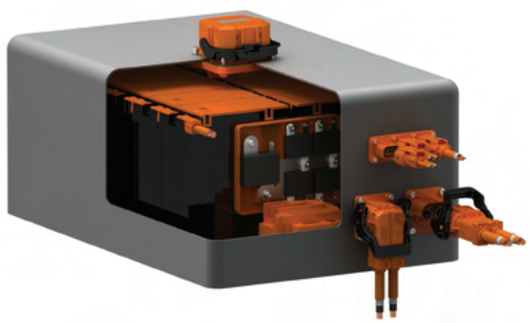

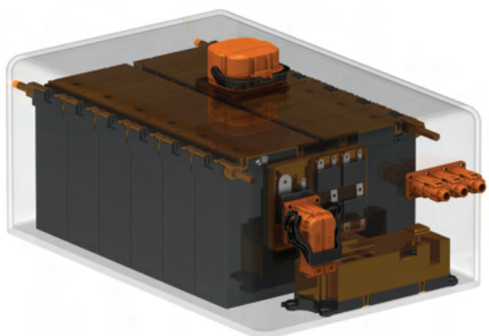

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Hybrid analyzer developments

Rozone has introduced the Midtronics HYB-1000 hybrid analyzer for safe, one-person testing and maintenance of the electrical system and battery without exposure to dangerous high voltages.

It significantly increases the service-offering capability for leading hybrid models.

The HYB-1000 allows the independent workshop to quickly and accurately test the performance of the hybrid battery. This is done via a wireless connection to the car's OBD socket and a brief half-mile test drive. The analyzer's on-screen instructions inform the user when to start the test drive, which consists of a period of braking and accelerating. The screen then displays how much information is being gathered. From here the technician can clearly see if any faults have been detected and view specific values that the battery encountered during the test drive.

This data can then be used to assess the battery pack state of health in terms of conductance; quickly determine whether the battery pack is getting weak; read and reset diagnostic trouble codes; and perform simple functions quickly without having to monopolize other complete diagnostic systems.

Midtronics
W: www.midtronics.com
ONLINE READER ENQUIRY NO. 565

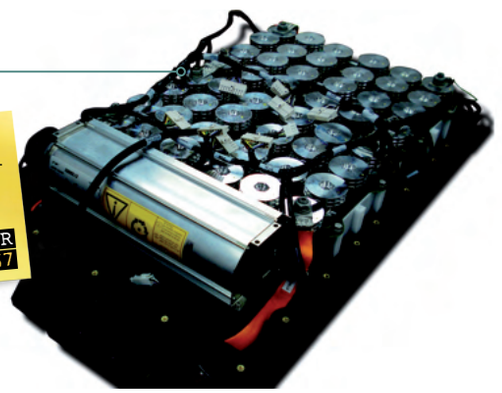
Delivering world-class engineering

Formed in 2004, Hybrid Design Services (HDS) is a privately held and funded corporation in Michigan, specializing in the commercialization of hybrid vehicle and electric vehicle technologies. Operating from an advanced facility in Troy, HDS offers complete development assistance from system specifications and failure mode analysis, to simulation and software development, as well as component design, manufacturing and testing support, including worldwide sourcing.

The HDS team has extensive automotive, heavy-truck, and alternative energy industry knowledge and experience in designing and developing electric and hybrid vehicles systems. HDS can lead advanced product development efforts or supplement engineering teams, providing flexible, cost-effective support for the entire product lifecycle. From advanced lithium batteries, ultra-capacitors, inverters, and motors to fuel cells, HDS allows customers to select or invent the right technology solutions to fit their needs.

With flexible manufacturing and prototyping facilities, HDS can provide full-vehicle build and integration, subsystem design and prototyping, system testing, and low-volume production. HDS is currently using ISO 9001 – 2008 practices in both engineering design and manufacturing.

Hybrid Design Services
W: www.hybriddesignservices.com
ONLINE READER ENQUIRY NO. 567



Complete vehicle integration solution

New Eagle has the hardware, software, and experience to address most aspects of electric vehicle control. For many years, New Eagle has been providing EV manufacturers with the tools and assistance required to bring systems to production.

New Eagle is able to supply the EV industry with high volume, automotive production qualified products from suppliers including Continental Automotive, Delphi, Kongsberg, Vee Three, Visteon, and Woodward. Through these market exclusive suppliers, controllers and components related to vehicle supervisor, LCD displays, DC-DC converters, high voltage power distribution, J1772 charging interface, and CAN networking are available to clients of all volumes.

In addition, New Eagle supplies model based control software tools including MotoHawk. Various aspects of production vehicle control and communications are available through this software including CAN network design and interface, driver interface sensors, system monitoring sensors, and final actuator commands. Available integration with ABS, ESP, and OEM instrument systems provide the end user with a fully integrated, seamless vehicle. For technical support or training, engineering services can be contracted for either short-term or long-term periods depending on the needs or scope of the program.

New Eagle can serve as a training and consulting resource, or as an embedded controls partner with full model based software tool-chain access from requirements generation, development, through vehicle validation and production support.

New Eagle
T: +1 877 2341410
E: sales@neweagle.net
W: www.neweagle.net
ONLINE READER ENQUIRY NO. 566

Delivering intelligent CAN gateways to Valence powered vehicles

Sensor-Technik UK delivers integration solutions and services to Valence Technology, the advanced energy storage provider. Sensor-Technik is supplying battery to vehicle gateway functionality for electric vehicles using the electronic control units of STW Germany. The ESX-Micro, ESX-LT, and ESX-3XM collate data from the battery CAN network. Once the ESX has collected the data from the battery integrated UBMS, it is converted into the CAN format required by the other vehicle systems, including the drivetrain and operator interface.

The application firmware is designed to handle additional system control functions such as multi-string redundancy or fast charge control. By making use of the multiple CAN ports (two on the ESX-Micro and LT, and four on the ESX-3XM), the controllers have been employed on multiple applications, ranging from electric trucks and buses, through to UPSs and taxis.

STW has a long history of involvement in electric and hybrid vehicle applications, and is a leading supplier of vehicle control units, battery management systems, fuel cell control electronics, teleservice hardware, and drive motors and inverters up to 140kW.

Based on more than 25 years' experience with industrial vehicles, the freely programmable STW control units and I/O modules are ideal for tough environments and extreme temperatures (-40°C to +85°C). All modules include protection against short circuits and have inbuilt diagnostics for all inputs and outputs. They offer flexible digital and analog inputs and outputs, RPM inputs, and PWM power outputs with current regulation. Robust cast aluminum housings (optionally IP67/IP69K) offer a high level of protection against electromagnetic disturbances, as well as mechanical protection. STW control units satisfy the standards of passenger and agricultural vehicles and machines.

Sensor-Technik UK
T: +44 (0) 1234 270770
W: www.sensor-technik.co.uk

ONLINE READER ENQUIRY NO. 568

Mobility conference

'The business of going EV' is the central theme of EV 2012 VÉ, Electric Mobility Canada's fourth annual conference and trade show, which takes place in Montreal's Palais des Congrès from October 23-26, 2012. Sub-themes at the conference will include business opportunities, implementation strategies, public outreach, and asking 'Where do we stand?'. The event is hosted by Hydro-Québec, one of North America's leading utility organizations in terms of supporting electric vehicles. More than 500 delegates are expected from across Canada and elsewhere, representing industry, fleet managers, government agencies, and researchers. Special emphasis on attendance by fleet managers and automobile dealers has been specifically added to this year's event.

The conference and trade show committees are busy turning this year's theme into practical business sessions and other opportunities of unparalleled value in Canada for manufacturers and retailers of vehicles with all forms of electric traction for on- and off-road applications. As a country, Canada has a wide range of companies developing and marketing a variety of EV technologies, and these will be part of the trade show on October 25.

Electric Mobility Canada is a national, membership-based, not-for-profit organization dedicated to the promotion of electric mobility as a solution to the economic and environmental issues in Canada's transportation sector.

Electric Mobility Canada
W: www.emc-mec.ca

ONLINE READER ENQUIRY NO. 569

Technical recruitment services

Consilium Group (UK) provides an innovative recruitment service to HEV and EV organizations and professionals, both in the UK and internationally. Launched in 2001, Consilium Group has close to 10 years of dedicated HEV and EV experience, and as a result, the company is now established as a leader on a global scale. Consilium Group's enviable database and network of vacancies and candidates provide an innovative ability to match the technical roles with industry specialists.

The company was built by degree-qualified engineers with real-world industry experience. So whether the client is looking to fill a new role or find a new job, Consilium Group recruiters can talk technically, whatever the discipline.

Consilium's services cover the full range of technologies, from OEM to electric motors, and from batteries to power electronics. This is all supported, with a long and successful record of building complete teams of engineers for major international clients, through to one-off placements at small design consultancies.

Put simply, if an organization is looking to recruit, or a person is looking for a new career, then Consilium Group is the company to contact.

Consilium Group
E: sdoyle@cgl.eu.com
W: www.cgl.eu.com

ONLINE READER ENQUIRY NO. 570

Ingerev...

bringing charging times down from 5 hours to just 20 minutes

At Ingeteam, we apply the concept **i+c** to every project that we undertake - innovation to find the best solution and commitment to provide the best service.

Ingeteam is developing a new technology that will make it possible to reduce charging times by more than 90%. For a range of 80 kms, it will take just 20 minutes to charge a vehicle compared to the 5 hours required with the slow charge systems.

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3,7 - 22 kWAC / 1 or 3 fases
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LAST **WORD**

The transportation revolution has begun and many agree that autonomous vehicles will be around within the next decade or two. Pictured here is GM's Electric Networked-Vehicle concept

Dr Gregory Offer is a research fellow at Imperial College London. Based within the Engineering Department of Earth Science and Engineering, Offer's pioneering research focuses on fuel cell, battery and supercapacitor technologies

I was invited to the launch event of an autonomous vehicle, built by Induct in partnership with Oxis Energy, a company that's developing lithium-sulfur batteries with very high energy density. The vehicle that was being showcased was not suitable for road use, but it was interesting nevertheless, and it got me thinking.

Just what are we working toward? As an industry, we are faced with massive challenges – or opportunities, depending on how you look at it. Which energy vector should we use for our future transportation systems? Electricity, hydrogen, biofuels, or something else? How will we drastically improve efficiency to maintain growth over the next few decades as conventional energy supplies dwindle and become more expensive? And, how will we reduce emissions, both local and global, in order to minimize the consequences of runaway climate change?

The thing is, this is all reactive, not proactive, and as a society we shouldn't just react, we should look ahead and plan. We should decide what a better future should be, and then work toward it. So what could that better future be, for road transport in particular?

"Most importantly, the driver can be released to do other activities while the vehicle is moving"

Previous technological revolutions have all had one thing in common: they have either reduced or removed a link between the time and effort of a human being and a particular type of economic activity that gives the revolution its name, such as agricultural or industrial. Have we had a transport revolution yet? No. Throughout the history of transport there has been an unbreakable link between the driver and the vehicle, and only recently have we begun to develop the technology that means we don't require one man-hour for every vehicle hour.

So, the revolution has begun; various driver aids have already started removing elements of control from the driver, and as such, we are on the path toward autonomous vehicles. Technologies such as platooning take it even further and begin linking vehicles into semi-autonomous road trains. The benefits are many; speed changes can be minimized and slipstreaming to reduce air resistance becomes safer, both of which reduces fuel consumption considerably. Road use can also be increased as more vehicles can use the same stretch of road, because they can be closer together, reducing congestion. But most importantly, the driver can be released to do other activities while the vehicle is moving.

Then, all of a sudden, it will become possible to do a full day's work while traveling in a mobile office. The disruptive nature of the revolution will put some out of jobs, but it will also generate new openings elsewhere. Car clubs with autonomous vehicles might become the norm, requiring regular servicing, cleaning and managing, and owning a car outright might be a luxury only the rich indulge in.

The unintended consequence of this is likely to be an increase in demand for transport services, offsetting improvements in efficiency and increasing demand for energy. That will not be a bad thing, but it does make sorting out the other challenges – such as bettering efficiency and the electrification of vehicles – even more necessary. For the industry, it is a vision to aim for as we sow the seeds for one of the next great revolutions that will free drivers from the chains of the steering wheel and enable them to enjoy unprecedented levels of mobility.

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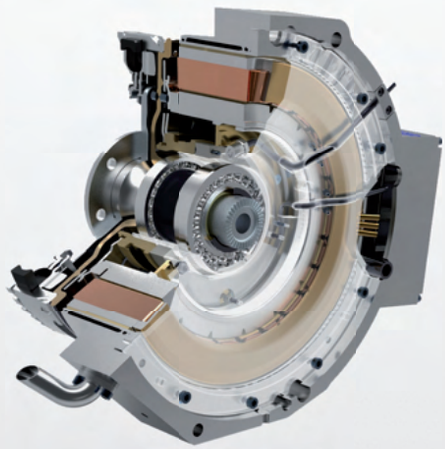

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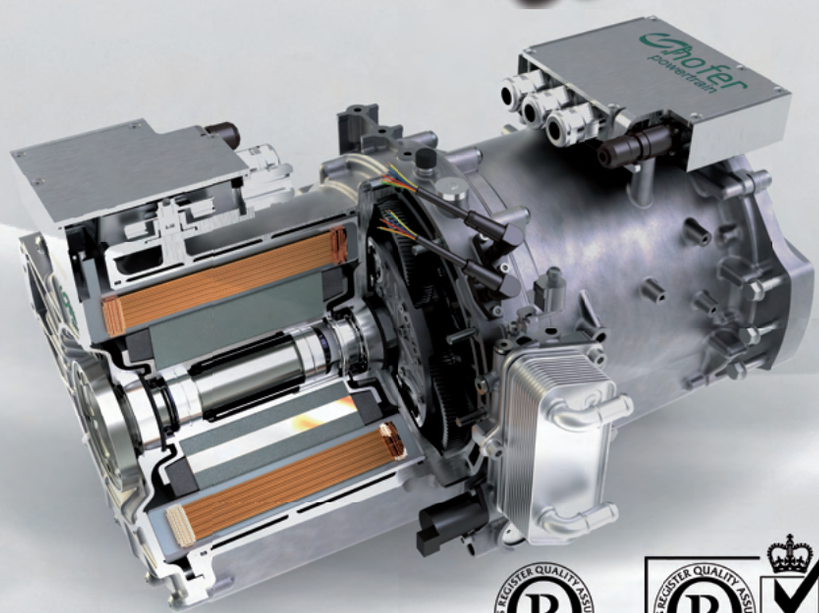

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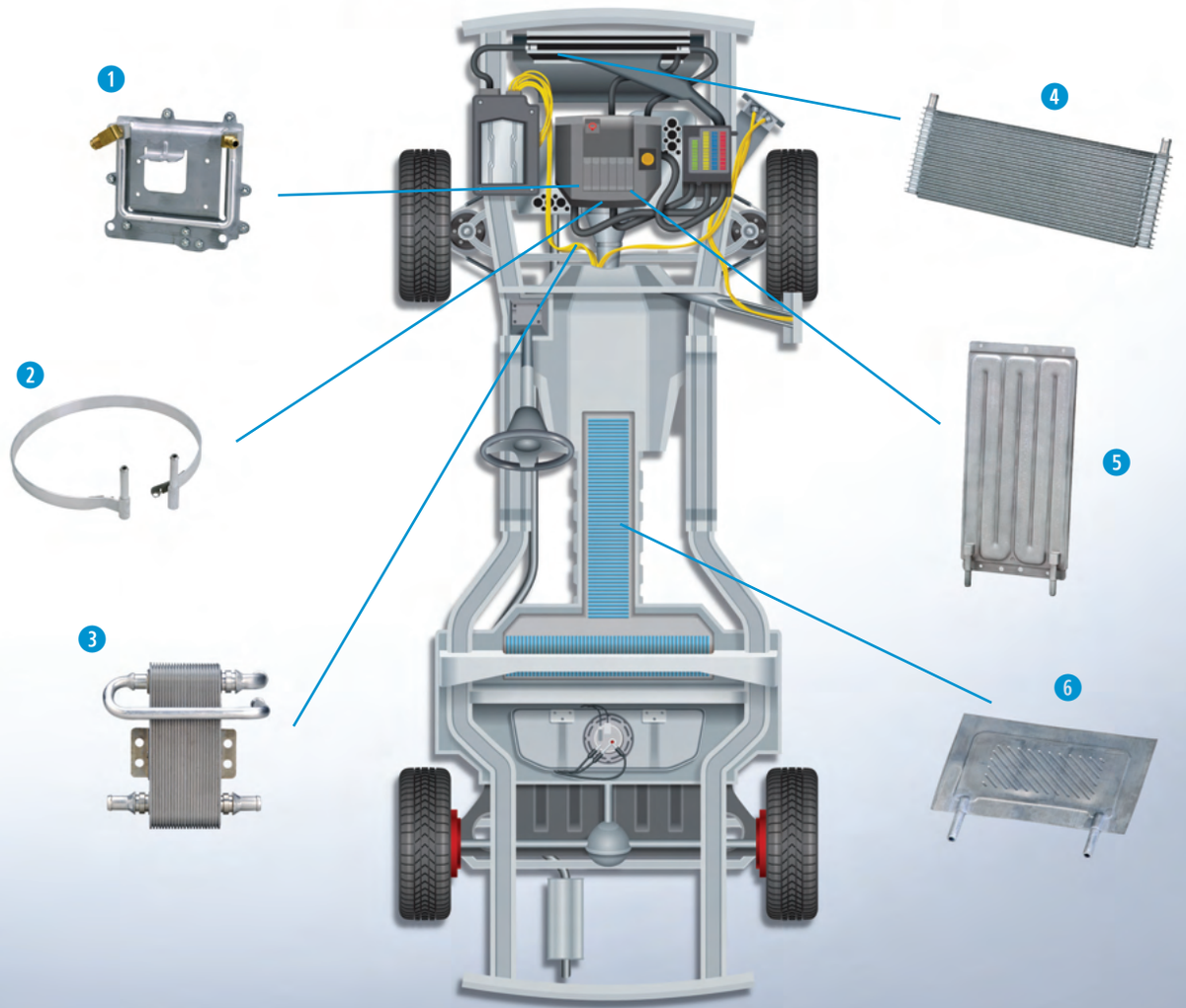

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