electric & hybrid vehicle technology international

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Has BMW lost its mind?

The IC king goes electric powertrain mad

Revealed: the inside story behind the Bavarian car maker's all-new 'i' family

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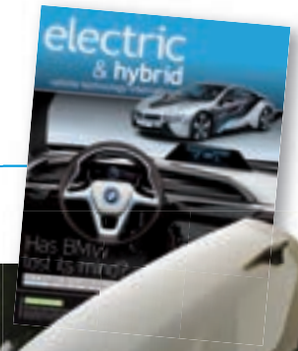

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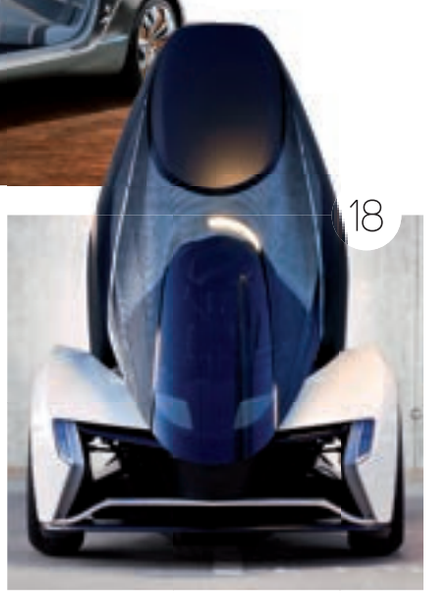

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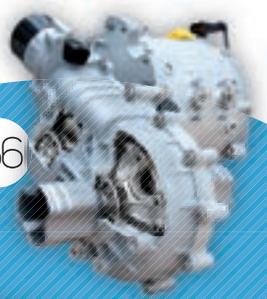

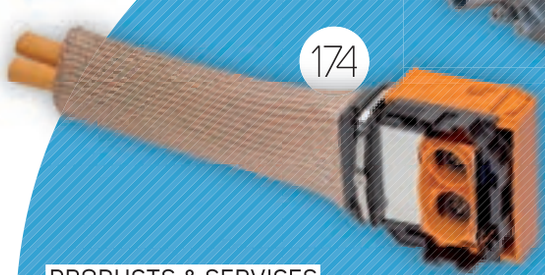

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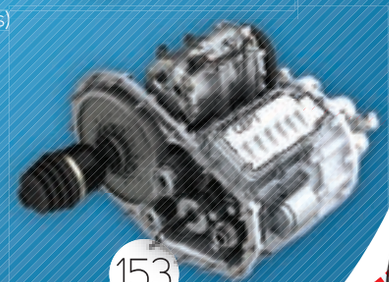

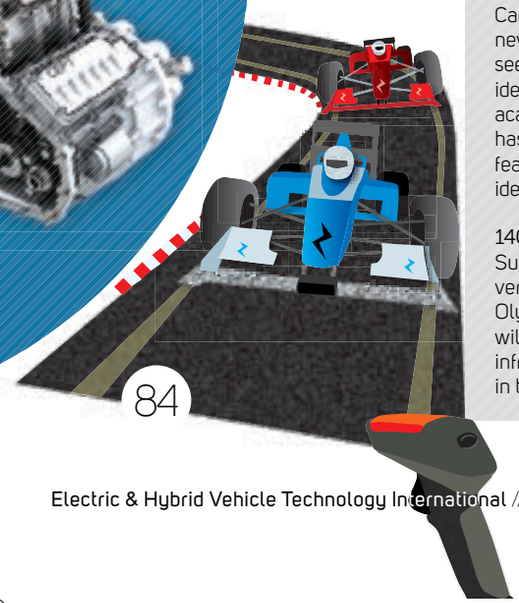

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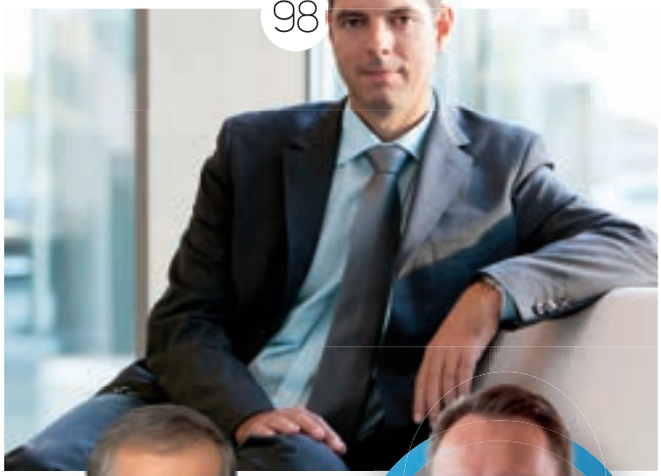

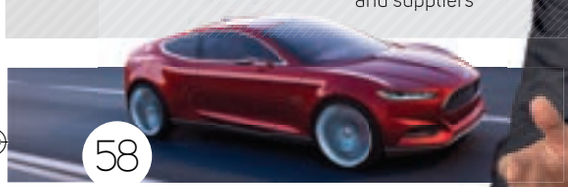

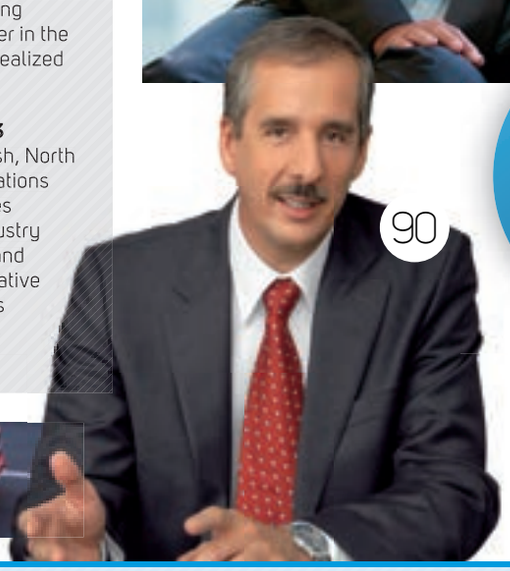

EDITOR'S NOTE

Evolution is described as any change recorded across successive generations, evidence for which revolutionized our view of the world and helped set out the view that life on our planet wasn't a result of 'intelligent design', but instead originated and evolved naturally, from a universal common ancestor. In automotive terms, the same model can easily be applied. The first steam-powered vehicle was designed (but not actually built) in the 1600s, and although it was many years until the basic IC engine took over as the powertrain of choice, there remains a commonality in the engineering and aesthetics of today's automobiles that can be identified and traced back through this technological evolution.

In fact, it is Karl Benz who is generally credited as the inventor of the modern automobile. Benz adapted many existing components and brought them together with several new technologies to create a four-stroke cycle gasoline unit. This evolutionary leap was instrumental in bringing the IC auto-age to the masses.

All very interesting I'm sure you'll agree, but why the history lesson? This issue of *Electric & Hybrid Vehicle Technology International* contains two features on BMW's latest evolutionary leap, the i series. We take an in-depth look at the launch of the i range and specifically the thinking behind its new DNA, LifeDrive. We also speak to Dr Klaus Draeger, BMW's head of development, about the ethos behind the i series itself, and his mission to marshal the brand into its next exciting stage of development.

Although BMW is not the only car maker embracing electric for its high-end vehicles, the i series can be credited as accelerating the evolution of the (electric) vehicle, creating a brand new strain of automotive engineering that takes lessons learned from current electric and hybrid vehicles and combining them with a ground-up approach to design. BMW's Mini E and ActiveE technology demonstrators, for example, were reverse-engineered to go electric; these two vehicles were originally designed to make the most from IC power. The project i models, on the other hand, started with a very different brief, aiming to develop a concept that overcame the inherent difficulties associated with the electric powertrain. As a result, BMW has engineered its symbiotic 'Drive' and 'Life' modules, advances that work together to reduce mass and improve performance and design flexibility, all the while paying homage to key elements of BMW's own brand genus, visible in i series' optimal 50/50 weight distribution.

BMW knows that it will take more than increased battery power and better motors to bring EVs to the masses. Thankfully the i series avoids the constrained approach of producing an electric concept based on the conversion of an IC engine model, instead reinventing the very fabric of the electric vehicle. In many ways this move reflects Karl Benz's approach in bringing revolution, not just evolution, to the concept of the automobile; surely evidence in favor of intelligent design after all.

Dean Slavnich

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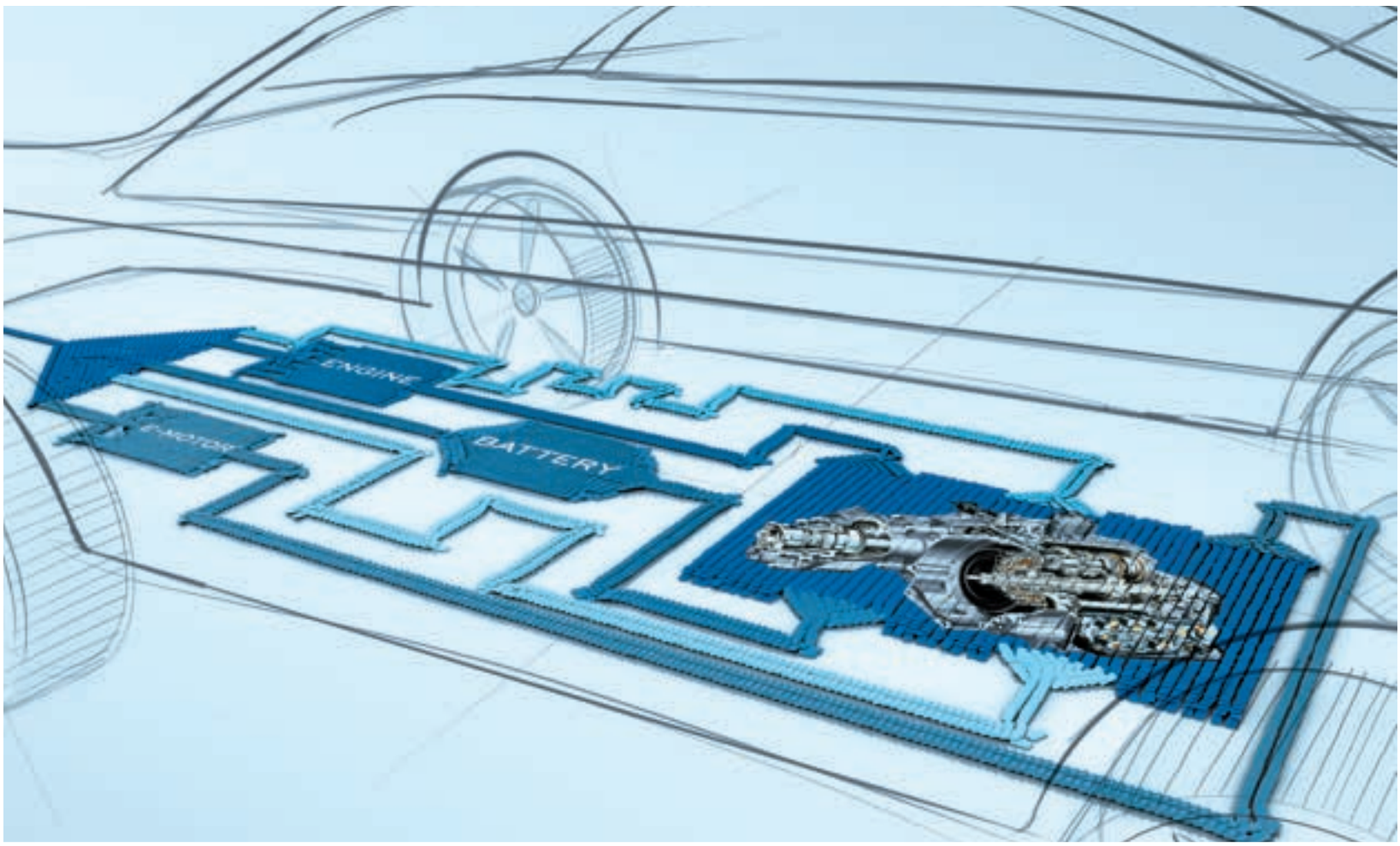

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It's all go on the electric powertrain front for the master of six-cylinder IC engine designs

WORDS: **DEAN SLAVNICH**

i

ration

In 2007 BMW formed the Number One project, which was tasked to get the Group ready for 2020. In 2014, the German OEM's i subbrand will launch the i8 sportscar, which will be heavily based on the plug-in concept car shown here

Seen by many as one of the greatest IC engine makers in the world, BMW is on the verge of becoming the first premium European mass-market car maker to scramble to market two high-end electric vehicles that will change the automotive industry forever.

But to fully understand how important the i3 and i8 concept EVs are to BMW, it's crucial to start from the beginning, says Dr Ulrich Kranz, head of project i, which first saw the light of day in 2007 under the banner of the Number One project that was charged with developing sustainable and pioneering concepts.

Kranz recalls, "The entire task centered as a holistic approach to look at all aspects of BMW Group, starting with raw materials, supplier base, production, production processes, development of the vehicle, use of the vehicle, reuse of the vehicle, recycling of the vehicle, and finally sales, marketing and distribution. We basically had to come up with innovative ideas to make BMW Group ready for 2020."

So, in four short years BMW's Number One project team has designed, developed and shipped out 600 Mini E cars and 1,000 BMW ActiveE vehicles to normal, everyday drivers in Europe, North America and China, all of whom are providing the company with important feedback.

Yet while such achievements are not to be sniffed at – BMW claims these trials are unparalleled worldwide in their scope – it's the i3 and i8 visions that the industry has really been waiting for, and the two, production-ready concepts did not fail to live up to such lofty expectations when shown for the first time at the Frankfurt Motor Show in September 2011.

Unlike their Mini E and ActiveE brethren – two vehicles originally designed to be powered by the IC engine – the i duo represent totally new development programs that start from the ground up, says Kranz.

This allowed the creation of what BMW terms the LifeDrive concept, which in contrast to vehicles with a self-supporting body, is a design that essentially comprises two separate, independent functional units. The 'drive' module within LifeDrive integrates into one segment the vehicle's suspension, battery, drive system and structural and crash functions in a construction made chiefly from aluminum. The 'life' module consists primarily of a high-strength and lightweight passenger cell made from carbon fiber-reinforced plastic (CFRP).

Kranz says this clever combination has helped BMW to achieve equal weight distribution for both i vehicles, something for which the Bavarian car maker is renowned for in its conventional IC engine models.

"Weight distribution is a key target and it's part of the BMW DNA," underlines Kranz. "Since we are a sub-brand of BMW, we have to come up with vehicles that are fun to drive and dynamic. That's the reason why we not only focused on developing the complete electric powertrain in house, which was key; we also looked into offsetting the additional weight of the battery by using innovative and lightweight materials."

In fact, through avoiding modifications to accommodate the electric drive components, LifeDrive ensures that the i cars are no heavier than a conversion vehicle of similar size, mainly because the design cancels out all the extra weight added by giving the car an electric drivetrain rather than a comparable IC engine.

I8 VITAL STATISTICS

Length: 4,632mm
Height: 1,280mm
Width: 1,955mm
Kerb weight: 1,480kg
Output: 260kW (164kW from the petrol engine; 96kW from the electric motor)
Acceleration (0-100km/h): 4.6 seconds
Top speed: 250km/h (capped)
Fuel consumption: 94mpg
Electric range: 35km

Megacity reality

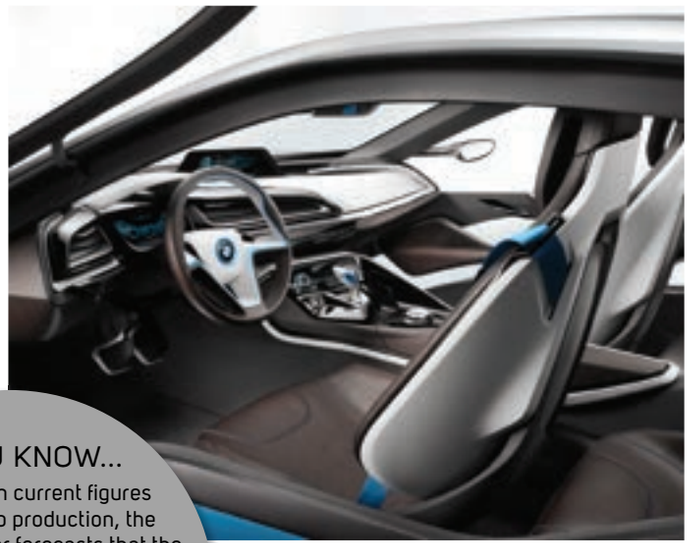
For the i3, which previously has been known as BMW's Megacity vehicle, the LifeDrive architecture is of a horizontal-split variant, so the drive module provides the basis for the life cell, which is mounted on the top of this arrangement. The key element to the drive module's design is the battery, which Kranz says has been made as large as possible to give the compact car a better driving range.

As a result, the battery, which features specially developed lithium-ion cells from SB LiMotive, has been placed in the i3's underfloor section, which Kranz's team concluded is the most space-efficient place to store it. This not only helps with the weight distribution mission, it also gives the car a lower center of gravity.

Creating the battery totally in house was an easy decision for the BMW board, says Kranz. He continues: "We have an approach that states that core competence should be within BMW boundaries and within our R&D team, and this is something that applies to the electric powertrain.

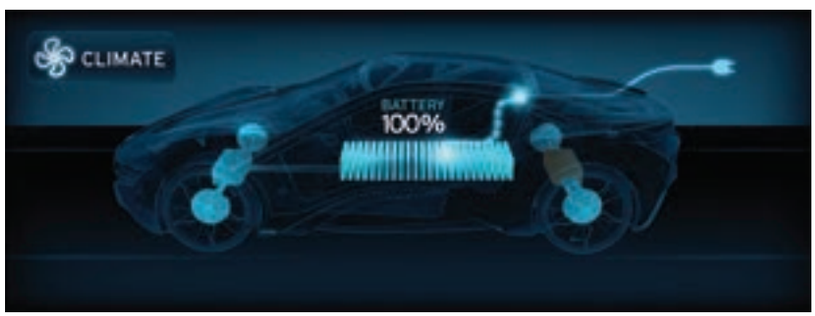
"We decided very early to buy just the battery cells and not the complete battery. That means we're buying the cells but building the battery. With the Mini E, for example, we learned that battery management is also key because one

The use of CFRP throughout the car, as well as other lightweight materials inside the cabin, helped BMW achieve an optimal 50/50 weight distribution for the i8



DID YOU KNOW...

Compared with current figures for BMW Group production, the German car maker forecasts that the future manufacturing site for i vehicles – Leipzig – will achieve 70% savings on water consumption and 50% savings on energy consumption for every vehicle produced. All energy used in the production of BMW i will be renewable



In pure electric mode, the i8 concept can go for 35km before calling upon the three-cylinder petrol engine. Expect the production version of the i8 sportscar to achieve an even greater EV driving range

"In both vehicles, we have been able to cancel out all the extra kilos added by the electric motor(s) through innovative use of materials and lightweight intelligent design"

has to have the complete system, and the complete system know-how needs to be in house. The most efficient powertrain is only possible if one knows the electric engine, the power electronics and the battery management. That's the reason why we had to keep this expertise in house."

An integrated liquid cooling system keeps the battery running at optimal temperatures, all the time. The unit can be charged fully from a standard socket in six hours. The battery pack is penned in by aluminum profiles that protect it from external impacts. Crash-active structures placed in front and behind the unit provide the necessary energy absorption in the event of a front or rear-end collision.

By being much more compact than a comparable IC unit, the electric drive system – which encompasses electric motor, gear, assembly and drive electronics – is located in a small area over the driven rear axle. Such is the integration of all of the i3's drive components that BMW engineers have removed the need for a center tunnel bisecting the interior, through which power would previously have been transferred to the rear wheels.

The i3's electric motor, which has been developed fully in house by BMW engineers, is based on the unit already tested in the ActiveE, albeit in modified form. Such are the inroads that project i has made, that the space requirements of the motor used in i3 have been reduced by 40% compared with the motor in the Mini E. The i3's hybrid synchronous unit generates 170bhp and torque peaks at 250Nm. This means i3 can sprint to 100km/h in less than eight seconds. The single-speed gearbox, for which BMW does not yet wish to disclose supplier details, channels power to the rear wheels of the i3, helping to realize a top speed of 150km/h.

The i3 offers an electric driving range of 160km, but BMW is clearly aware of range anxiety, so the i3 concept also comes with an optional range extender petrol engine that drives a generator to maintain battery charge level. Not much more is known about the e-rev option (presumably because BMW is keen to keep i3 a full EV), but *E&H* has learned that the engine will be different from the one that features in the i8.

Groundbreaking plug-in

Onlookers at the Frankfurt Motor Show who thought the i3 was impressive were treated even further when details about the i8, a sports car based on the Vision EfficientDynamics concept, were finally confirmed. Putting it simply, the i8 promises to be truly groundbreaking, boasting a unique plug-in hybrid solution that brings together an IC engine and an electric drive system.

Unlike its smaller brother with its horizontal configuration, i8's LifeDrive concept is of a vertical nature. This means that the drive systems are integrated into the front and rear axle modules, with the CFRP module providing the bridge between the two. Its plug-in hybrid nature means the i8 carries far fewer SB LiMotive cells than the i3, and these cells are stored in a passageway that has a similar structure to a central transmission tunnel. By placing the high-voltage battery in the tunnel, and positioning both motor and engine over the axles, Kranz's team were able to achieve an optimal 50/50 weight distribution for the plug-in sportscar.

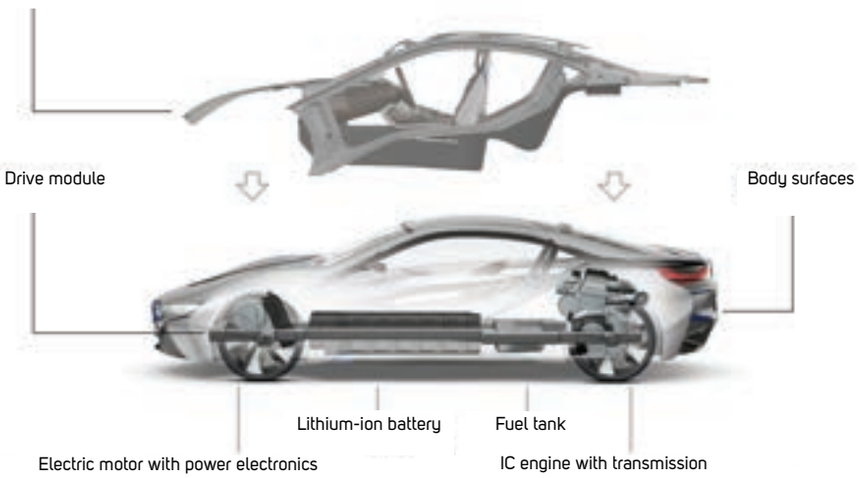
In fact, weight was a crucial factor that Kranz's team always had in mind when developing the i8. "The LifeDrive concept avoids the additional weight involved in making the necessary modifications to conversion concepts," points out Bernhard Dressler, who is responsible for bodywork on project i.

"In both vehicles, we have been able to cancel out all the extra kilos added by the electric motor(s) through innovative use of materials and lightweight intelligent design."

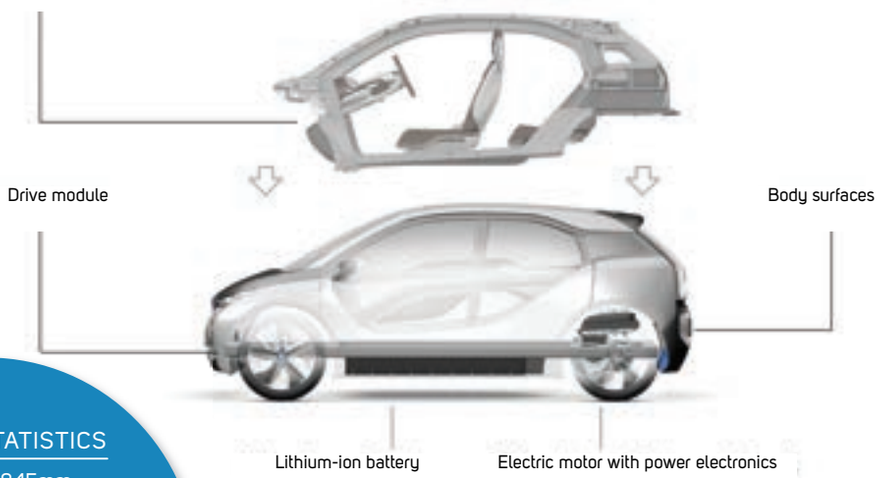
CFRP, admits Kranz, played a major role in achieving such challenging weight targets. The head of project i points to the fact that CFRP is as strong as steel, but some 50% lighter. Using aluminum, team i would achieve only a 30% reduction in weight. In the i8, specially woven CFRP structures are used – known as braided profiles – that allow for greater design freedom and fewer joints.

Go to page 90 to read an exclusive interview with Dr Klaus Draeger, BMW board member for development and purchasing

i8 life-module with CFRP passenger compartment



i3 life-module with CFRP passenger compartment



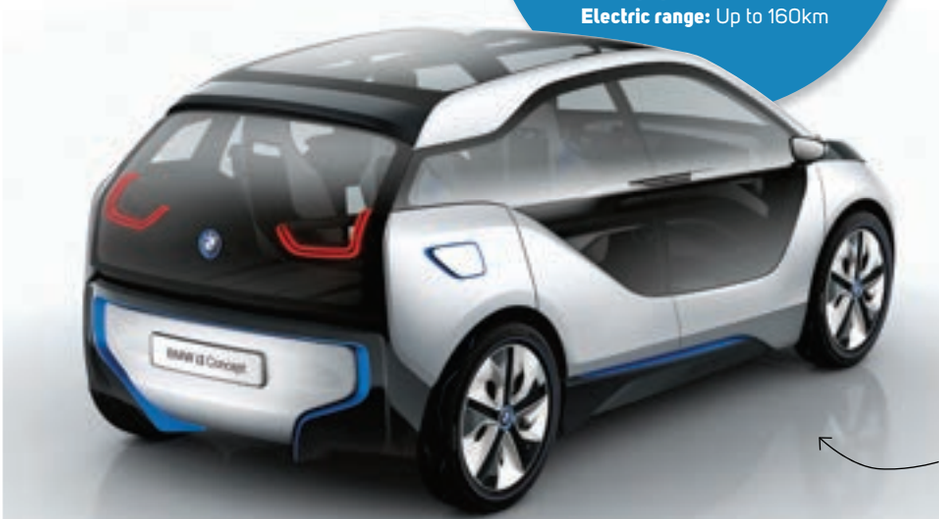
i3 VITAL STATISTICS

Length: 3,845mm
Height: 1,537mm
Width: 2,011mm
Kerb weight: 1,250kg
Output: 125kW
Acceleration (0-100km/h): 7.9 seconds
Top speed: 150km/h
Electric range: Up to 160km

The plug-in hybrid setup along with the lightweight design means a 0-100km/h time of less than five seconds is easily achieved by i8, while fuel consumption in the European test cycle of 94mpg is possible. Such figures have got commentators and analysts buzzing with praise for BMW.

As is the case with the i3 electric city car, the i8's electric motor derives from the ActiveE tech demonstrator vehicle, but like the i3, the design of the electric motor has been modified to suit the particular needs of the i8 project. In this instance, the motor powers the front axle, while a 220bhp turbocharged three-cylinder petrol engine generating 300Nm of torque drives the rear axle. With such power, the i8 has been capped to a limited top speed of 250km/h, but i8 can easily go faster if it wasn't electronically governed. Like nearly all other aspects of project i developments, the 1.5-liter three-cylinder petrol engine has been designed entirely in house, but that's all that BMW is willing to reveal at present about the IC powertrain. When driving in pure electric mode, i8 is good for 35km.

BMW is now readying i3 for market launch in 2013, while i8 will follow a year later.



The i3's battery pack has been placed in the vehicle's underfloor section because the development team concluded this was the most space-efficient place to store it

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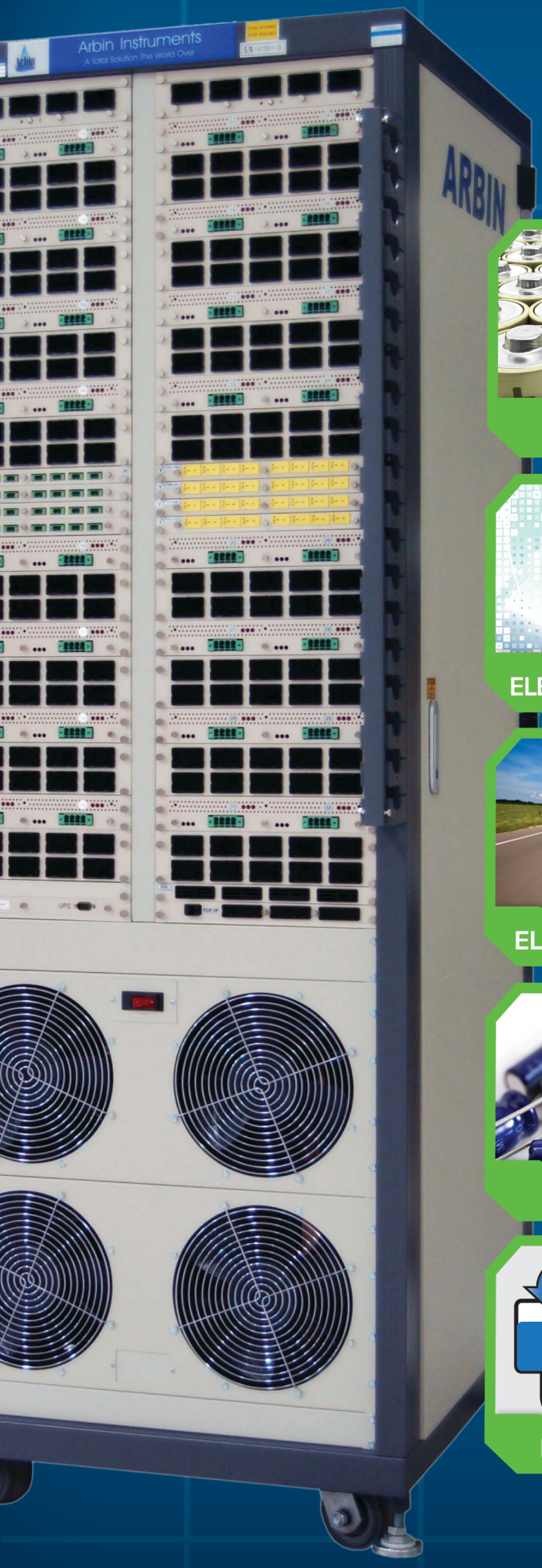

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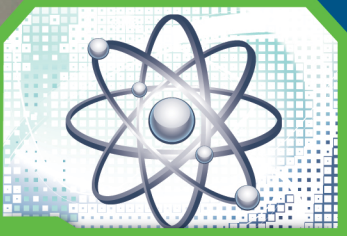

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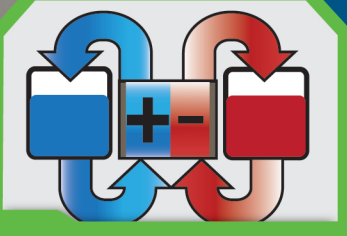

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VITAL STATISTICS

MERCEDES-BENZ F125!

Flywheel mass category: 1,700kg
Peak output of rear motors: 100kW
Torque of rear motors: 200Nm each
Hydrogen consumption: 0.79kg/100km
Peak output of front motors: 50kW
Torque of front motors: 75Nm each
Total sustained output: 170kW
Total peak output: 230kW
Wheel torque: 3,440Nm

Survival of the fittest

M-B says powerful, executive sedans will be around for a long time – but only if they evolve quickly

The range extender setup in the Mercedes-Benz B-Class (*see page 14*) should hit European markets within the next three years, but that does not mean Daimler's sustainable transportation drive is focusing only on the immediate future.

Sitting alongside the Concept B-Class E-Cell Plus at the Frankfurt Motor Show in September was the stunning F 125! – the German car maker's homage to 125 years of the automobile – and a trailblazing concept for large and luxurious eco-friendly vehicles in 2025 and beyond.

The four-seater, gull-winged Mercedes is oozing with state-of-the-art powertrain technologies, some of which will probably be realized in production form in the next decade.

The tech demonstrator boasts a 1,000km driving range, which is chiefly made possible due to a powerful lithium-sulfur battery and a high-tech fuel cell drive system. The battery pack, which is stored behind the rear seats of the F 125!, offers a storage capacity of 10kWh, therefore being able to propel the high-end vehicle for 50km in pure electric mode.

The fuel cell stack in F 125! is essentially an uprated version of the one shown in the B-Class F-Cell, so this means performance, consumption and practical suitability are all improved upon. In the F 125!, the stack provides the power for four electric motors installed near the wheels of the vehicle. The modular system, which Mercedes terms e4MATIC, features improved components and subsystems from the SLS AMG E-Cell vehicle. The technology generates continuous output of 170kW and peak output of 230kW. This means that on the road, F 125! has a 0-100km/h sprint time of 4.9 seconds and a top speed of 220km/h. The NEDC fuel consumption is rated at 0.79kg of hydrogen per 100km.

Along with the drive system, the F 125! research car provided Mercedes-Benz engineers with the ideal opportunity to investigate further hydrogen storage. Thomas Weber, head of R&D, explains: "The structural integrated hydrogen composite unit of the F 125! represents a real technological revolution as it allows the hydrogen tank to be fully integrated into the bodyshell structure for the first time.

"This means that in the future, vehicles with emission-free fuel cell drive systems could achieve the operating ranges of current diesel models, but with no loss of interior space."

The tank integrated into the floor assembly of the F 125! can hold 7.5kg of hydrogen. Compared with the high-pressure tanks currently in use, the Mercedes tank requires less installation space. This is because to withstand pressures of up to 700 bar, today's tanks need to be cylindrical and their circular cross-section means cavities can appear between tanks that are installed next to or above one another.

In contrast to such designs, says Weber, tanks that can be filled at a pressure of 30 bar or less can be better integrated into the bodyshell, as well as being able to act as structural components.

The F125! not only proves that high-end executive cars have a future in tomorrow's greener automotive world, the tech demonstrator also houses a key breakthrough design that will help realize hydrogen fuel cell production

Such is the excitement behind the hydrogen storage unit in the F125! that Weber and his team believe this development could make it into series production by 2025, further underscoring Daimler's commitment to hydrogen fuel cell vehicles.

With so much innovation on show, Weber says that the F 125! proves that vehicles such as the S-Class can survive the automotive industry's need to be green. "With the F 125! we want to show that large, comfortable, and safe saloon cars have an excellent future, partly because they are able to operate with no emissions," he says.

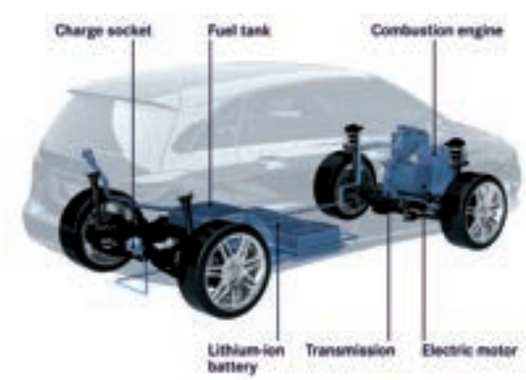
"The legend that is the S-Class will continue into the future, thanks to intelligent solutions that have the customer's needs in mind."

Tailor made

Daimler has enhanced its fleet of electric vehicle tech demonstrators with a B-Class range extender that will go into production within three years

Daimler is so hot on exploring all facets of new engine technologies – from ever-efficient IC units and pulsating V designs, through to longer-lasting EVs and the very latest hydrogen fuel cells, that on face value, the German engineering powerhouse seems to have all powertrain boxes ticked, except for one: range extenders. And while Audi, BMW and GM (to name but a few) have openly looked at range extenders – to the point that the latter has now launched the Chevrolet Volt in the USA and the Opel/Vauxhall Ampera in Europe, Daimler has been surprisingly quiet on the technology. But that's all set to change.

Representing a first for Mercedes-Benz – and making its public bow at the 2011 Frankfurt Motor Show – the Concept B-Class E-Cell Plus is living proof that Daimler is now also seriously investigating the potential of pairing electric drive technology with a small IC petrol engine, with the intention to launch such a vehicle in 2014.



The Concept B-Class E-Cell Plus offers a total driving range of 600km, which is made possible due to the combination of a powerful electric drive developing a peak output of 100kW and a continuous output of 70kW with a further 50kW of power coming from the petrol engine. This all results in a top speed of 150km/h for the concept, and acceleration of 0-100km/h in 11 seconds.

The IC unit charges the battery via a generator at low speeds, and then at high speeds it serves as a direct driving engine, acting on the front wheels together with the electric motor via a newly developed automatic transmission. In combined mode, the tech demonstrator emits 32g/km of CO_2. In all-electric mode, the B-Class can cover a distance of 100km, but expect this figure to be improved upon by the time the production car is finalized.

Both drive units are accommodated in the engine compartment in the front of the vehicle, together with the transmission and generator. The lithium-ion battery, which comes from Deutsche Automotive, a joint venture between Daimler and Evonik, and the fuel tank for the IC unit are both located in a false floor compartment at the rear, which Mercedes-Benz terms as energy space – a design that's been especially created for the car maker's alternative-drive vehicles. Interestingly – and keeping to Daimler's hydrogen fuel cell belief (*see* F 125! *on page 13*), other drive variants, such as gas or hydrogen tanks, can also be installed in this energy space compartment of the Concept B-Class E-Cell Plus.

The Concept B-Class E-Cell Plus represents Daimler's first piece of work on range extender technology. The German OEM will launch a production version of this concept in 2014

With space being a premium in this type of vehicle, both drive units will be as compact as possible, and this means the range extender engine will be a three-cylinder turbocharged unit of 1 -liter in displacement.

Daimler's growing fleet of EV demonstrators is impressive enough, but there's a feeling around Stuttgart that the range extender fills a hole that the German car maker has been missing. Dr Thomas Weber, member of the board of management at Daimler, responsible for R&D, adds, "The Concept B-Class E-Cell Plus shows that our new range of compact cars is all set for the future. The variant involving a battery-electric vehicle with a range extender further broadens the range of alternative-drive concepts from Mercedes-Benz."

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Mirror image

It's one thing to develop batteries and electric motors that last longer and are more powerful, but what will tomorrow's EV actually be made from? Smart's latest concept provides more than just a glimpse

Putting aside for one moment the very latest eco-drive systems, when it comes to making serious inroads in emissions reduction, facets such as total mass and material type are not only crucial but also often overlooked, especially when one considers how many near two-ton HEVs and EVs are already on the market.

It's for these reasons that Smart teamed up with BASF, the largest automotive supplier in the chemicals industry, to create the forvision. And while it's only a tech demonstrator, the concept features lightweight thinking and temperature management solutions that will no doubt find their way into future production vehicles.

The first point of interest is the forvision's all-plastic wheels, which *E&H* has learnt are being further developed by BASF in preparation for high-volume production. A new form of plastic containing long reinforcing fibers is used to construct the wheel, and it's this material that not only improves the mechanical properties of the component, but also realizes weight savings of 3kg for each wheel. Early testing of the plastic wheels at Daimler has indicated excellent thermal and chemical stability levels, dynamic strength and toughness.

In addition to the 12kg wheel saving, the Smart/BASF team also used carbon-fiber-reinforced epoxy resin for the tridion passenger cell and doors, enabling a further weight saving of more than 50% to be achieved compared with steel, or 30% compared with aluminum.

While the weight gains are more than impressive – and realistically very achievable – forvision's most futuristic feature is a light-transmitting roof that generates energy. The concept has transparent solar cells covering the entire roof, and these cells are placed on top of organic dyes that are also embedded into the roof. The dyes of the cells are light activated, and such is their capacity that even in poor light conditions, they generate enough energy to power multimedia subsystems and three fans that assist with climate management within the interior of the vehicle.

In fact, thermal management was a key focus area for the project. The concept uses a heat shield that has never before featured in an automotive application. Consisting of a new type of infrared-reflective layer, the BASF shield has been applied in the windshield and side windows to protect the interior of the car from heating up. Integrated between the panes of the safety glass, the metal-free film ensures that infrared rays are reflected effectively. Unlike metallized films, which are already in use in some vehicles, BASF's film reflects only the infrared rays of the sun.

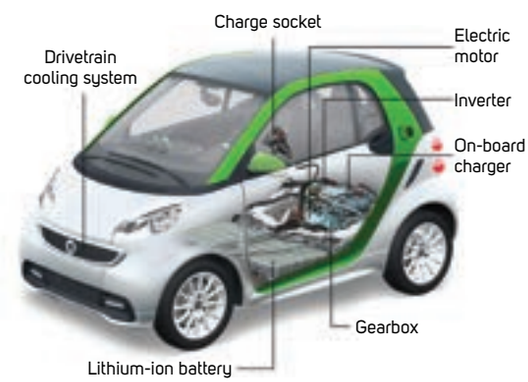
Working with BASF, Smart engineers have showcased a number of weight saving innovations on the forvision concept, including plastic wheels

FORTWO ED POWERS AHEAD

While the forvision showcases breakthrough ideas for tomorrow's EV world, Smart's third-generation fortwo electric drive is being readied for market launch in the next six months.

The key differences center on what the EV gets from the upgraded 17.3kWh battery from Deutsche Automotive (replacing the Li-ion Telsa battery in the second-generation Smart electric drive), and the more powerful 55kW magneto-electric motor – the first product from the EM-motive JV that Daimler and Bosch formed.

As such, torque is up at 130Nm, enabling a 0-60km/h time of five seconds. Top speed is now more than 120km/h, which puts the new electric drive model on a par with IC-engined Smart cars. Finally, the all-important driving range also increases, to well above 140km.



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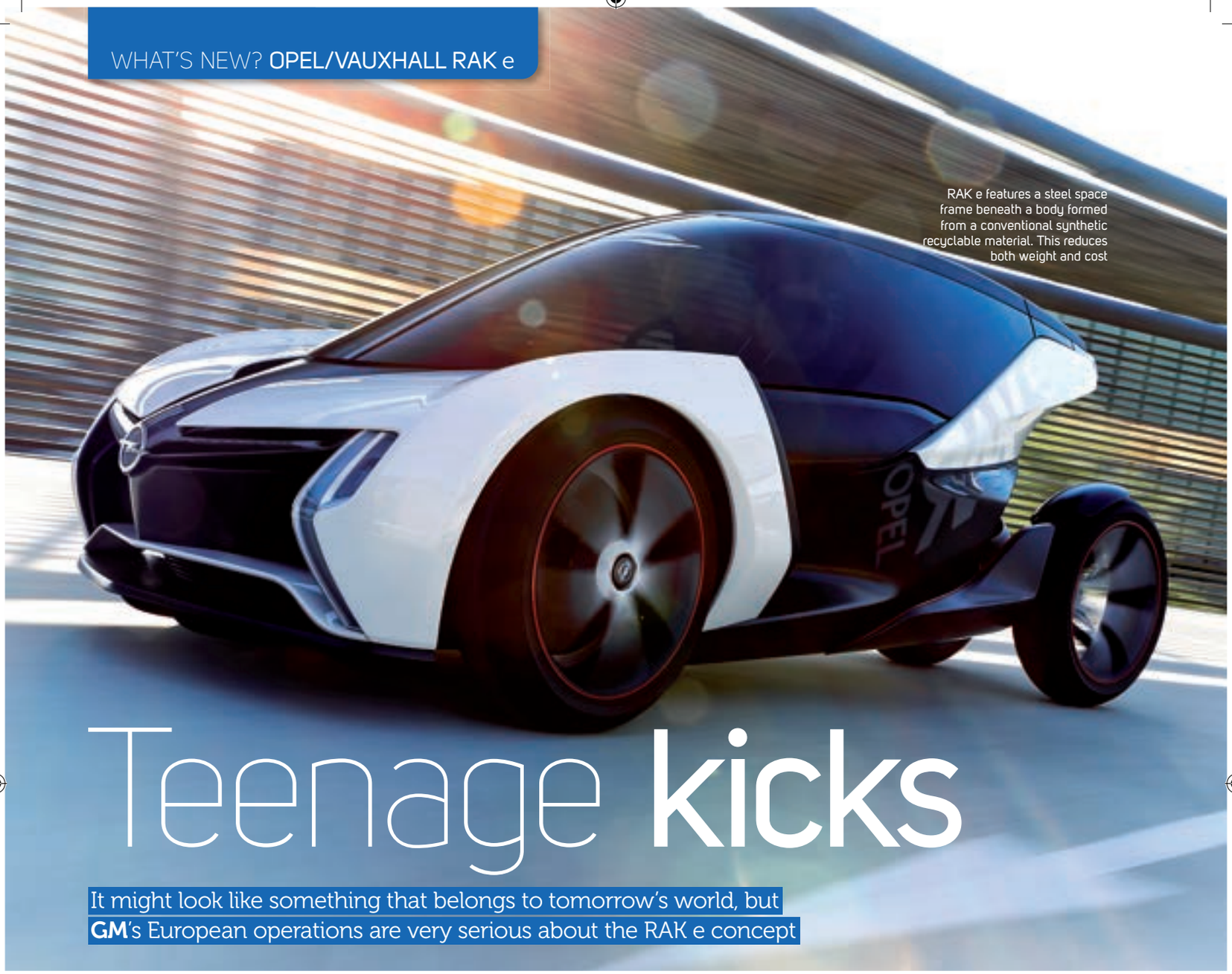

RAK e features a steel space frame beneath a body formed from a conventional synthetic recyclable material. This reduces both weight and cost

Teenage kicks

It might look like something that belongs to tomorrow's world, but **GM**'s European operations are very serious about the RAK e concept

What's this all about?

RAK e is an EV concept with a 60-mile range and top speed of 75mph. More than that, though, it weighs just 380kg and has been initially developed in a bid to entice younger buyers to electric transportation. "We want to develop electric vehicles that everyone can afford," says Karl-Friedrich Stracke, CEO of Opel.

But it's only a concept?

Yes, but *E&H* has learned that GM Europe is seriously looking into how this tech demonstrator can make it to production.

What about the technology?

The concept's party piece is its weight. RAK e is based on a steel space frame beneath a body formed from a conventional synthetic recyclable material. This clever arrangement allows for high levels of safety with affordable pricing. Such light weight means RAK e can do a lot on little power.

For example, peak power is 49ps, with at least 14ps being constantly available, while a 5kWh battery capacity ensures a decent, around-town driving range. RAK e can sprint from 0-60mph in less than 13 seconds.

So, no Volt technology crossover?

Not in the range-extender sense. RAK e is a pure electric vehicle, but GM's work in battery development, along with partner LG, is no doubt benefiting the car maker when it comes to development vehicles such as this.

And the name?

It's part of Opel's heritage. In 1928, the grandson of founder Adam Opel drove a revolutionary rocket-powered car to 140mph, a remarkable achievement at that time. That car was named RAK 2. For this modern day concept, the number has been replaced by a letter standing for – yes, you've guessed it – electric.

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Cars for the concrete jungle

Audi continues to build on its growing fleet of eco-friendly tech demonstrators in preparation for its production EV assault on the market later next year

QUICK FACT

A2 CONCEPT

Length: 3,804mm
Width: 1,693mm
Height: 1,494mm
Weight: 1,150kg

DID YOU KNOW...

It's not just the supplier community that's investigating contactless induction charging. As part of both the A2 and Urban projects, Audi engineers have also delved into the wireless charging arena, creating the Audi Wireless Charging (AWC) system. The long-term hope for the German OEM is that the technology will be able to be integrated into the transportation infrastructure as a retrofit for parking garages and residential streets

In the last 24 months, the clever engineers at Ingolstadt have rolled out the likes of the A3 e-tron, R8 e-tron, e-tron spyder and the A1 e-tron in an effort to gather experience and valuable data on electric vehicles. The next stage to Audi's learning curve was presented at the Frankfurt Motor Show, and while the Urban concept (*see next page*) grabbed the attention of the world's media, it was the A2 that caught our eye.

Megacity war

Essentially, the A2 concept is Audi's take on urban mobility in the massive cities of the not too distant future. What's really interesting here, though, is that this tech demonstrator is being prepped to take on BMW's i3 EV as the two successful German OEMs get ready to expand their battle from the IC engine world into the EV realm.

For this research vehicle, Audi placed its lithium-ion battery technology in a sandwich arrangement within the floor of the A2. The pack stores 31kWh of energy; 24kWh of which is usable. The electric motor is transversely mounted in the front, delivering 85kW of peak power, 60kW of continuous power and 270Nm of torque, all of which is directed to the front wheels via a single-speed transmission. Audi says A2 concept has a driving range of 200km and it takes the vehicle around 90 minutes to fully recharge the battery with a 400-volt three-phase current.

Drawing upon the original A2's lightweight ethos, one of the central aims of the A2 concept project was to ensure it did not become a heavy EV burdened by unnecessary mass from the electric drive systems. As such, the show car tips the scales at only 1,150kg, and this is thanks mainly to the use of Audi's ultra-lightweight construction that's been used for the body of the

vehicle. The A2 concept marks a first for the car maker's ASF technology in that it has been combined with a hybrid multimaterial construction, which essentially sees very different materials being combined with one another. For the A2, the suspension is constructed from aluminum components and is complemented by add-on parts that are made from CFRP.

The lightweight nature of the A2 concept means that it is nippy – just the ticket for a vehicle that will spend most of its life in built-up cities. A2 accelerates from 0 to 100km/h in 9.3 seconds and offers a top speed of 150km/h.

City slicker

Unveiled at the same time as the A2 concept at the Frankfurt Motor Show was the Urban concept, which hints at a totally new direction for Audi's EV thinking. Unlike the e-tron demonstrators shown in the past – and the A2 tech demonstrator, the Urban study represents new ground for the Ingolstadt OEM: the 1+1 vehicle weighs just 480kg and like the Opel's RAK e concept (*see page 18*), it could start a shift toward a new type of mobility.

With the thinking that 'less is more' being etched into the minds of engineers throughout the development of the Urban, it's no surprise to see that the Audi team came up with something truly different for this project. Not only are there no doors – you step into the vehicle as if you were entering a bath tub – there's also a roof that slides back to help facilitate entry. Lightweight material is used throughout the vehicle: the outer skin of the concept is made from CFRP; the occupant cell is a mix of CFRP monocoque and an aluminum structure. The wheels are manufactured using cladding technology, which ensure they too are very lightweight. They also feature a variant of the blade design that's found in all e-tron models. Tire sizes, in fact, are as unusual as the car as a whole – 125/60 up front and 145/50 at the rear.

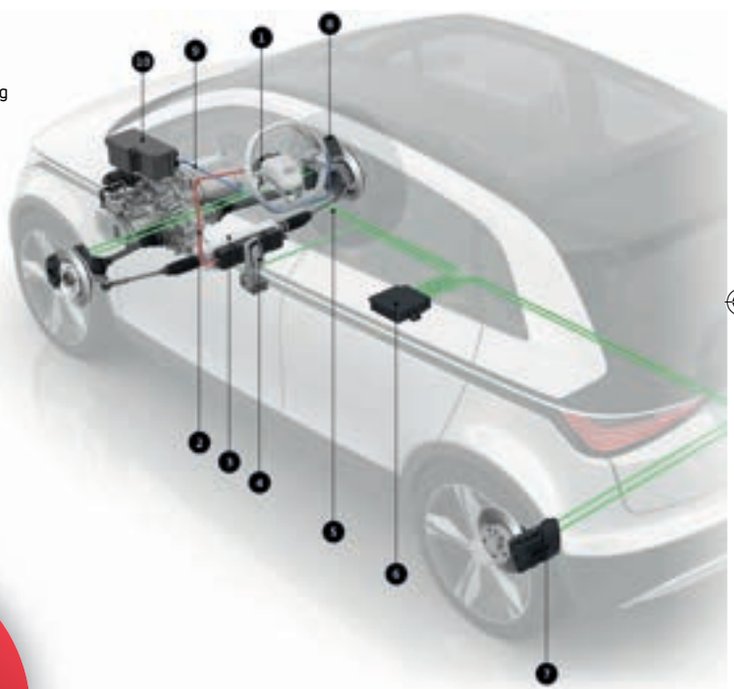
Such is the layout of the Urban that its battery pack has had to be mounted transversely behind the seats. Like the rest of the vehicle, the Li-ion unit is also light in weight, tipping the scales at 90kg. It has the capacity to store 7.1kWh of usable energy. Two electric motors also grace the concept, producing together 15kW of continuous power and 47Nm of torque. The motors are mounted between the rear wheels, which they drive via a single-speed transmission.

While its power rating sounds low, the 480kg curb weight of the Urban means that on just 47Nm of toque and 15kW of continuous power, the concept can muster a top governed speed of 100km/h. The 0-100km/h sprint is around 17 seconds, but a more appropriate measure for this city car is its green-traffic-light sprint to 60km/h, which takes just six seconds. The Urban's driving range is over 70km and Audi says the battery recharges completely in only 20 minutes with a 400 volt three-phase current.

MICROMOBILITY, VW STYLE

It's not just Audi that has designs for future mobility, as stablemate VW has also previewed its take on 'less is more' with the NILS concept, a single-seat EV that features an aluminum space frame, wing doors and freestanding wheels. Dr Ulrich Hackenberg, VW board member and development head, explains the concept in greater detail: "NILS anticipates the future. The goal of this project is to research a technically concrete and economically feasible concept for micromobility that restructures individual transportation to make it more efficient and environmentally compatible based on electric drive technology."

NILS features the same layout as an F1 car, with the driver placed in the middle and the all drive unit systems in the rear, shrouded completely in aluminum housing. The concept uses an e-motor, weighing only 19kg, with just 15kW nominal power and short-term peak power of 25kW, but it can afford to get away with such low outputs thanks to the vehicle's total weight of 460kg. A Li-ion battery with a capacity of 5.3kWh supplies energy to the electric motor to help it develop 130Nm of torque.



1: Electric motor and sensors
2: Control wires
3: Electric steering system
4: Brake pedal with electric pressure sensing
5: Control wires
6: System control unit
7: Electrically actuated brake calipers
8: Gearshift operation (forward, neutral, reverse)
9: Control wire
10: System control unit and operation of the single-stage gearshift

The 1+1 Urban concept represents a new EV direction for Audi

QUICK FACT

URBAN CONCEPT

Length: 3,219mm
Width: 1,678mm
Height: 1,189mm
Weight: 480kg

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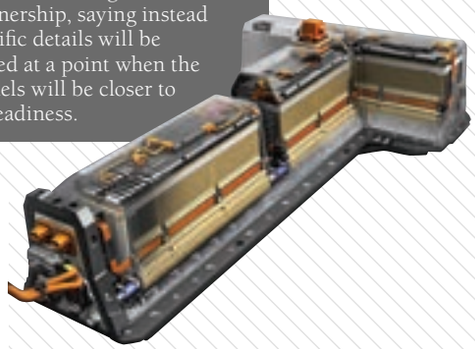
PRODUCTION **NEWS**

GM AND LG TO BUILD ON VOLT RELATIONSHIP

GM and LG Group will jointly design and engineer future electric vehicles, expanding on a relationship built on LG's work as the battery cell supplier for the Chevrolet Volt and Opel Ampera range extender models.

The agreement will help GM increase the number and types of EVs it makes and sells by using LG's expertise in battery technology. For LG, the deal represents a widening of its portfolio as an automotive solutions provider. GM vice chairman, Steve Girsky, says that the agreement makes sense for all, including car buyers: "Consumers benefit by getting the latest fuel-saving technology faster if we work with the best suppliers, and we save time and money in the development process."

The GM-LG relationship, which began with LG delivering the cells for the battery pack of the Volt, expanded last year with work on a demonstration fleet of Chevrolet Cruze electric vehicles. However, both partners are refusing to divulge further information about the timing of the launch of the first vehicles resulting from the new partnership, saying instead that specific details will be announced at a point when the new models will be closer to market readiness.



BYD SEALS GROUNDBREAKING AGREEMENT WITH HERTZ

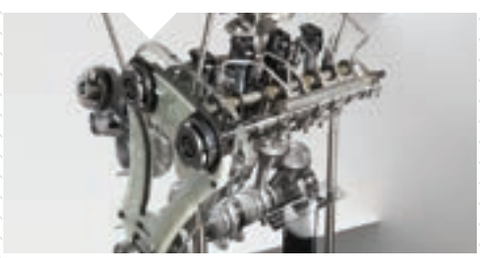
BYD and the Hertz Corporation have signed a strategic partnership that will see the two partners promote new energy applications and propel EV development and production in China. As part of the venture, BYD, one of China's largest car makers, will supply Hertz, one of the world's leading vehicle leasing organizations, with the e6 EV for the Chinese rental market. Speaking about the tie-up, Hertz CEO Mark Frissora stated, "Hertz is once again first to market with innovation. We are the first global car rental company to offer EVs in China for businesses and consumers to rent. With our partnership with BYD, we can offer a complete solution, including rental and sales – another first for our industry."

BMW ENGINES FOR FISKER

Fisker has confirmed it has signed an agreement with BMW that will cover the supply of engines and other components for future Fisker range extender models.

The deal states that the German OEM will supply a four-cylinder turbocharged engine for the next generation of Fisker cars, codenamed project Nina, which are scheduled for market launch in mid-2013. The first project Nina derivative will be a mid-sized premium sedan using Fisker's EV technology. The agreement between the two car makers calls for up to 100,000 BMW engines per year at peak volume.

Commenting on the deal, Fisker CEO Henrik Fisker said: "The BMW engine was an obvious choice for us, as BMW is known for producing the best and most fuel efficient gasoline engines in the world. We are very pleased to have signed this agreement with BMW." Fisker's COO, Bernhard Koehler, added: "This is an important agreement for us. We are focused on building environmentally responsible cars that deliver pure driving passion to our discerning customers. Who better to be a part of this exciting 'recipe' than BMW – the maker of the ultimate driving machine?"



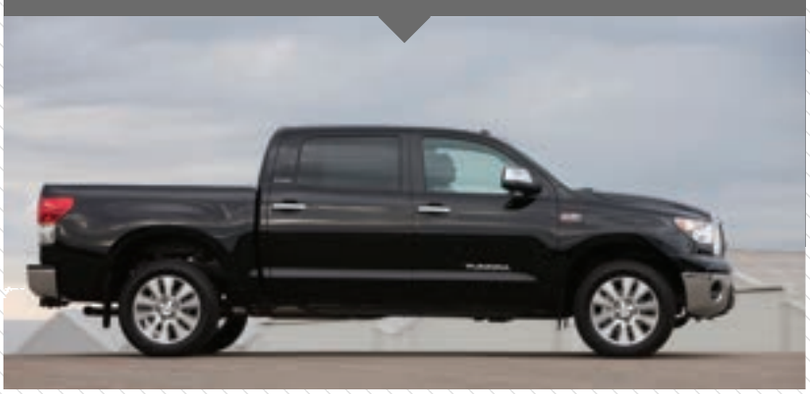
HYBRID PICK-UP PARTNERSHIP FORMED

Ford and Toyota have announced they are to collaborate as equal partners on the development of an advanced new hybrid system for pick-ups and SUVs.

The two companies have signed a memorandum of understanding, with a formal agreement expected to be in place by the first quarter of 2012. Up until now, both OEMs have been working independently on their own future-generation rear-wheel drive hybrid systems, but they are now committed to working together to develop a new hybrid.

The OEM partners say that by collaborating together, they will be able to deliver all-new and advanced hybrid technologies to customers sooner and more affordably than if they worked alone.

Although the hybrid system will share significant common technology and components, each company will determine the calibration and performance characteristics of their respective models that use the new powertrain, ensuring that the end applications look and drive differently.



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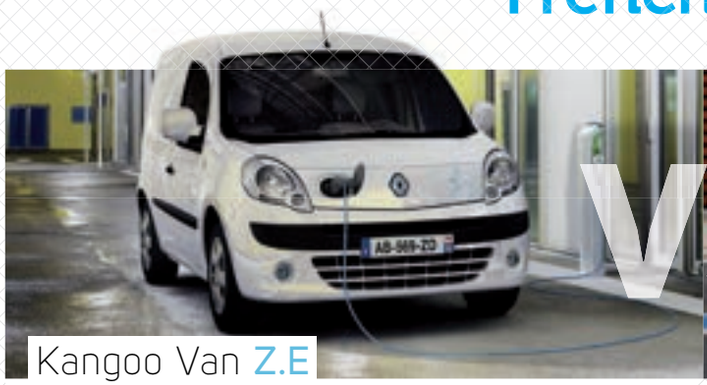

Kangoo Van Z.E

VS.

Fluence Z.E

It was at the Frankfurt Motor Show in 2009 that Renault – along with its partner Nissan – made public its intentions to become a leader in the development of electric vehicles for the mass market.

Since then, the latter has launched the Leaf to great acclaim, but now it's the French car maker's turn to storm the market with no fewer than four EVs in the next 12 months, starting with the Fluence Z.E (see right) and the Kangoo Van Z.E, which is being heralded as the first affordable all-electric van.

Unlike the two other electric vans on the market at present – the Ford Transit Connect, which was co-developed with Azure Dynamics, and the Citroën Berlingo, which features input from Venturi, including the electric motor – the Renault Kangoo Van Z.E is a pure OE-level in-house development, something that the French OEM is keen to stress. Perhaps the most telling factor about Renault's electric van is the silent running of the powertrain. An obvious statement, for sure, but for those that have to spend their working lives – sometimes more than nine hours every day – in a rugged, rumbling and noisy diesel van, the Kangoo Z.E should present itself as a calmer, less stressful environment; just the ticket for those who drive these vehicles for a living. Electric Kangoo boasts the same dimensions and carrying capacity as its IC-engined brother, and this is due mainly to the central, underfloor location of the battery, which comes from the Nissan-NEC JV. For the record, Kangoo Z.E's 4,210mm length ensures a possible load length of 2.5m (with the passenger seat folded flat), and the payload is 650kg. The 22kWh lithium-ion battery enables a driving range of 170km. The battery in both the Fluence and Kangoo Z.E models comprises 48 power modules, each of which incorporates four cells and delivers 8.3V. An electric motor rated at 44kW delivers instant maximum torque of 226Nm.

Battery type: Lithium-ion **Battery capacity:** 22kWh
Transmission: Direct transmission with a reduction gear
Engine: Synchronous electric motor with rotor coil

In developing the Fluence Z.E, Renault says that its engineers have created the first affordable, all-electric three-box sedan.

And although the price point is something the French OEM is particularly proud of – with help of a government tax break Fluence Z.E enters the market with the same US$28,800 showroom sticker as the diesel derivative – for us, it's the EV's simplicity that's most impressive. Climb inside the vehicle, and just like with a conventional, IC-engined sedan, one is not burdened with fancy, overly complicated graphics, interfaces, and charts conveying to the driver every last bit of data that, in the real world, one can do without. No. Fluence Z.E is simple – turn the key and drive, and there's real mileage to be had in the 'less is more' approach, especially when it comes to EVs.

On the road, Renault's first of four electric vehicles is steady and very capable, thanks mainly to its 100-mile driving range. Part of that comes from an advanced lithium-ion battery (which is the same as the one in the Kangoo Van Z.E). For the Fluence Z.E, however, the pack is located behind the rear seats, meaning that it has grown in length by an additional 130mm compared to the IC-engined derivative. As such, weight distribution was another key change for Renault engineers to deal with, especially with the 280kg battery pack mass at the rear, and the electric motor that tips the scales at 160kg – some 40kg less than the entry-level diesel powerplant. All that meant is that the Fluence architecture needed to be modified for the Z.E version, with the car's front end benefiting from softer suspension to offset the changes in weight.

Peak power of the synchronous electric motor with rotor coil is 70kW at 3,000rpm, and torque gets to a 226Nm high – all of which is more than enough for a sedan such as this.

Battery type: Lithium-ion **Battery capacity:** 22kWh
Transmission: Direct transmission with a reduction gear
Engine: Synchronous electric motor with rotor coil

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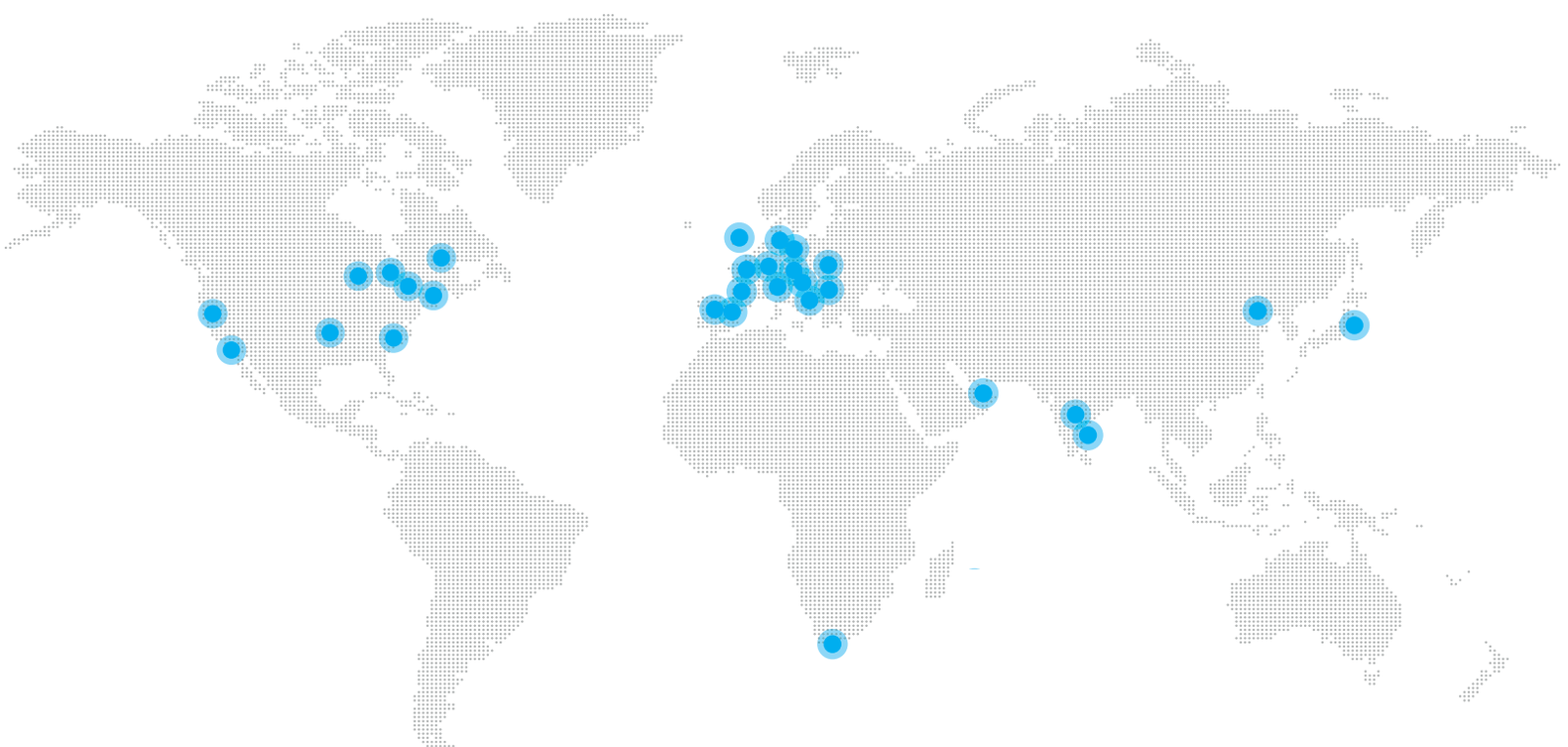

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PROFILE: PHIL BARKER

Job title: Chief engineer, hybrid and electric vehicles
Company: Lotus Engineering

What career did you dream of when you were growing up, and what was your first job?
I remember that I was always interested in how things worked – I just simply wanted to know more. I was forever taking things apart and reassembling them, much to the despair of my parents! At the same time, I also had a very healthy interest in cars, and this meant I would help my father back in the days when cars needed regular maintenance and repair. This interest led me to graduating in mechanical engineering, and my career then started in 1990 at a UK independent design consultancy, International Automotive Design (IAD).

When did you first start playing around with powertrains?
One of my first jobs at IAD was, coincidentally, working with powertrain engineers on a hybrid vehicle development project. My task back then was to create an engineering parts list for the auto-shift manual gearbox for the vehicle. Before I joined IAD, I used to enjoy playing around with engines and components on my own cars.

What was your career path to the position you currently hold?
My career path has involved developing my expertise from traditional chassis engineering through to encompassing powertrain and whole vehicle engineering. An understanding of the complete vehicle is necessary to pursue a career in hybrid and electric vehicles as it is so important to be able to manage the vital trade-offs with all the interactions of the key vehicle systems. I have now been in the automotive industry for over 20 years, predominantly in the field of vehicle and chassis engineering, but for the last six years I have worked with hybrid and electric vehicle technologies at Lotus Engineering.

What are the best and worst elements of your job?
The best is working with like-minded people who are enthusiastic and creative. The worst is not being able to spend enough time with my family at home.

What car do you currently drive?
A Fiat 500 TwinAir.

> For me, personally, an electric vehicle would be suitable for everyday commuting, but I also need a car that I can drive for a few hours to get to the airport in order to jump on a flight for a business trip

What would be your ideal engine specification for today's eco-friendly world?
What's emerging within the wider automotive industry and the car market itself is that the ideal engine/vehicle specification is more dependent than it ever was on the vehicle usage profile. For example, people are thinking more about aspects such as total cost of ownership. For me, personally, an electric vehicle would be suitable for everyday commuting, but I also need a car that I can drive for a few hours to get to the airport in order to jump on a flight for a business trip. It's a balance between the two.

Emissions legislation aside, what's your dream engine spec?
I have owned many cars over the years, including some classic models, and I can't help but like straight six and V8 engines.

What could legislators do to make your working life easier?
It would help if legislators caught up with technology development. For example, there are technologies being developed that mean we can look at deleting conventional hydraulic friction braking but there are many clauses in the Federal and EU braking legislation that either do not allow this or are simply not relevant to 100% regenerative braking.

In your opinion, what is the best engine that's ever been produced?
For me, one of the best engines ever produced is the humble British Motor Company A-Series engine. The reasons are personal, as I have fond memories of building and heavily modifying these engines for my own cars during my school, student and early career days. The fact that the A-Series engine was in production for nearly 50 years is a testament to the robustness and simplicity of the design.

What OEMs do you have particular respect for in terms of engine development?
I won't name any company in particular but I have to say that the reliability and specific power output of modern engines continues to impress me.

In your opinion, what will be powering a typical family sedan in the year 2030?
The market is big enough for numerous powertrain solutions and I suspect that the majority will still be IC engines, but perhaps they'll be flexfuel-compatible for second-generation biofuels. Hybrid solutions will have an increased market share but I think pure EV powertrains for family sedans will still be niche.

Time Warp

E&H looks into the future and asks, just what will the battery of 2022 be made from?

WORDS: **MIKE MAGDA**

Illustration by Ben White

Optimizing energy density in lithium-ion batteries will be the focus for most EV and HEV battery development projects over the next 10 years. Most experts say that the industry has settled on Li-ion technology for the near term, and target objectives will address reducing manufacturing costs, increasing durability and lowering weight, in addition to fulfilling changing market needs.

"There's always a chance of that 'eureka' moment," says Dr Allan Paterson, senior electrochemical engineer at Axeon Technologies, "and you get a crazy new technology that potentially will be the next building block. But for the next five to 10 years, it will be lithium-ion in some form."

Paterson is not alone in tipping lithium-ion to be around for at least the next decade.

"The first generation was clearly something we had to commit to three to five years back, so we had to stabilize that technology for production," explains Ted Miller, senior manager for energy storage strategy and research at Ford. "But that leaves some optimization to be captured [for the next generation]."

So just what does the long-term future hold for battery developments? "Ten years from now, we'll be seeing the first meaningful potential for something significantly different," predicts Bill Wallace, director of global battery systems at General Motors. "But it will have to compete with a highly developed lithium-ion solution. It's not clear who will be the winner 10 years from now, but I think we'll start seeing bits and pieces of competition."

1

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"Ten years from now we'll be seeing the first meaningful potential for something significantly different"

Ted Miller, Ford's senior manager for energy storage, says that understanding the consequence of the higher cell potential is very important. The car maker's Focus Electric, due next year, gets all of its power from a high-voltage lithium-ion battery

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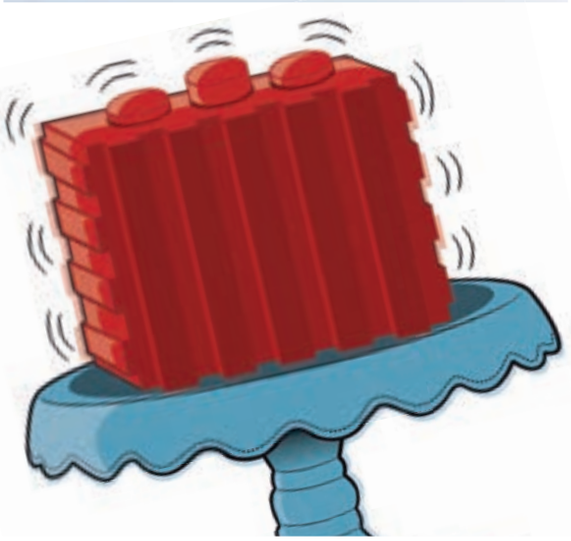

1. Scientists at the Argonne National Laboratory investigate all stages of a battery from basic chemistry to engineering better cathodes and anodes

2. Argonne researchers Daniel Abraham (right) and Sun-Ho Kang assemble a battery for evaluation

3. The production start of the Mercedes-Benz A-Class E-CELL at the Rastatt plant. The EV features a Li-ion battery

4. SB LiMotive individual lithium-ion cells are put together to form modules, and then combined with thermal management components, a BMS and electronic parts to form a battery system

Counting cells

Increasing cell voltage from the current range of 3.3-3.8V to upward of 4.5V will likely be the next major milestone for EV battery systems.

"It's a chicken and egg issue," says Dr Andrew Jansen, principal electrochemical engineer in electrochemical energy storage at Argonne National Laboratory. "To have a high-voltage cathode, you have to have a high-voltage electrolyte."

Miller agrees: "We need to understand the consequence of the higher cell potential. If we are maintaining the same kind of solvents and electrolyte formulation, what's the limit? What more work has to be done to maintain the higher voltage? And are there any consequences if that higher potential leads to less stability and may impede life?"

Experts mention blue sky chemistries such as lithium sulfur and metal air – especially when pointing to solving problems with the electrolyte – but they note more that laboratory work continues to identify higher voltage versions of metal-based oxides for the anode and silicone-based materials to replace graphite on the anode.

"I wouldn't limit any one material right now," says Jansen. "There is work going on with high-voltage spinel. These are 5V spinel materials based just on nickel and manganese. A little tweaking, and we could have a winning material."

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With R&D budgets being watched more closely than ever before by most automotive organizations, collaborations, joint ventures and partnerships appear to be a necessary strategy in keeping pace with new technologies. GM has announced a significant investment in Envia Systems, a California company developing manganese-rich cathodes with a layered-layered composite structure that was licensed from Argonne.

"This is certainly the kind of technology that we are pursuing for our second generation," hints Wallace. "We work closely with many material suppliers. Those chemistries are somewhat proprietary. I would call them refinements and derivatives of the current lithium-ion technology. Also, there's a lot of focus on blending current chemistries into the most efficient product."

While some research may try advancing battery chemistry using rare resources, researchers are usually focused on materials that will be economically viable.

"They're not going to be based on exotic elements that exist only on certain islands," says Jansen. "The low-hanging fruit is to create processing conditions that lower the amount of energy that's put into it."

And lowering costs by improving the manufacturing process is an area where car makers have significant experience in optimization.

"Yield is very important from a customer cost standpoint," continues Wallace, noting significant efforts to reduce variation and scrapping issues are making contributions to overall cost reduction. "It's maybe not as sexy as other stuff. Our scrap rates on modules and packs are quite low, but there is room to improve at the cell level."

Major OEMs are also looking at improving cell-joining methods, especially low-cost and low-energy processes.

GET CONNECTED

Being at the very heart of the electrified powertrain means that the battery receives and distributes high-voltage power through its arteries and veins. As a result, connecting and protecting the wiring harness assembly is intrinsic to system integrity and safety.

OEMs and suppliers involved in cell or pack production and assembly or vehicle integration, require robust connection solutions to link devices to wiring harness assemblies. The high-voltage battery and other high-voltage devices consume a considerable amount of additional space, an issue that's further highlighted when taking into account that package size must be optimized and header and connector combinations must create flexible wire harness routing solutions.

TE Connectivity AMP+ high-current connectors and headers are designed with this in mind. An optimized package size and plug and header selections create multiple wire harness routing options. The HVP 800, for example, features current carrying capability of up to 250A (continuous) on 50mm² wire, as well as wide temperature and wire ranges.

"I wouldn't limit any one material right now. There is work going on with high-voltage spinel. These are 5V spinel materials based just on nickel and manganese. A little tweaking, and we could have a winning material"

1. Pouch cells, such as these Axeon designs, make very efficient use of available space thanks to the absence of a metal can, which also lowers overall weight

2. Prismatic cells, such as these from Axeon, have high energy density, and can be packaged more efficiently than cylindrical cells

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2

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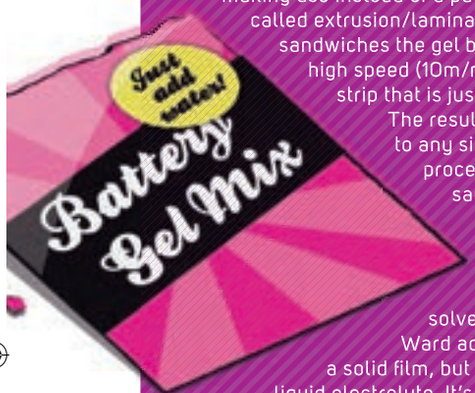
GEL POWER

Researchers at the University of Leeds in the UK have created a new type of polymer gel that they say can be used to make safer, smaller and cheaper lithium batteries. The breakthrough technology has already been licensed to US company Polystor Energy, whose R&D engineers are conducting trials to commercialize cells for portable consumer electronics, but could this gel also be applied in the automotive sphere?

In short, the University of Leeds does not want to speculate. However, it's a well-known fact that traditional lithium-ion batteries are based on cells (sealed containers) that contain a porous polymer film separator plus liquid chemical filler, allowing the lithium-ions to carry charge to flow between the two electrodes as well as acting as a barrier, thus holding the electrodes apart to prevent short-circuiting.

The innovative gel, on the other hand – which has been developed by Ian Ward, a research professor of physics at the University of Leeds – removes the need for the separator, making use instead of a patented manufacturing process called extrusion/lamination, which essentially sandwiches the gel between an anode and cathode at high speed (10m/min) to create a highly conductive strip that is just nanometers thick.



The resultant polymer gel film can be cut to any size and permits a fully automated process that is cost-effective and safe, says Ward.

The innovative lamination process also seals the electrodes together so that there is no excess flammable solvent and liquid electrolyte.

Ward adds: "The polymer gel looks like a solid film, but it actually contains about 70% liquid electrolyte. It's made using the same principles as making Jell-o: you add lots of hot water to the 'gelatine' – in this case there is a polymer and electrolyte mix – and as it cools, it sets to form a solid flexible mass."

1

1. Bill Wallace, GM's director of battery systems, says lithium-ion solutions will be around for at least the next decade, but there will be new challengers to the technology

2

2 and 3. GM opened its new battery systems lab – the largest automotive battery lab in the USA – in 2009. The high-tech center is helping Detroit's largest car maker to accelerate the domestic development of advanced battery technology, such as the T-shaped battery pack that powers the Volt

3

"Ultrasonic may play a role, if it's feasible," continues Ford manager, Miller. "But relatively traditional welding technology could be optimized around these large-format batteries."

GM is also studying options in pack design and structure that would have some elements that can multitask to improve efficiency.

Wallace explains the thinking: "Today we have fairly distinct components in the pack: those that do cooling and those that do structure. We're looking at strategies to combine those elements to get multifunction out of basically the same components."

The virtual world

While constant tweaking of material combinations and structures continues in the laboratory – and especially at an academic level – officials are seeking more significant advancements in computer modeling and simulation, taking battery development away from the real world and into the virtual one.

"We have electrodynamic electronic structure models, and they're at where you can zero in on what is the ideal state," says Jansen proudly. "This is coming to be very useful, particularly for electrolyte work and trying to predict which compounds are stable at higher voltages."

Axeon's Paterson is also a fan: "There's a lot of development for computer modeling, all the

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way down to atomic scale – so things like ion migration and solid materials. We're also getting a handle on failure mechanisms and analysis for the lifetime of cells. At pack level, it's used extensively for design, especially CFD for cooling strategy."

At GM, Wallace and his team are working closely with several key universities in the field of predictive modeling.

"We're looking at cell failure modes and driving those models and prediction methods into a battery management system, and also to modify our usage patterns of the pack in the field to maximize their life as well as prognostics," explains Wallace.

According to the GM director, tools that synthesize cell performance are coming on line and proving to be fairly accurate. But there can be a problem with material properties associated with those advanced tools.

"This is kind of where the secret sauce is," adds Wallace. "Those material properties are very hard to predict, and those have to come out through tests. It's an area ripe for improvement and still very much a chemist's field right now."

Computing power is also an area of particular interest for Ford senior manager, Miller: "You can look at the CAE modeling for crash testing; it took some time to have that as predictable as it is today. To me, that's the benchmark I'd like to see in terms of our ability to predict battery behavior and performance. I'd also like an analytical tool to predict abuse response. It would help with packaging for crashes and designing a proper control system to comprehend what can occur in an abusive-treatment situation."

BMW Group continues to further the development of electric drivetrain power electronics in preparation for the market launch of the i vehicles. Both the i3 and the i8 will use lithium-battery technology

IN CONTROL

Experts agree that the vehicle's BMS must keep pace with battery technology, whether improvement is incremental or there are dramatic breakthroughs.

"The more advanced BMS actually model the cells, so they have an understanding of the internal model of the battery chemistry and thermal properties, which allows it to accurately do a control strategy as well as accurately predict future performance," says Axeon's Paterson. "The management system also must draw the minimum amount of power to maximize energy available for the vehicle."

BMS can also trickle down to simpler green technologies on existing platforms.

"Stop/start, we believe, is going to become standard across the board," adds GM's Wallace, noting that cost considerations would keep car makers from applying high-tech solutions to a simpler gas-saving feature. "The real key to making traditional technologies like AGM batteries and 12V systems reliable and live longer is actually the battery management system. So, we actively roll all development out of our large lithium-ion applications, our smaller lithium-ion applications like e-assist, and push that down into stop/start. We've got our best stuff from a control standpoint going straight down into those products to improve overall reliability."

In addition to monitoring cell and pack voltages and watching over temperature levels, developing safeguards against an internal short should be a priority for a BMS.

"Say there's a little ripple in the voltage that signals a soft short is developing," suggests Jansen at Argonne. "If you could have a BMS that is smart enough to recognize what a developing short looks like, then it could quickly try to get the battery down to a safe state of charge."

Typical HIL simulation setup for BMS tests comprises a processor board, HIL I/O boards for I/O interfaces, a board for CAN interfaces and a failure insertion unit for testing electric failures. Restbus simulation is used for simulating unavailable cell stacks. A leading developer in this area, dSPACE, offers specialized hardware and software for testing a BMS, such as the battery cell voltage emulation board for simulating high-voltage batteries at cell level and the ASM multicell models. The test system can represent the electrical and thermal properties of a battery down to cell level.

Other components are high-precision voltage sources from 0-6V, which can take the load of the current flowing in cell balancing. Requirements for cell voltage simulation are a precision of about 2mV and a current up to a few hundred mA. The voltage sources are galvanically isolated and can be switched in sequence to form cell modules. The voltage of the entire battery can be simulated in this way.

Furthermore, failure simulations such as a break in the measurement cable or the cell connectors can also be conducted. The voltage sources are connected to the processor board via an LVDS interface, with connection distances of up to 5m with copper cabling and up to 100m with optic cabling.

1

High-tech options that can support an advanced battery may have promise, but only if the overall benefits are cost effective.

"Capacitors always enhance battery life," explains Jansen. "But [manufacturers] don't want to deal with two electronic systems. You have to have [separate] systems that monitor the battery and capacitor, and then link them together. If you do that in a hybrid vehicle, then you link that in with the engine control system. So it's just the complexity of the issue."

Even as R&D continues at an optimistic pace, market conditions are challenged by mixed signals. Experts at Pike Research, for example, predict cumulative sales of hybrids, plug-in hybrids and EVs will reach 13.9 million units by 2017, a number that's hardly mass market.

"Increasing fuel costs, government purchase incentives, increasing fuel economy standards and increased vehicle availability will benefit all three types of electric vehicles to varying degrees," outlines Pike Research senior analyst, Dave Hurst.

A report from Lux Research says the overall market for battery vehicle energy storage will grow from US$13 billion in 2011 to US$30 billion by 2016. However, media-prominent vehicles such as the Chevy Volt and Nissan Leaf are unlikely to generate the majority of growth.

"Although battery prices for all-electric and hybrid passenger cars are dropping, they're not dropping far enough or quickly enough to fuel the sort of broad adoption that advocates expect," outlines Lux analyst, Kevin See. "Instead, the substantial growth we see for vehicle-related storage technologies will be powered mostly by e-bikes, which are shifting from lead-acid to Li-ion battery technology, and microhybrids, which offer a more incremental, low-risk way for car makers to improve fuel efficiencies."

At the same time, analysts also warn that government grants and incentives are fueling a possible global glut in lithium-ion batteries, especially if consumer acceptance of battery vehicles stagnates or costs remain too high for the average car shopper.

"My personal opinion is that we have to improve the efficiency of vehicles across the board," sums up Miller. "Electrification is going to be key to that, and reliable, affordable energy storage is the key enabler."

1. The Volvo V60 plug-in hybrid, which will be available on the market in 2012, has its front wheels driven by a five-cylinder 2.4-liter turbodiesel producing 215bhp. The rear axle has a 70bhp electric motor, which receives power from a 12kWh lithium-ion battery

2. The Nissan Leaf makes use of a laminated lithium-ion battery that is said to weigh around 250kg. The design features 48 modules and 192 cells

2


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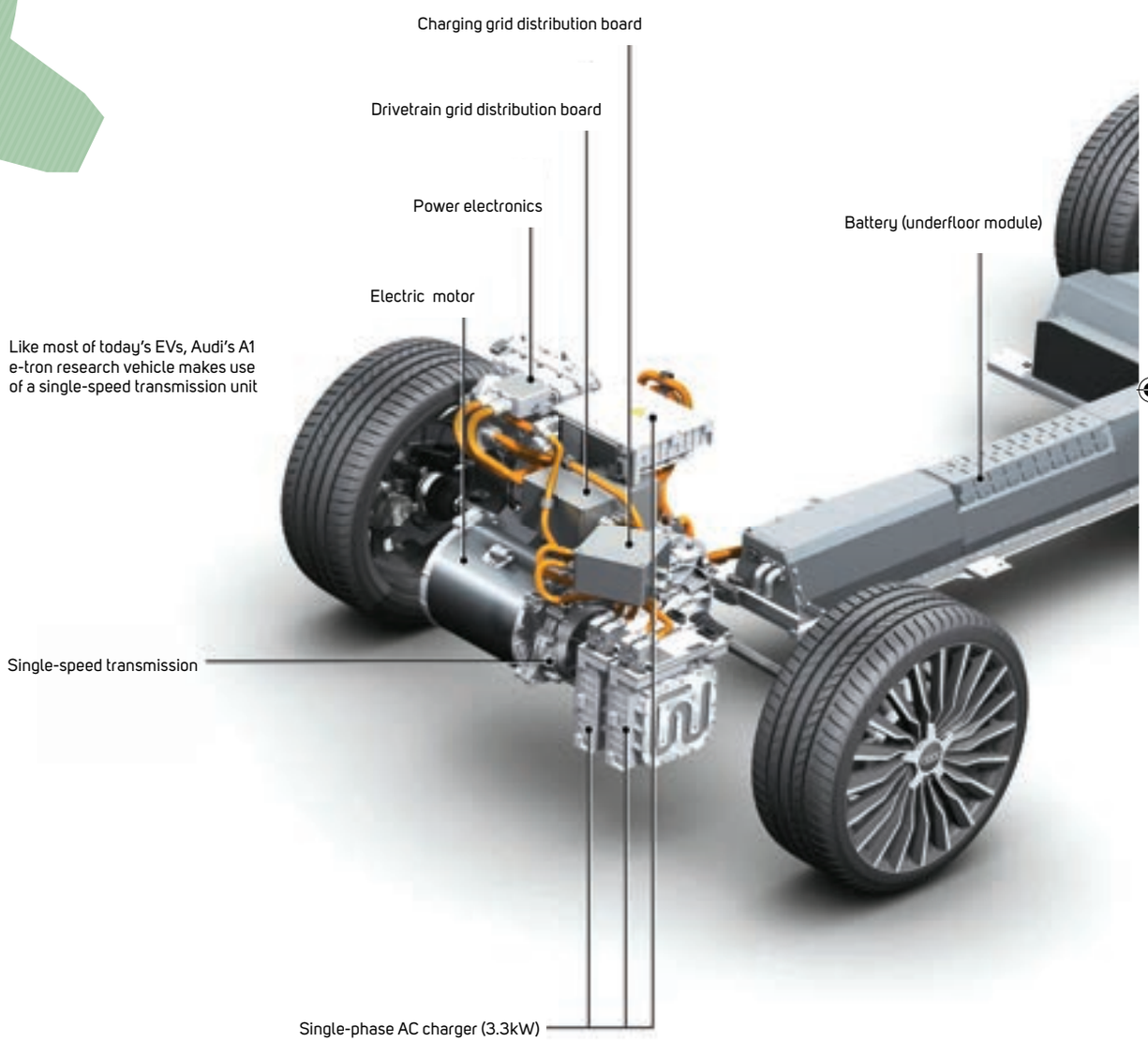
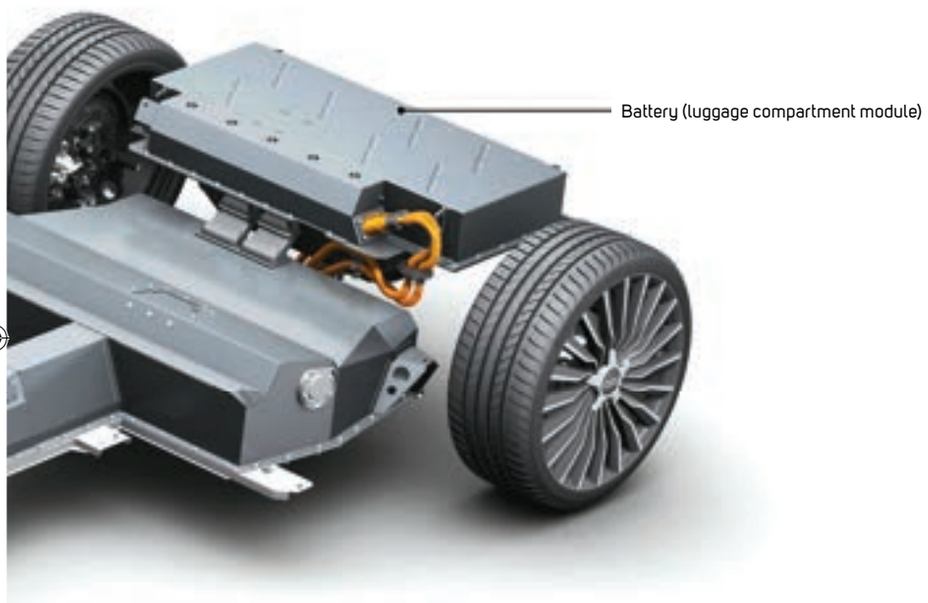
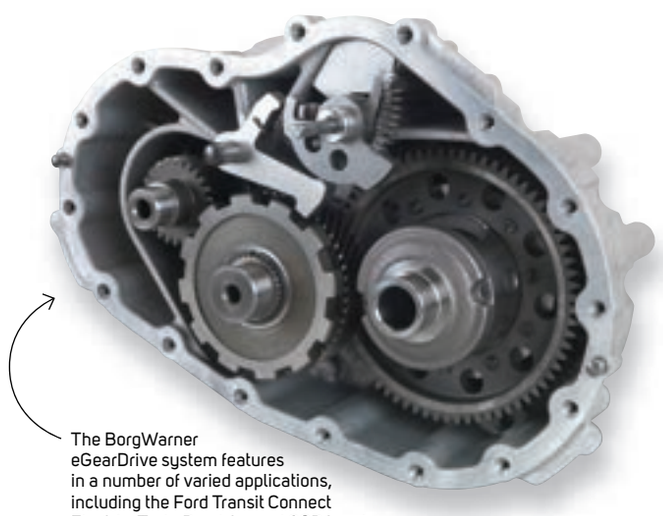


Like most of today's EVs, Audi's A1 e-tron research vehicle makes use of a single-speed transmission unit





The BorgWarner eGearDrive system features in a number of varied applications, including the Ford Transit Connect Electric, Tesla Roadster and CODA sedan

Are automotive suppliers prepared for a new era in transmission technology?

WORDS: **FARAH ALKHALISI**

Forward, reverse, park: single-speed transmissions are currently fitted in the majority of EVs today, from the exotic Tesla Roadster to the family-friendly Nissan Leaf, as well as the urban, about-town Smart Fortwo Ed.

Given that full torque is instantly available from the start-up of an electric motor, single-speeders have been considered adequate for the first-generation of production-ready EVs – at least in terms of getting trial fleets out onto the roads and delivering cars to enthusiastic early adopters. And while Honda's CR-Z boasts a sportier six-speed manual gearbox, most mass-market hybrids, such as the Honda Insight and Toyota Prius, have featured uninvolving CVTs, with limitations to their refinement and all-round flexibility.

However, demand for greater sophistication, a less-compromised driving experience and better management of the battery range are all factors that increasingly need to be considered when developing transmissions for the growing electric vehicle and hybrid sectors – and a variety of multispeed solutions are now on the brink of production.

A certain ratio

"Multispeed transmissions enable improved launch performance and increase maximum vehicle speed," says William Kelley, VP of research and technology at BorgWarner. "The battery savings can really only be quantified at the vehicle level by the OEM. However, transmission efficiency is a key enabler that can help optimize battery range and cost. The multispeed transmission also enables the motor and generator to be operated in a more efficient range."

Among other e-drive projects, BorgWarner engineers have developed a three-speed version of its single-speed eGearDrive unit that already features in the Ford Transit Connect Electric, Tesla Roadster and the CODA sedan. The technology also features in the Proterra EcoRide BE35 electric bus.

Meanwhile Getrag, whose Smart Fortwo-based BEV demonstrator features a two-speed transmission, is seeing energy efficiency gains of 8% compared with a single-speed transmission, as well as better performance.

"The first gear provides more acceleration torque from standstill, therefore less nominal e-machine torque is necessary", explains Dr Ulrich Knödel, chief engineer on Getrag's eDrive program. "The second gear provides speed, so the power is constant for the whole range. Therefore the second gear can be chosen in regard to best efficiency."

Above: Getrag's 1eDT160 system can transform a vehicle into being a mild or a full hybrid application

Such an engineering setup enables either an enhancement in battery range or a reduction in battery size, as well as the use of a smaller motor, Knödel notes.

In Britain, Zeroshift engineers have started in-vehicle testing of its AMT for EVs, as managing director Bill Martin explains: "Multiple ratios enable peak motor efficiency for more of the drive cycle.

"The simulations are seeing 10% gains. Three ratios are better than two, and we believe in most applications that four ratios would be optimal."

Zeroshift has also developed an eight-speed AMT for hybrid vehicles, as has Aachen-based FEV, which is in discussion with several OEMs. FEV's chief engineer for the project, Kiran Govindswamy, says the benefits of an increased ratio spread in EVs and HEVs include "better efficiency of the traction motor, better trade-off between launch performance versus achievable top speed, and improved efficiency that translates to an extended driving range. Also, NVH is improved, as the motor can spin at lower speeds."

PEDAL POWER

Fallbrook Technologies of San Diego launched its NuVinci continuously variable, planetary-geared (CVP) concept as a transmission for human-powered bikes and electric bicycles. Its application in automotive accessory drives is also underway as it is said to be suitable for such things as lawnmowers and wind turbines. The company's roots in the bicycle business have determined the design and development of the technology.

"The bicycle application demands a combination of low-cost, compact packaging, absolutely stable control, high efficiency, durability under high torques at low speeds and low weight," says Rob Smithson, CTO for business development. "In bicycles, especially mountain bikes, very high torques at zero-to-low speed are common occurrences. The NuVinci CVP, with its characteristic large number of traction contacts to share torque, is inherently suited to this application."

The CVP can be packaged in a cylindrical fashion with a 'U-drive' concentric input and output, and just one belt. Smithson says that its layout "mirrors that of the electric motor, lending it to easier packaging in electric drivetrains".

Such benefits can be shared with lightweight neighbourhood EVs, but larger EV applications are also under consideration. "We believe the NuVinci CVP system is scalable and suitable for a wide range of vehicles," adds Smithson.

> "EVs need at least two ratios. AMTs are the most cost-effective means of providing this without introducing losses"

Types of transmission

Unlike many other developers, FEV believes that AMT architecture is well suited to EVs and HEVs because it is both inexpensive and efficient.

"The only drawback for AMT technology is the torque interrupt that leads to poor shifts," states Govindswamy, "although jerkiness can be eliminated by actively synchronized shifts, reduced shift times and torque fill." Zeroshift's Martin agrees, adding, "EVs need at least two ratios. AMT is the most cost-effective means of providing this without introducing losses."

BorgWarner, however, has experience in DCTs for conventional IC engine vehicles, so it makes sense for the Tier 1 to develop designs based from these existing transmission architectures. "In hybrid applications, the DCT does not have a torque converter, so during the restart (in stop/start mode) you can contain the pump oil flow, enabling a quick pump prime," explains Kelley. "In EVs, the DCT provides high efficiency and low parasitic losses, enabling smooth shifts without torque interruption."

In developing a DCT for such applications, Kelly says the difference is, "the emphasis placed on the electronic communications, which is needed to match the electric machine to the torque and speed requirements during shift events. The transmission enables more robust shifts and control strategies, while the clutch sizing and cooling requirements are lower."

Getrag engineer, Knödel, further explains: "DCT enables a greater flexibility concerning cost, performance and fuel consumption," he says. "We can work with different layout possibilities, either as parallel hybrid with the e-motor between IC engine and DCT; as torque-split hybrid with

The BMW and ZF hybrid transmission:

1 V8 engine with twin turbos generating 650Nm of torque

2 E-motor that develops 210Nm of torque

3 Eight-speed automatic

4 High-voltage electronics

5 High-voltage wire to the battery unit

the e-motor attached directly to the DCT; or as torque-split hybrid with the e-motor coupled to both gear subsets. We are able to use a pre-gear ratio and are flexible for optimized ratios to match gasoline or diesel applications."

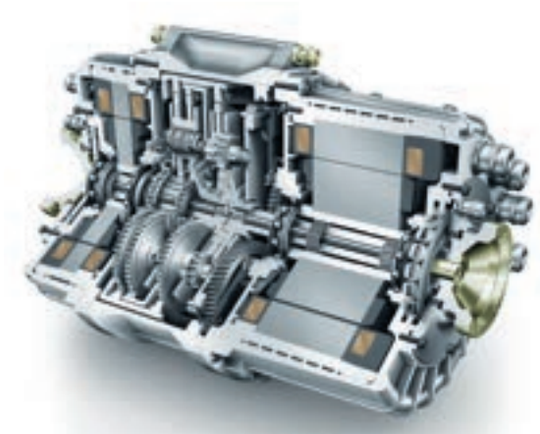
Yet the expansion of this new market also opens up possibilities for innovative and alternative concepts. Zeroshift has its clutchless AMT with a damper inside the gearhubs and electronic motor control, and new start-ups are pitching some interesting solutions, most notable of which is San Diego's Fallbrook Technologies, which is working on a versatile, simple and cheap planetary-geared continuously variable concept called NuVinci.

Above: Zeroshift has started vehicle testing of its AMT unit for EVs

Shift work

The reliability shortcomings of the two-speed design that was initially fitted in the Tesla Roadster and quickly abandoned in favor of BorgWarner's eGearDrive, were an all-too public demonstration of the challenges that remain in the transmission EV arena. Not only does a gearbox need to be tough enough to handle peak torque at high rpm, it has to change gears smoothly without any jerkiness.

"The shift transient needs to be seamless between the transmission clutches and the electric motor torque control," warns Kelley. "Shift feel can be replicated if you want it, but the expectation for EVs is for it to be seamless, quiet and undetectable by the driver."



Left: Schaeffler ACTIVEeDRIVE, which takes center stage in the company's all-new four-wheel drive, battery EV tech demonstrator

FEV's Govindswamy points out that, "for hybrid applications, the key complications are incorporation of stop/start, calibration to optimize all modes of operation and the design of new disconnect/launch clutches."

Such development has led to a plethora of new, novel ideas coming to life. Prototypes of a multi-speed transmission for EVs have begun on-road testing with a European OEM. Designed by Oerlikon Graziano with British control systems specialist Vocis, the concept promises to increase vehicle range or allow reduced battery pack size, as well as providing improved low-speed pull away. Meanwhile, engineers at Antonov have developed a three-speed EV powershift for Jaguar. Netherlands-based Drivetrain Innovations is the driving force behind a two-speed planetary AMT that could evolve into a three- or even four-speeder for EVs. Engineers at Prodrive are working on several projects to integrate electric drives into automated transmissions, and in Germany, ZF has its eight-speed auto with fully integrated electric drive, fitted in the Audi A6 and Q5 hybrids, and the BMW ActiveHybrid 7 model.

As the variety of electric and hybrid vehicles on offer expands, so too will the transmission solutions available. It seems certain that the stop-go-park, single-speed gearboxes on offer today will soon seem archaic and almost laughably crude.

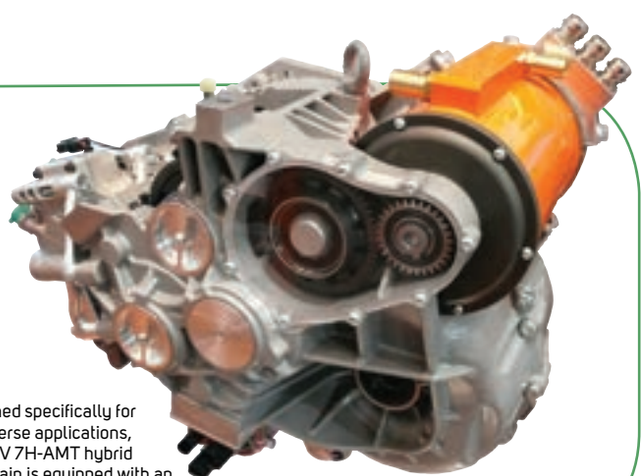
MONEY NO OBJECT?

At a time of general financial constraints for many car makers and suppliers, extensive investment into e-transmissions is nonetheless continuing, despite the perception that this is still a relatively niche market. Smaller start-ups are having to be creative with their more limited resources, however, and look to different sectors.

BorgWarner anticipates accelerated demand in the electric and hybrid sectors. William Kelley says that, "typically, the company tries to match funding levels with growth opportunities in the market. The overall percentage of hybrid and EV components is small but growing." Zeroshift's Bill Martin notes that "the focus of our R&D is changing to suit the needs of our customers. Some of our customers are investing heavily in EVs and hybrids".

FEV claims its approach is not to increase complexity, but to find intelligent arrangements to increase functionality, thus keeping costs on a reasonable level. Govindswamy says there will be increased demand for simple two- or three-speed units for EVs, besides the growing market in conventional and hybrid transmissions.

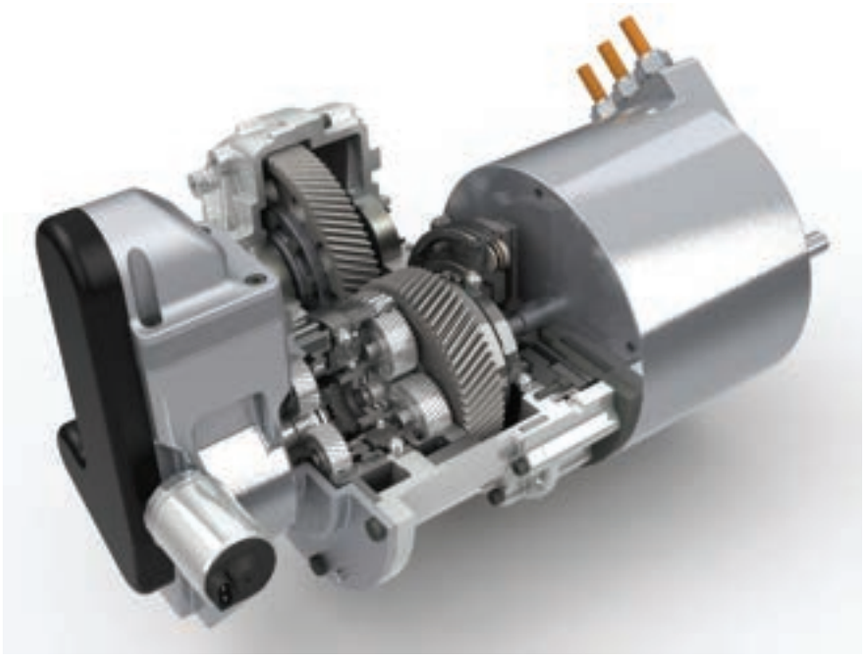
However, Rob Smithson of Fallbrook Technologies cautions that, for its NuVinci technology, "its numerous applications will pave the way for economies of scale in smaller markets, which, taken by themselves, would not be commercially attractive".



Designed specifically for transverse applications, the FEV 7H-AMT hybrid drivetrain is equipped with an electric motor that eliminates torque interruption

PLUG-IN HEV POWERTRAIN

DTI
Drivetrain Innovations

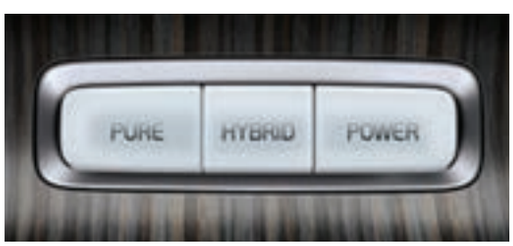


Attributes:

- 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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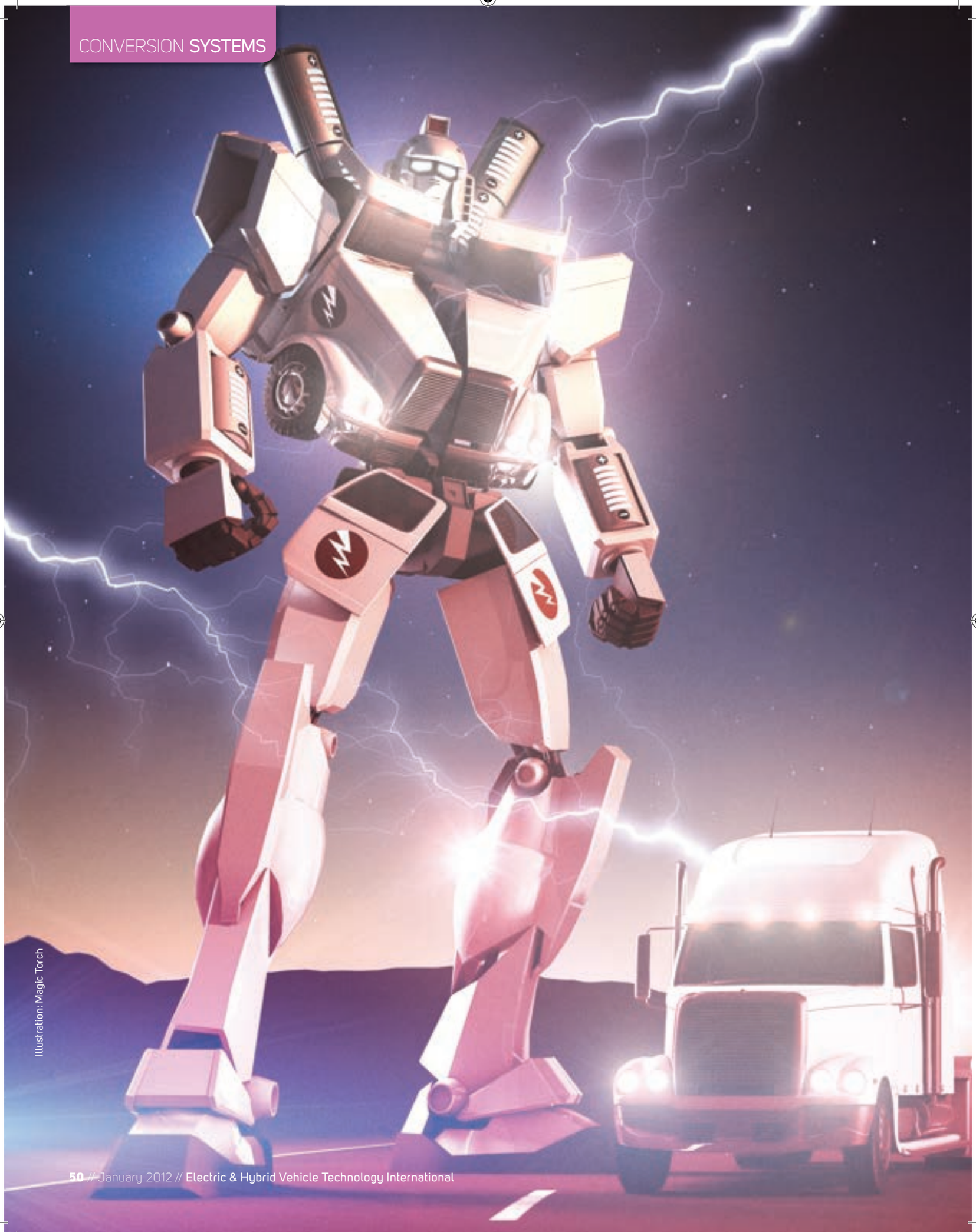
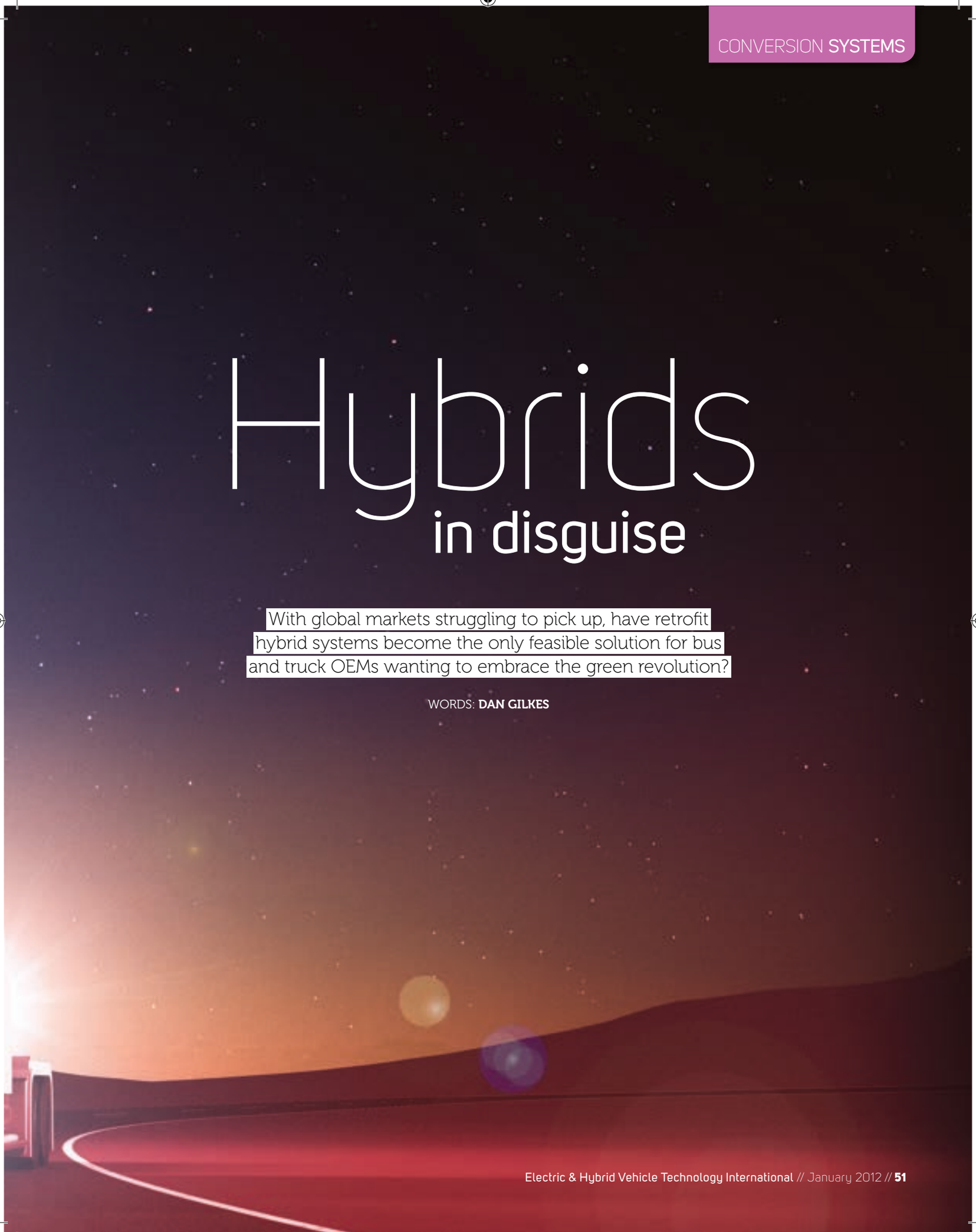


Illustration: Magic Torch

Hybrids in disguise

With global markets struggling to pick up, have retrofit hybrid systems become the only feasible solution for bus and truck OEMs wanting to embrace the green revolution?

WORDS: **DAN GILKES**



"All hybrids are suffering from the cost of technology being very high. The fuel savings are decent, but it doesn't change the basic economics"

HEV motor

We know that the urban bus market has led the way in adopting diesel hybrid technology. After all, continual stop/start operation means that these applications are the ideal candidate for a series hybrid installation, making the most of regenerative braking energy to provide pull-away power and to reduce fuel consumption and emissions.

The truck market, on the other hand, has been far slower to adopt hybrid powertrain technology, partly due to the simple fact that even an urban delivery truck will make far fewer regular stops than a bus. Also, in this world, a weight penalty of a battery pack and motor/generator exists.

Yet despite all this, 2011 has been a big year for OEM hybrid introductions in Europe, with DAF, Iveco and Mercedes-Benz providing production versions of their light and mid-weight delivery chassis. A Volvo FE Hybrid plus a Fuso Canter Hybrid are soon to join the ever-growing, eco-friendly party as the truck industry looks to improve fuel consumption and drive down emissions.

"We have managed to engineer all the hybrid technology into the Iveco Eurocargo hybrid, with only a 250kg payload deficit over a conventional diesel-engined model," says Martin Flach, product director at Iveco UK.

The Eurocargo hybrid is available as a 7.5-ton and a 12-ton gross weight truck, both offering parallel hybrid drive. As with the Mercedes-Benz Blue-Tec Atego Hybrid, the Iveco vehicles use a system developed in conjunction with transmission specialist Eaton.

Above and right: The Mitsubishi Fuso Canter Eco is the latest hybrid truck to be launched. It combines a 123bhp turbo diesel engine with a 47bhp brushless permanent-magnet synchronous electric motor/generator


Iveco's product director, Martin Flach, expects the cost of battery cells to decrease within five years

The 12-ton model, launched in September 2011, comes with an 180bhp EEV diesel engine and a 60bhp electric motor-generator, powered by a 1.9kWh lithium-ion battery pack. The smaller 7.5-ton Iveco unit uses a 160bhp engine with the 60bhp electric motor. Both the engine and motor drive through a six-speed Eaton automated gearbox.

Headline fuel savings are anything between 25-30%, though Flach concedes most operators will probably achieve closer to 15-20%, and even that is driver dependent. He says that at that level it will be almost impossible for an operator to justify the near doubling of the cost of the truck on fuel savings alone.

"All hybrids are suffering from the cost of technology being very high," says the product director. "The fuel savings are decent, but it doesn't change the basic economics.

"If I look at hybrids, they consist of a motor/generator, which is a fairly mature technology; a control system, which will benefit as car volumes improve; and battery technology, which can be as high as half the cost of the vehicle. Once you can get the cost of a cell down, that's where the real reduction in cost will come. But I would expect to see that in three to five years' time."

DOING THE SPLITS

Shown recently at the RWM waste exhibition in the UK, Finnish truck converter NTM is offering a very different take on hybrid power. The company showed a split-body recycling truck with twin Li-ion battery packs mounted either side of the standard Volvo chassis.

However, the electrical system has nothing to do with powering the truck; the batteries are purely used to run the loading, compaction and discharge of the recycling body at the rear.

Charging overnight at the depot, the packs offer 18.5 hours of operation, sufficient for two shifts of collection work. Combined with a stop/start system on the engine – so the truck can be switched off during loading and compaction – NTM is predicting fuel savings up to 20%. The system weighs around one ton using current battery technology, and costs about US$58,000.

Retrofit revolution

But truck and bus manufacturers aren't the only players in the hybrid sphere. A number of retrofit and aftermarket hybrid systems are being offered or trialed, each promising a considerable cost saving over an OEM hybrid.

The Flybus consortium, which consists of kinetic recovery specialist Torotrak, Allison Transmission, bus manufacturer Optare, and engineering specialist Ricardo, is currently assessing the Flybus flywheel hybrid on an Optare Solo Midibus.

"The recovery and reuse of kinetic energy during stop/start drive cycles is a priority for bus operators," says John Fuller, product leader for kinetic energy recovery systems at Torotrak.

The Flybus system uses Torotrak's CVT transmission to transfer kinetic energy to Ricardo's Kinergy flywheel under vehicle braking. As the vehicle pulls away, this stored energy is returned to the wheels, reducing the engine power required to accelerate. "It is about torque control, too," continues Fuller. "You get torque delivery and braking torque at the wheels – so it really is all about torque control."

Above: Torotrak product leader, John Fuller, says a production version of the Flybus system could weigh around 150kg

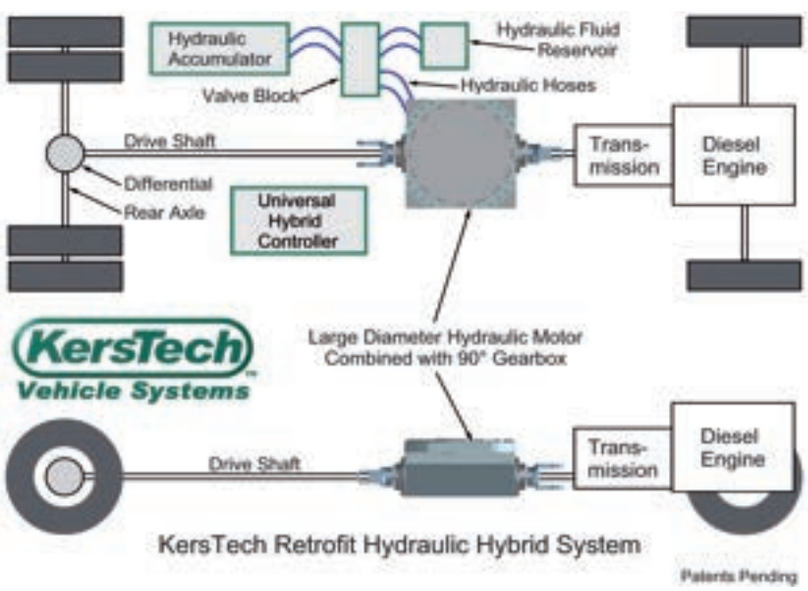
Below: The inner workings of the KersTech system

"We anticipate 80-90% of the fuel consumption and emission reduction of an OEM system, but at less than half the cost of the OEM system"

The Flybus system weighs around 100kg, although Fuller admits this could rise to about 150kg for a production version. However, it can be both an OEM installation or a retrofit to older vehicles, the connection being made through the existing transmission's power take-off.

"There is a very large market for retrofit, as buses in particular last up to 10 years in service," he says. "There is no limit on vehicle size, either, because the system is fully scalable. We are working on a 60kW output, but that could be scaled up to 120kW, no problem."

And since there are no costly batteries involved, there are also potential savings to be made when compared with a conventional hybrid. Fuller continues: "The costing picture will become clearer next year [2012], but estimates are favorable. We imagine the cost will be one-third or less than that of a full electric hybrid. The hardware is running now and Flybus is expecting first fuel results by the end of next year. Then, next year, we'll be looking to get the technology closer to production."



Hydraulic hybrid

One aftermarket system that is available in the USA is the KersTech hydraulic hybrid. Intended for installation on Class 7 and 8 trucks (18 tons and above), the system uses a hydraulic accumulator to store kinetic energy, with a hydraulic motor and a 90° gearbox mounted behind the transmission. Priced at around US$50,000, the system

costs far less than the US$90,000-120,000 premium asked for a US hybrid truck, or the US$150,000-200,000 additional cost of a hybrid bus.

"Our universal retrofit hybrid controller does not fully integrate with the host vehicle's engine management system, to simplify installation on a broad range of vehicles, and so does not match the fuel efficiency of an integrated OEM hybrid," explains Lester Eriston, CEO of KersTech Vehicle Systems.

"We anticipate 80-90% of the fuel consumption and emission reduction of an OEM system, but at less than half the cost of the OEM system, it offers better value, faster payback and a higher return on investment."

The KersTech system weighs about 360kg, plus 160kg for the hydraulic accumulator and oil reservoir. The company is focused on US sales, but given the higher fuel cost in Europe, it is intending to export to overseas markets, possibly through local distributors and manufacturers.

Super-capacitor option

Staying within the US market, another option is available from Variable Torque Motors, of Indiana. Their VTM system can be installed on new vehicles or retrofitted to older trucks, because the system is mounted between the transmission and the drive axle unit. The big difference here comes in the use of super-capacitors, rather than batteries, to store the energy, with less of a weight penalty.

"Our system produces 540Nm of launch torque to the driveshaft and is designed for Class 3 to Class 7 trucks and buses," explains Larry Zepp, the system's inventor. "In many stop/start applications, such as an airport shuttle bus, the VTM hybrid improves mpg by 20-35%."

PASSING THE TEST

Iveco's Irisbus division is one of a number of bus manufacturers making use of BAE Systems' series hybrid technology. The company's Citelis hybrid urban bus series features a downsized 6-liter EEV diesel engine with an electric motor/generator, providing regenerative braking and stop/start.

The OEM has carried out tests in Lyon, France, using a 12m hybrid Citelis with the equivalent weight of 50 passengers aboard. This was followed around the same route by a conventional diesel-powered version of the bus.

Iveco reports that the hybrid's fuel consumption gain was an impressive 39% under non-hilly conditions. This reduced to 33% on a hilly route, and to 29% on an intercity application with higher travel speeds.

The design of the Citelis bus allows the batteries, power converter and cooling circuits to be mounted on its roof. The bus is available in 12m rigid and 18m articulating models.

BAE Systems has so far provided hybrid technology to more than 2,500 hybrid vehicles in the North American and European markets.

All below: The Flybus project aims to cut fuel and emissions for new and existing buses. The innovative technology is currently being tested

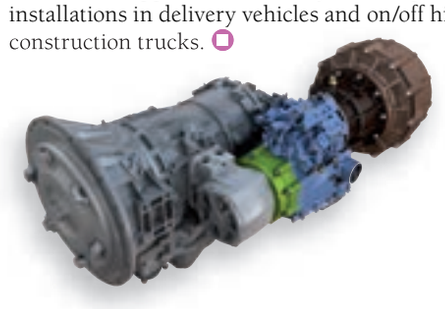
While few delivery trucks stop and start as often as a city bus, refuse collection vehicles (RCVs) do. UK manufacturer Dennis Eagle has joined forces with BAE Systems to trial its HybriDrive system in a Dennis RCV.

Unlike the series hybrid system that BAE Systems supplies to a number of bus manufacturers, the truck system uses a parallel version of HybriDrive. This is because the refuse truck has a need for high-speed diesel power to access depots and landfill sites.

HybriDrive incorporates a Caterpillar automatic transmission and a lithium-ion battery pack that is capable of providing 70kW or 110kW of energy. It offers the option of power take-off from the transmission and electrical accessory power. The system weighs 350-500kg and BAE Systems predicts that fuel savings of about 15-20% should be possible.

"We are confident of achieving payback within the first five years of ownership," adds BAE Systems business development manager, Paul Childs.

The company aims to have the HybriDrive parallel hybrid ready for sale from the fourth quarter of 2012. As well as RCV applications, BAE Systems is planning installations in delivery vehicles and on/off highway construction trucks.



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WORDS: **JIM McCRAW**

It might seem as though Detroit's second largest car maker has most of its corporate eggs in the EcoBoost basket, but that doesn't mean turbocharged IC engines are the only types of designs on the minds of Ford engineers

1. Next-generation Ford Fusion Hybrid will be lighter, far more advanced and boast greater efficiencies than the outgoing model

2. The plug-in Ford C-Max Energi use an Atkinson-cycle 2-liter petrol engine and a lithium-ion battery pack

As Ford's vice president of powertrain engineering, Joe Bakaj is not only extremely busy, but very influential, too. In fact, the former Mazda man oversees all engine and transmission engineering not just on a Detroit level, but globally, helping to shape Ford's powertrain offerings in all markets.

In its home territory, Ford is leading the way in offering US consumers downsized, forced induction engines, and the man that has been steering the company's powertrain direction for exactly a year, says that by 2020, most – but not all – of the car maker's products will feature either turbocharging or supercharging technology. "For instance, those engines we use in hybrid applications won't need forced induction, but I would say the majority of conventional engines by that time will," adds Bakaj, outlining future powertrain trends.

In fact, according to Bakaj, Ford's hybrid and plug-in electric programs are well along their developmental paths, and as such, there will be natural growth in this sector: "The Evos concept we showed at the Frankfurt Motor Show had a plug-in hybrid powertrain, and we are planning to bring out our own plug-in hybrid next year," he says. "We're still on track to launch our Focus electric vehicle at the end of this year. We've also announced that we're bringing out a hybrid version of our next-generation Fusion, so those are the next three programs on the radar."

The man who played key roles in developing a number of Ford Europe vehicles, including Mondeo and Galaxy, as well as the new Fiesta global car, insists that the third-generation Fusion hybrid will see a large number of improvements in terms of size, volume, weight, complexity and efficiency over the outgoing model. Bakaj says that Ford's partners on these programs – Magna on the electric vehicles, LG and Sanyo on batteries, and Azure on Transit Connect Electric – all played important roles, and that these partnerships will naturally vary with the planned production volume and manufacturing capacity of each supplier.

"We continue to be involved in our joint-venture effort with Mercedes-Benz and Ballard, and we're still testing hydrogen cells, but at this point in time we're not doing any full-vehicle work"

NOT YOUR AVERAGE JOE

Joe Bakaj is a Ford man through and through, having worked for the Blue Oval in the USA, Europe and Japan, and it's this rich global experience of key automotive markets that is influencing Bakaj and his outlook in terms of powertrain strategy for Detroit's second-largest car maker.

Bakaj's career can be traced back to 1985, when he received a degree in mechanical engineering from City University in London. Shortly after graduating, he joined Ford of Britain, marking the start of what would become a very successful career. The next three decades would see Bakaj amass more than 20 years of hands-on product development experience at Ford, leading engineering teams based in the UK, Germany, Japan and the USA. His past experiences include powertrain engineering and extensive NVH development, as well as chassis work.

As engineering manager for the Ford Mondeo in 2000, Bakaj played an integral role in helping to create one of Europe's most successful passenger cars.

His career path then took him to Japan, where he was appointed senior managing executive officer in charge of design, product planning and R&D for Mazda, essentially becoming responsible for the Japanese OEM's global development of all products.

Prior to the Mazda posting, Bakaj also worked at Ford in Dearborn as vehicle engineering director for North American truck product development. When he returned to Ford of Europe in 2005, he managed the development and launch of new products, including the 2006 Ford Galaxy and S-Max, the current Mondeo, new Kuga, and global Ford Fiesta small car, which was launched to high acclaim.

In April 2008, Bakaj continued to climb the ranks at Ford, realizing the role of vice president of global product programs, and vice president of product development for Ford of Europe. Such was his success in Europe that Ford's mothership in the USA appointed him vice president of powertrain engineering in September 2010.

"One of the greatest challenges is getting the costs to the point that a program is viable, and then working down the costs so that the sticker price becomes attractive to the customers, and the payback period gets shorter." In specific terms, Bakaj says, "We've done a lot of work on battery management, energy density, battery life and charge management. There's been a lot of work done on the algorithms and how you use the energy, how much energy you can recoup, and how you put it back into the vehicle to save fuel for the customer.

"There's also been good work done on the optimization of the electric motors and how they're blended in, and on power electronics, as well as the cost side. We're also working hard on the gasoline engine itself, so that it is achieving maximum efficiency when it's running."

Several commentators have predicted that Ford plans to offer some kind of hybrid or electric powertrain in everything it sells in North America by 2020, but Bakaj insists that's not the case, citing truck applications as an exception, but also pointing out the company's recent linkup with Toyota to develop hybrid systems for a range of rear-wheel-drive vehicles (see *Pick-up partnership* sidebar).

"We've said that our cooperation with Toyota will focus on rear-wheel-drive utility vehicles,. We've partnered with Toyota because they've also decided to partner with us. We've both concluded that we're working with the best partner in the business.

"We have very good technology in hybrid vehicles, and we believe Toyota has, too. This is not a case of one OEM buying the complete solution from the other; this is a 50/50 effort, with both companies participating equally in the engineering and development of the systems."

Such a focus on EVs vehicles has led some to question Ford's long-term support for hydrogen fuel cells, but the US car maker's powertrain head says such technology is still being reviewed. "We continue to be involved in our joint-venture effort with Mercedes-Benz and Ballard, and we're still testing hydrogen cells, but at this point in time we're not doing any full-vehicle work.

"We are constantly monitoring how far we're progressing with hydrogen fuel cells to get to the right cost point for production vehicles. We really see it further out; we're still engaged in what we consider to be the core work in this area. There are a lot of synergies once you develop an EV; it's a case of plugging in a fuel cell rather than a battery pack. It isn't such a huge job once you've got the rest of the vehicle running full electric. You're just changing the power supply."

PICK-UP PARTNERSHIP

Ford and Toyota's intent to collaborate as equal partners on the development of an advanced new hybrid system for pickups took many by surprise when the news was announced in September 2011. Until that point, both companies had been working independently on their own future-generation rear-wheel-drive hybrid systems, but have now committed themselves to working together to develop a new hybrid powertrain.

The partners say that by working together they can deliver hybrid technologies to customers sooner and at a better price point than if they worked alone. Derrick Kuzack, Ford president for global product development, added: "This agreement brings together the capability of two global leaders in hybrid vehicles and hybrid technology to develop a better solution more quickly and affordably for our customers. Ford achieved a breakthrough with the Ford Fusion Hybrid, and we intend to do this again for a new group of truck buyers, customers we know very well."

Takeshi Uchiyamada, Toyota executive vice president for R&D, said: "In 1997, we launched the first-generation Prius, the world's first mass-produced petrol-electric hybrid. Since then, we have sold about 3.3 million hybrid vehicles. We expect to create exciting technologies that benefit society with Ford, and we can do so through the experience the two companies have in hybrid technology."

Although the hybrid system will share significant common technology and components, each company will determine the calibration and performance characteristics of their respective models that use the new

Bakaj says hydrogen fuel cells are still on his radar. Pictured left is the chassis to Ford's HYSeries plug-in hydrogen fuel cell that was jointly with Ballard

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Comeback king

Having very nearly been sold off in a quickfire sale two years ago by the mother ship in Detroit, **Opel/Vauxhall's** turnaround is complete with the launch of the Ampera. And there has never been a more exciting time to be a powertrain engineer for GM Europe, says Jeffrey Lux, vice president of powertrain engineering for Opel/Vauxhall

WORDS: **DEAN SLAVNICH**

In terms of new powertrain development for GM Europe, is emissions reduction now the top priority, even over performance?

I really like to consider fuel economy and CO_2 as more or less the same thing – they are two different measures of the same fundamental issue. So, if I talk about emissions, I'm talking about classic emissions control like CO, NOx and hydrocarbons. In that case, the standards are already very low, and it's a given that you have to meet these standards because it's a legal requirement to sell the car(s). At a market level, though, I don't think the end consumer thinks about these issues any more. Maybe, once upon a time they did [think about this] – like if you look at the introduction of DPFs, which was a case where there was a market pull for a specific emission technology even though it should have been a 'who cares' thing, but there was some clever marketing around that technology. So, we now discuss more performance or [less] CO_2 and fuel economy. Well, I like to think at both ends: you either have to think that for a certain CO_2 target you have to deliver the best performance and driveability, or the other way, at a certain driveability/performance attribute, you have to have the best CO_2. There's very much a market competitiveness aspect around that, partially because car buyers are concerned from their own perspective about the price of fuel, but then when you couple that with the tax incentives that governments offer, it's a tremendous way to move the market and move consumer behavior and consumer demand.

Do diesel hybrid powertrains and diesel range extenders make sense?

We've looked a lot at that, but the thing about the Ampera is that what we see from the usage profiles from the people that have bought the sister car – the Chevrolet Volt

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in the USA – is that customers look at it as an electric vehicle. So, it's an electric vehicle that the owner is recharging. You're only using the range extender engine once in a while, and as a result, you'll want the most economical range extender possible, which turns out to be a petrol engine. I can't rule out diesel range extenders, but at present it seems to make most sense that it's paired with a petrol engine.

But a diesel offering was looked at during Volt development?

We looked at it – and we continue to look at things that might make sense in the hybrid diesel space.

Is there a concern that the range extender will only be around for a few years until full EVs have a much greater driving range?

Personally speaking, I'm not scared that this technology will only be around for three years or so. Ampera represents a better value proposition for the customer. For example, if I'm a customer of a Nissan Leaf, yes it does everything I need when I'm around town, but if I need to go to other places, I'll either need to rent a car or own a second car. I think the range extender is a really powerful concept.

Some academics say that the industry is merely reinventing the wheel: today, we have IC engines running on crude oil; tomorrow we'll have EVs running on lithium-ion. Are we simply swapping dependence on one natural resource for another?

All these technologies move in phases and you've got to take the first step before you can take the next step, so who knows where it all leads. Will lithium batteries be with us as long as petrol and diesel engines? Who knows, it's too early to say. When you think about it, this is probably one of the most disruptive times for powertrain technology in the last 110 years. You have to go back to the turn of the last century and at the dawn of the automotive era when there were a lot of competing powertrain technologies: there were electric vehicles, steam power, diesel and gasoline engines, and it all quickly consolidated on petrol and diesel. It'll be interesting to see what happens in the next 20 to 30 years.

Forced-induction, downsized engines – such as this Corsa turbo unit – represent the future for IC powertrains, especially in hybrid applications and range extender vehicles

"You're only using the range extender once in a while, and as a result, you'll want the most economical range extender possible, which turns out to be a petrol engine"

Below: Opel is taking part in the MeRegioMobil research project with three EVs based on the Meriva

Are hydrogen fuel cells the endgame?

We are very active in this area, what with our demonstration fleets. We are very bullish on hydrogen, but the key there is how does the infrastructure develop? I think that from the perspective of the customer use of the vehicle, it looks so much like how the customer uses the vehicle of today that it would be hard not to say this is somehow the endgame. However, we are dependent on the infrastructure, and I don't know how enthusiastic governments will be to spend billions of dollars – if not more – to create that hydrogen infrastructure. So, it will depend on how things develop once we get some of those vehicles out.

From an engineering perspective, are you concerned about the platinum count of hydrogen fuel cells?

Right now, if you look at our generations of learning, we see a path where we can at least get it close to the amount of platinum that we have in catalysts. So, if you then think about the potential to do recovery from old catalysts and other such things, you're not so far off.

Do you think the industry has forgotten about hydrogen fuel cells?

The industry hasn't, no. There are at least a couple of other organizations – Daimler being one, Honda being another – that are still pursuing hydrogen fuel cells. It's something that you almost have to have spent some time

1

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with and invested in to get to a certain point, and if you've been doing that all along, I think your game looks more realizable. If you haven't been doing that, then maybe those companies are trying to now figure how to do so.

How excited are you about GM Europe's powertrain future?

It's a really exciting time for us, absolutely it is. There are lots of new products alongside the Ampera, but I'm really proud at how this particular product offers the market a practical electric car that can be somebody's only car – so it can be used for a daily commute to work but also on longer, family journeys as well.

With the electrification of the powertrain gaining momentum, what do the next 10 years hold for the IC engine?

There are two things I'd like to say about this matter. First, for the V6 and V8 engines in North America, there will continue to be a utility truck market that will have

3

1. The Volt technology will be used in other applications and GM brands, such as an MPV range extender offering

2 and 3: GM Europe continues to work hard to further develop hydrogen fuel cells. The HydroGen4 research vehicle has been designed to have a lifespan of 45,000km, but GM's next-generation system will last up to 200,000km

larger engines. I do think you'll see V8s move down to V6s and V6s move to fours – and that's in North America. Here, in Europe, I think there's still going to be an ever-smaller population of eights and sixes – there aren't so many now and there will be even more of a squeeze. However, I think you will see these V-engines replaced by high-performance four-cylinders and then even three-cylinders and two-cylinders too, like what Fiat has. Small, IC engines are here to stay. As for how long do I see IC engines being around for? Well, quite a long time, to be honest – two decades easily. The reason being is that I think you'll see increasing electrification used with a petrol or diesel engine, but the IC engine will be there and used as a basis.

With such downsizing taking place, does that mean that GM North America will very soon have only forced induction IC engines on the market?

There's no denying the trend around downsized boosted engines, but are all engines in North America going to be boosted? No, I don't think so. There will always be naturally aspirated engines available because you still have to reckon with the cost of turbochargers. However, as you get to more and more challenging emissions regulations, be it CAFE or other greenhouse gas standards, there will be more of a push toward downsized boosted engines.

Finally, by 2020, what will GM's cars in Europe mainly be powered by?

I think in that timeframe, it'll still look like today, so half petrol, half diesel and a growing share of hybrid and electrified powertrains, which will be a thin end of the wedge that will grow some more.

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Mass appeal

Words: Farah Alkhalisi

SEAT is embarking on an e-mobility program that focuses on creating mainstream, affordable EVs – something that is easier said than done

SEAT is sending a 12-car test fleet of EVs and plug-in hybrids out to Spanish governmental institutions, with a view to launching the latter in 2015 and the former in 2016. These are indeed grand electric plans, and the market will see this as a statement of intent: SEAT is preparing itself for a new powertrain direction.

Both the Altea XL Electric and León Twin Drive have been developed at SEAT's technical center in Martorell, and the Catalonia-based facility is now preparing to build production models using the EV technology showcased in the two tech demonstrators. These upcoming EVs will be variants of IC-engined cars in the SEAT range, rather than standalone models, and they will be built on the same production lines.

While the powertrains in both test vehicles are effectively the same as those in the other VW Group EV and plug-in prototypes, the Martorell team has been specifically tasked with creating the e-powertrains to be accessible and affordable for the mass market, which means there are plenty of challenges to overcome. "We need to bring down the cost," states Dr Matthias Rabe, VP for research and development at SEAT. "We have to scale our efforts and share our core technologies."

At the moment, a León Twin Drive costs roughly five times as much to make as its conventional IC-engined equivalent – but a price premium of between US$3,400 and US$4,000 over a comparable diesel model is targeted for the launch in four years' time.

A 20-person specialist group will work on the battery integration, and while SEAT has confirmed that it is working with Sanyo and Spanish tech company Ficosa on a plan to build batteries in Spain and Portugal, final supplier contracts have not yet been signed. "There won't be just one supplier," admits Rabe, "but we will not limit Ficosa and Sanyo to the Iberian peninsula; they will supply to some other locations. We will be in discussion with the Volkswagen Group, and conducting all activities in the pre-development phase with a lot of battery suppliers."

León Twin Drive

Like the latest Golf Twin Drive, the León has a 1.4-liter TSI petrol engine producing 115bhp, and an 85kW electric motor, giving a total 163bhp when both are engaged. Its all-electric range is 52km and overall range is up to 900km, with average fuel consumption being in excess of 166mpg, and carbon dioxide output of just 39g/km. Top speed is 170km/h.

The León Twin Drive combines a 1.4-liter TSI powertrain with an electric motor to boast a driving range of 900km

The two powertrains can work independently or in parallel. The Twin Drive starts in all-electric mode (the battery will only drain to a defined level, thus always giving enough for ignition), and it can run in 'e-mode' – which remaps the throttle for heightened efficiency – at up to 120km/h. The engine starts up to work in series for recharging, acting as a generator to produce electrical energy, but not driving the wheels directly. When higher speeds or sudden bursts of acceleration are

required, the clutch is engaged and acts in parallel with the motor in sending torque to the axle. A 'sport' mode, selected via the gearshift lever, sharpens up the acceleration and brakes.

This versatile – if somewhat complex – solution could suit a variety of owner needs or tastes, without compromising on range or performance. With this in mind, SEAT sees more of a role for plug-in hybrids than pure battery-electric vehicles in the near-to-medium term: a projected 10% of its sales in the next five to six years, forecasts president James Muir.

Keeping options open

"But one technical solution will not be enough," says Rabe. All-electric technology is currently being tested in the Altea XL Electric, which has an 85kW motor delivering 270Nm of torque from start-up, and a top speed limited to 135km/h. Recharging takes eight hours from a domestic supply or two hours on a fast-charger, and there are solar cells on the roof that collect energy to power the ventilation system. The batteries are housed under the rear seats and in the transmission tunnel, so luggage space and rear legroom are unaffected.

Transmission is via a single-speed reduction setup, with a selectable 'S' mode giving extra engine braking to augment energy capture under deceleration. A further selectable 'range' mode that limits top speed to 115km/h, turns off the air con and heating, and remaps the throttle response, is an extra emergency measure, say engineers, to get drivers to a charging point as energy-efficiently as possible.

SEAT is ready to accelerate the introduction of both technologies if it proves expedient. However, company forecasts for near-future EV sales are relatively modest (3-5% of sales in the next five to six years), and there are issues still to be resolved – namely the recharging infrastructure. This is being researched by an initiative called Cenit VERDE, a partnership led by SEAT that includes technology companies, universities and research groups across Spain.

"This reinforces that SEAT's home in Martorell is a leading center of excellence in the arena of e-mobility. We want to be a clear leader in Spain and we are well on track," states Rabe. "It is acknowledged in the VW Group that we have the competence in development and integration."

The León Twin Drive (left) and the Altea XL Electric (above) represent the start of SEAT's EV program. Both vehicles will be launched in the next five years

A SUSTAINABLE PRODUCTION PLANT

It is not just SEAT's cars that are getting greener. The Spanish OEM is also committed to eco-friendly production, which means a number of emission-reduction processes have been introduced at its Martorell plant. Firstly, there has been the implementation of EuroEnergest, an energy consumption monitoring system that enables more efficient energy use and savings of 3,900 tons of CO_2 per year. Then there has been an increased use of rail for transporting finished cars. But most significant is the 'SEAT in the Sun' strategy, which has allowed the base to have the largest rooftop photovoltaic facility in Spain, and the biggest of its kind in the European automotive industry. Equally innovative has been the decision to install the photovoltaic cells on temporary holding areas. Capacity has doubled from 4MW to 8MW with the start-up of a new stage. Next year will see the completion of this project with connection of the final stage, taking installed power to 10.6MW, allowing CO_2 to be reduced by 6,200 tons per year.

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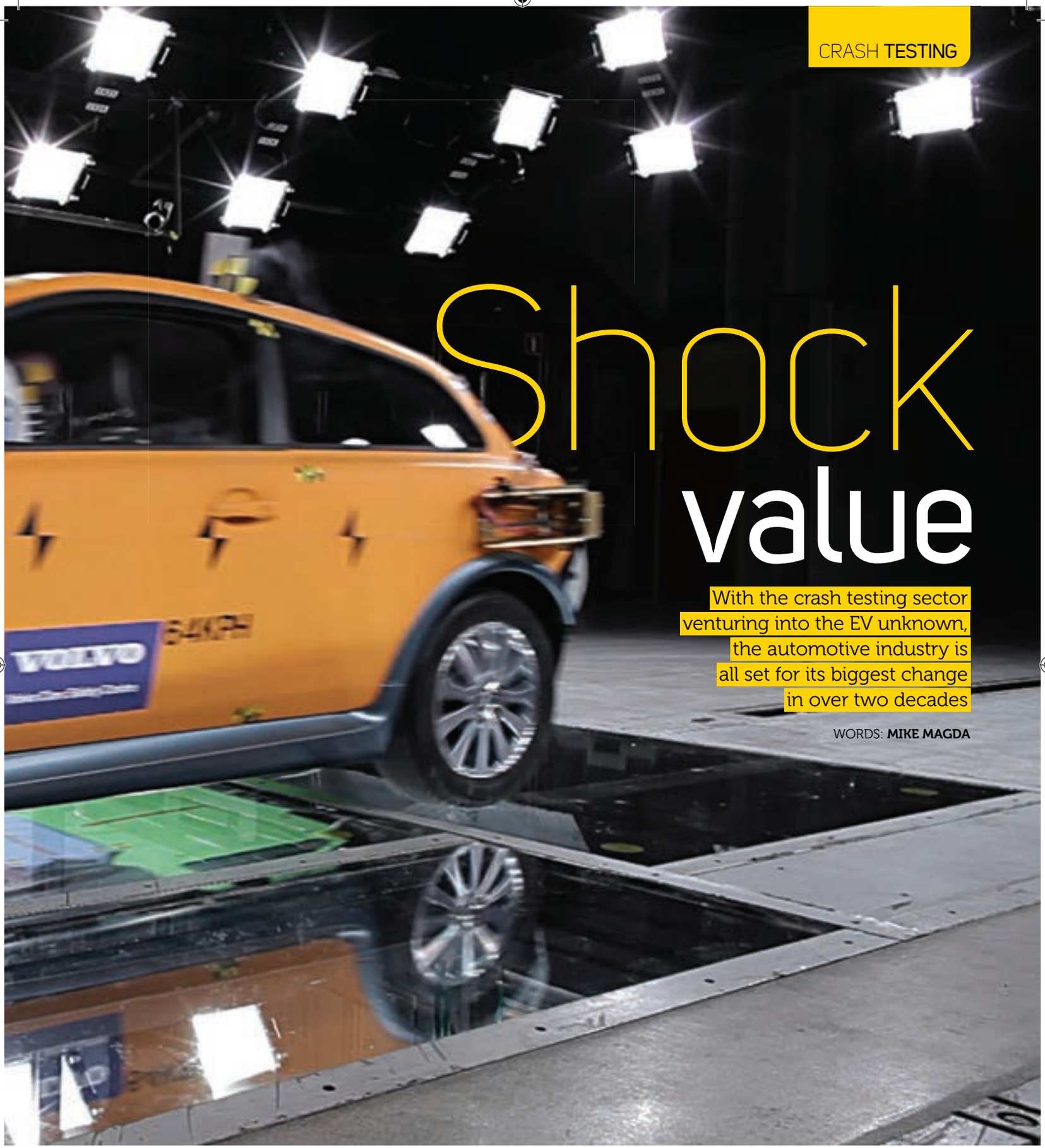


Shock value

With the crash testing sector venturing into the EV unknown, the automotive industry is all set for its biggest change in over two decades

WORDS: **MIKE MAGDA**

Reassuring consumers that EVs and HEVs are safe from high-voltage mishaps will be a crucial part of marketing battery-powered cars. After all, the sector is already a fruitful source of material for joke writers, with many favoring: 'What do you call the shock absorbers on an EV? The passengers!'

It is also a target for television personalities: David Letterman, on US TV, pretended to receive a shock when he touched a Chevrolet Volt. Then there was even a celebrated, albeit totally exaggerated, story that Ford boss Alan Mulally stopped then-US President George Bush from plugging an electric power cord into the hydrogen port on a concept hybrid fuel-cell vehicle – thereby saving the leader of the free world from instant vaporization. Although Ford officials apologized for generating what was clearly intended to be a satirical gag, that didn't stop such headlines as, 'Bush Nearly Turned Hydrogen Car into the Hindenburg'.

GM is not new to crash testing electric vehicles, such as the Volt pictured above. The US car maker gained valuable experience in the 1990s with the EV1 project

Safety measures

So, with all that in mind, car makers are now showcasing crash test videos and photos of their latest electric cars to ease buyer anxiety and advance safety technology that's designed to isolate the high-voltage power sources from vehicle occupants. To back up the high-profile safety promotions – as well as meet new government regulations

A WHOLE NEW OUTLOOK

It's one thing to get OEMs' perspectives on EV validation, but what's the take from independent vehicle test and development organizations? To get a clearer picture, *E&H* visited Millbrook Proving Ground in Bedfordshire, UK, which has a crash test facility that has so far conducted around 30 different tests on six different EVs, including an NCAP assessment. Such experience has enabled the lab to develop EV test methodologies to improve safety. Simon Jones, (above), head of safety and structural development at Millbrook, has been managing these tests, both for OEMs and for smaller companies making aftermarket electric vehicle conversions that want to be sure their changes don't affect overall crashworthiness.

"EV crash testing is different and you need to know what you're doing," states Jones. "You need to take special precautions to test safely. The majority of the crashing is the same, but you have different potential outcomes, which you have to manage safely. The majority of work is checking you test in a safe way.

"The crash testing is quite a lot more involved," he continues, "because you are testing in unusual circumstances. The fact is that you are actually testing with a live battery. You're testing a motor where the engine is turned on, and you've got it in neutral, but it's akin to testing a petrol vehicle with a tank full of fuel and the engine running, which is not something you do. So there are two elements you have to consider: the testing is different, and the things you have to measure are different."

So what specific problems has the lab discovered to date? "The precautions you have to take in the laboratory are quite different, and you have to consider the risk of electric shock post-event. The new European regulations require you to make some measurements within 60 seconds of the impact, which is challenging when you've got health and safety issues regarding approaching the vehicle. Probably the biggest thing from a laboratory point of view, considering it's a crash area, is the fire risk with current battery technology. Most lithium-ion batteries contain an organic solvent, which is flammable. There are bits that make up the battery from the lithium side that will dissociate in a fire exothermically, and will potentially produce oxygen as well, so you've got something that can potentially produce a thermal runaway. You have to manage that, and manage it safely. We once crash tested a Li-ion battery and it burst into flames."

Despite such problems, solutions have already been presented to help crash test EVs safely. "We use thermal imaging cameras to check hot spots on tests. But really our only methodology is to contain the heat within the vehicle itself and prevent it from expanding to the laboratory as a whole. The issues that you used to get with EVs where the batteries exploded are now managed very well. Vehicle manufacturers have put a lot of effort into making sure that there are ways of venting the pressure. The batteries are sealed, so if there is a problem, there's nowhere for the gasses to go, so pressure builds up. As I said, it's akin to testing with a fuel tank full of fuel: you have to consider how you do those tests a lot more carefully. It's not that the vehicles themselves are inherently less safe; it's the nature of the testing that makes it harder to do.

"We are looking at adapting our multi-action shakers to provide a means of vibrating the batteries and cycling them electrically, but again there needs to be consideration of how you manage the fire risk. Going forward, we're looking at secure extraction methods after the crash. So basically, we have a way of moving the vehicle from the building immediately post-test, while not creating a safety issue for the staff."

– manufacturers have improved their crash-test strategies, developed new proprietary equipment and initiated extra cautionary procedures in their crash test facilities.

Even independent crash test bodies such as the USA's Insurance Institute for Highway Safety (IIHS) and Euro NCAP are addressing the challenges of testing full electric vehicles as well as hybrids. The Mitsubishi i-MiEV – and its stablemates, the Citroën C-Zero and Peugeot iOn – was the first electric vehicle tested by Euro NCAP, and officials said that only specially trained personnel were allowed in the crash lab. Extra firefighting measures were put in place as NCAP specialists covered new crash testing ground.

"We coordinate very carefully with the manufacturers to understand if there are any special precautions we that need to take from a worker safety standpoint," says chief administrative officer for the IIHS, Joe Nolan, noting that the group's additional EV-related activities are more "preparatory, not crash-related".

IIHS technicians disconnect the main battery when mounting instrumentation, but no special measuring equipment has been developed for their EV tests. They also consult with the OEM to ensure the battery is reconnected properly before testing begins.

"The only other tool we've used is a multimeter," adds Nolan. "We measure the voltage of the chassis relative to the ground after the test, just to make sure there hasn't been a compromise. So far we've not seen that."

"If you don't have a badge that says you're Volt trained, you stay away from the car"

As for the ever increasing use of new, lightweight materials in green vehicles, Nolan adds, "It's a theoretical concern but so far we've not observed any problems in our crash testing."

EV1 expertise

Tapping into its experience from the EV1 program in the 1990s, GM, in many respects, had a head start in crash testing the new Chevrolet Volt and other hybrids it has been hurriedly developing of late.

"Some things were carried over that we used as foundations, and some things we understood as a result of our experience with the EV1," outlines Brian McGee, performance integration team leader for the Volt program. "But there aren't many parities because of the dramatically different technologies."

Key to the program's specific assessments is a new high-voltage isolation module (HVIM), that's been designed and built totally in-house. Different interfaces were created to test other battery-powered vehicles, including

Millbrook has readied itself for the growing EV market by investing in new crash test and development systems

This solution will use rails or a caddy system. Millbrook is looking at adapting the end wall of the crash facility, so that some side or rear impacts can be conducted there. "At the very early development stages of tests, we may need to take a higher level of precaution regarding those risks, so we can conduct tests outside. Once we've reached a certain level, we have a much higher level of confidence that those problems are being resolved. The risks are pretty low; it's just that the consequences of not managing them well are severe."

One of the big risks is related to electricity. Safety regulations focus on electrocution, and as such, specify a series of measures. For Millbrook, this means ensuring that the customer attending the test is qualified, and an expert is on site to handle anything out of the ordinary. "If there's 600V on the chassis after the test, we need someone who can shut that down. We can make the measurements, but turning it off is very much the vehicle manufacturer's job," explains Jones.

The team ensures the vehicle is electrically isolated before anyone touches it post-crash, and they have moved toward testing with the service plug removed. This plug connects all the battery cells. When it is removed, the battery is still connected but there is no current path, which reduces the risk of electrocution. Following the test, the plug can be reconnected in a lab environment for further tests.

However, safety officials are making the job riskier, says Jones. "Euro NCAP, and some other tests, require you to test with a live battery. If you're testing with a live battery, you need the ignition in the 'on' position to check that the disconnect circuitry and battery management systems work properly, so you are often just a nudge of a gear-lever away from the vehicle driving off. So if you do a crash test and the throttle jams open, or the arm of a dummy knocks it into drive, the vehicle could drive across the lab."

Further problems come from the very nature of the tests, which require that the systems are altered in order to add measurement equipment. This is not a new concept, but it is still troublesome, as Jones explains, "It's like someone testing the integrity of a petrol tank by drilling a hole into it for a pressure transducer – the most likely place the tank will fail is where you tapped into it. It's the same with electrics. If you want to test them you have to get into the conductor, which means going through the insulation. So you need to try to splice into connectors in a way that won't cause a problem in itself. Also, good battery management systems will detect anything out of the ordinary, so to measure the isolation resistance of the chassis, for example, you switch a resistor on the live side of the battery and the chassis. Some management systems won't like that and will shut the system down, making it impossible for you to make that measurement. So we have to work a lot more with the vehicle manufacturer than we would normally."

Clearly there is still work to be done, but Jones finishes on a positive: "EVs are not unsafe. If you invented the petrol car now and told the public it would have a thin-walled plastic bag filled with 70 liters of highly flammable liquid, they wouldn't be comfortable about driving it. Familiarity and good design remove those problems. The same challenges exist now, as EVs are a step change. Engineers need to make sure they have considered the implications of those steps, which will take good design and a lot of imagination from designers to make sure they have covered all scenarios."

the two-mode hybrid offerings. For the USA specifically, these tests ensure the vehicles meet FVMSS 305 standards, which cover electrolyte spillage as well as electrical shock protection.

"We also have internal safety strategies that go beyond Federal regulation," adds Keith Schultz, senior manager of global vehicle high-voltage electrical and battery safety at GM. Schultz says GM didn't stage crashes specifically to monitor high-voltage concerns, but rather rolled out new tests into the existing strategy that involved more than 50 full-scale events on the Volt. "At least two-thirds of those had rigorous high-voltage evaluations," adds McGee.

Although not directly driven by advanced-vehicle technology, new cameras for recording the crashes were installed. Officials say that the test dummies were not modified with electrical-sensing capability as an element of the high-voltage testing.

"If your high-voltage circuits are isolated from the chassis or body structure of the car, that's how you ensure the occupants are safe," explains Ed Hadfield, a crashworthiness test engineer at GM.

Special measures

OEMs across the globe are also taking extra precautions in the lab to address any post-crash EV problems that could result from electrical shorts or fires.

"We did our first test outside the lab because we were not sure about all the things that could happen inside the lab," admits Jan Ivarsson, manager of safety strategy and requirements at Volvo, when discussing the company's

NEIGHBORHOOD WATCH

The USA's Insurance Institute for Highway Safety (IIHS) has conducted crash tests with small EVs, classified as low-speed vehicles (LSV), not to evaluate their crashworthiness but to demonstrate how vulnerable they are in a collision with conventional, IC-engined small vehicles.

Also known as neighborhood electric vehicles, these cars are required to have seatbelts, headlights and a VIN. They are limited to 25mph and were originally intended for use in low-risk, controlled environments, such as gated communities.

But as pressure grows to promote EVs, more states are allowing LSVs on roads where the speed limit can reach 45mph. Officials claim LSVs are an inexpensive and cleaner alternative to conventional A- and B-segment cars.

"Our concern is not that these vehicles exist but that localities are expanding the allowable usage," says Joe Nolan of the IIHS, noting they are likely to be on the "losing end" of a collision with larger

conventional vehicles. "Our test was a demonstration," he adds.

The IIHS tested two GEM e2 EVs, built in the USA by a subsidiary of Chrysler. Both were side-impact tests: one with a moving deformable barrier at 31mph and the second with a Smart Fortwo – the smallest vehicle in the USA that meets conventional crash-test standards – as the striking vehicle at 31mph. In both tests, measurements on the GEM crash dummies indicated serious injury or fatality. The Smart performed well.

IIHS officials said after testing, "It's obvious how devastating the side crash is to the GEM. It doesn't resist the crash forces at all." Supporters of LSVs say most owners understand the limits of their vehicles and will avoid larger, fast-moving traffic.

BEING SAFE - SWEDISH STYLE

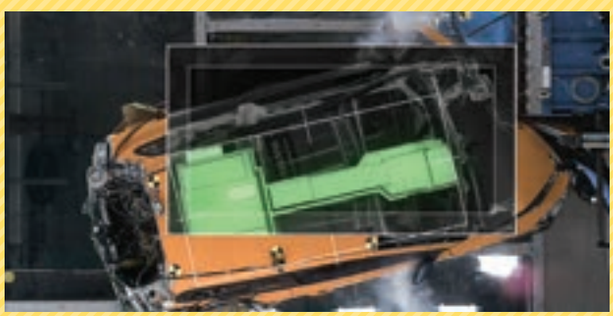
Volvo is very proud of the crash results for its C30 Electric, which had a fully charged EnerDel lithium-ion battery when it was tested at Volvo Cars' crash test laboratory. The crash was an offset collision in which 40% of the front hit a barrier at 40mph.

"The test produced exactly the results we expected. The C30 Electric offers the very same high safety level as a C30 with an IC engine. The front deformed and distributed the crash energy as we expected. Both the batteries and the cables that are part of the electric system remained entirely intact after the collision," says Jan Ivarsson, senior manager for safety strategy at Volvo Cars.

To ensure safety, Volvo decided to separate the 300kg battery pack from the crumple zones. This was achieved through EnerDel's expertise, whereby a 'split battery' was developed, with half the battery located in the central tunnel between the seats and the other half under the rear seats where the gas tank would normally be located. The BMS is integrated with the electronics and the vehicle control systems, and in the event of a collision, the crash sensor cuts power in 50ms using the same signal that deploys the airbag.

The system has several fuses that cut directly if a ground fault is detected, such as a damaged cable coming into contact with the body frame. The BMS also optimizes capacity and actively prolongs cell life, monitors and reports the state of health and charge, and controls safe and efficient pack recharging and cooling for safe operating temperatures. It has multiple levels of redundancy built in to its control protocols for extra-safe operation. This is important, given the vehicle's 400V electric system.

Further challenges were posed by the absence of the engine that features in the conventional C30 design. For example, a regular C30 has an IC engine to help distribute incoming collision forces. In the electric version this task is performed by a reinforced frontal structure that also helps absorb



Safety levels of the C30 Electric have been boosted thanks to a split battery design. Volvo management has insisted on the C30 Electric to be just as safe as the IC-engined version

the increased collision energy created as a result of the car's added weight. In addition, the batteries are robustly encapsulated, beams and other parts of the car's structure around the battery pack are reinforced, and all the cables are shielded.

Further to the frontal full-scale tests, the C30 Electric has been subjected to other scenarios such as side and rear impacts. "For us, the technology behind electric power is yet another exciting challenge in our drive to build the safest cars in the world," adds Ivarsson.

Controversy plagued the Ford Pinto during the late 1970s due to its fuel tank

IN YOUR ELEMENT

Electricity may be dangerous to engineers inside the lab, but a hydrogen accident can upset the local area outside. As a result, testing with care is a necessity

"With hydrogen we wouldn't test the full 700 bar in an indoor facility, though to be honest the tanks are a lot more vulnerable at lower pressure," says Simon Jones, head of safety and structural development at Millbrook, when quizzed about hydrogen fuel cells.

"We have done many tests on hydrogen storage tanks, including drop tests and detonation. It's like stamping on a drinks can; if it's full and you shake it up, you might twist your ankle. If you let the gas out and stand on it, it will crush. The same applies to pressurized tanks. You're better off conducting the tests, in my opinion, under lower pressure and then, in post-testing, evaluating the performance of that tank related to high pressure. You have quite a lot of other things to consider post-test, such as the electrocution risk, which is quite high due to the various different electrolytes."

Pressurized gas storage, says Jones, is a challenge and needs the people involved to be fully educated and aware of what's going on. "A 700-mile tank tested to detonation makes quite a big bang, and you have to work out how to safely vent it in the event of a fire.

"For example, we investigated a crash involving an exploded CNG tank, which turned out to be caused by acid ingress from the battery of the vehicle that rear-ended it. The car was repaired following the crash, but after a few more fill-ups, the tank exploded and killed the driver because the acid from the battery had contaminated it. It's critical that you understand new materials, how they behave, and the consequences."

Tests have shown that packaging is key to when using hydrogen power. Jones continues: "From a crash point of view, it is important where you put the additional mass. If you put it in the front, it creates less of an issue in terms of mass, because it deflects against what you're hitting in the front. If you put it in the rear, it will soften the crash pulse, which increases intrusion, so you have to manage that.

"Hydrogen tanks are almost bulletproof – you'd have to use an armor-piercing bullet to get through one as they are made of material much like bulletproofing material, and are very thick to contain the pressure. So they won't crumple, but if you put them either side of the fuel tank and someone drives into the side of you, they will displace and rupture the fuel tank before you get to the crush zone.

"In the late 1960s there was a lot of work on fuel tanks and litigation in the USA with Ford and GM. We saw a case where, to fit batteries into a hybrid, someone moved the fuel tank behind the rear wheel. So the problem is not necessarily the new components and subsystems that you're introducing, but how you manage those that you're displacing. You also have to consider, if fitting a battery and motor into the same space, you then have a smaller gap under the body to protect pedestrians."

C30 Electric test-fleet program. "We had positive results and then moved into the lab. We've made no changes to the lab but we do now have a higher level of rescue possibilities in the event of a failure."

Ivarsson says Volvo already had systems in place to measure airbag deployment technology that trigger battery shutdown and isolation. "Then we added new sign-off tests for [high-voltage battery] installation."

An independent focus

Based on the same platform as the Volvo C30 – but with very little else in common – is the new Ford Focus Electric. Even though the Blue Oval has experience in testing the Fusion and Escape hybrids, the team in charge of the Focus Electric is taking a more independent direction.

"We're up to verification prototype level testing right now," explains Matt Makowski, Ford crash safety engineer. "We are using some equipment to evaluate high-voltage and battery-cell damage, and we are also developing the procedures to measure damage or exposure from high-voltage cables, pre- and post-crash. The way the batteries are assembled and put into this vehicle requires us to use innovative equipment."

The Focus Electric crash program is a separate entity from the normal Focus model, which underwent 12,000 virtual and real-world crash tests. Makowski says that a

"We did our first test outside the lab because we were not sure about all the things that could happen inside the lab"

A Volvo C30 Electric undergoes a 30mph pole test. The EV's Li-ion batteries survived as they are installed in the propshaft tunnel and fuel tank space

THE EURO ZONE

Euro NCAP has conducted its first raft of EV crash tests, on the Mitsubishi i-MiEV and the Nissan Leaf.

The safety organization tests plug-in vehicles with live battery packs, and the cars are exposed to the same conditions as the others in the program, with tests for frontal impact, side impact, side pole impact and whiplash. Special attention is given to post-crash battery integrity and the proper functioning of the battery cut-off switch that isolates the high-voltage battery in the event of an actual crash.

To test EVs in a safe manner, extra precautions are taken before, during and after testing. Tests can be performed only at laboratories with specially trained personnel. Service plugs are removed during vehicle preparation, and extra firefighting measures are put in place to ensure the safety of laboratory personnel and equipment.

No electrical or fire hazards were detected during the testing of the i-MiEV. The battery was properly isolated from the bodyshell and was not damaged during the tests, earning the i-MiEV a four-star rating.

"We recognize the efforts by Mitsubishi to demonstrate that plug-in battery-powered cars can be as safe as others," says Euro NCAP's secretary general, Dr Michiel van Ratingen, following the test. "It shows that a future five-star accolade for EVs is not unthinkable. Whether produced by established car manufacturers or by new players on the market, consumers should expect to get electric vehicles that meet the same safety standards as conventional vehicles."

And it's not taken long for van Ratingen's thinking to be realized, as the Nissan Leaf has become the first EV to achieve a Euro NCAP five-star rating. Much of this was owed to the Leaf's 48 lithium-ion battery modules being housed in a compartment beneath the floor, ensuring not only that occupants are well protected in a crash, but also that the risks of battery damage or high-voltage leakage are reduced to zero. The battery pack completely withstood all the impacts.

The Leaf earned an 89% rating for adult safety, an 83% rating for child protection, and 84% for its onboard safety assist systems, which include ESC and a speed limiter as standard. It also earned a 65% score for pedestrian safety, due in part to the low nose design and the comparative lack of 'hard points' under the bonnet.

Leaf's battery system was switched on during the crash simulations to test the in-built safety measures of the electrical system, which includes automatic cut-off isolation in the event of an accident. The car passed these tests too. "We are not surprised by these results," says Jerry Hardcastle, Nissan's vice president of vehicle design and development. "Nissan Leaf has gone through more tests than any car we have ever produced. On top of the conventional offset barrier and side-impact tests, we have tested the electrical system in every way to ensure it can never be overcharged and that the isolation program works as intended in a crash."

Hardcastle's thoughts are echoed by van Ratingen: "The Leaf proves that EVs can be just as safe as common cars. The standard is now set for the next generation of cars."

A defining EV moment: the Nissan Leaf becomes the automotive industry's first ever electric vehicle to achieve a five star rating from Euro NCAP

similar test total will be tallied for the electric-powered version, including 50 physical tests that have been matching up quite well with the CEA calculations.

"I think we were concerned that the degree of what we were analyzing would be too fine, but the team has been quite surprised that the model has been extremely close – we're now talking about deformation down to millimeters."

There's no doubt that OEMs are taking extra precautions when testing their products with high-voltage batteries, such as issuing technicians with safety gloves. GM insists on strict key controls, with limited staff access to the lock box, and each technician requiring extensive training before they are allowed to work near a crashed EV.

"If you don't have a badge that says you're Volt trained, you stay away from the car," warns Hadfield. "We don't want anybody to get hurt because they're treating it the same as another car."

What's more, all OEMs stress the importance of preliminary component testing by suppliers, in addition to follow-up inspections and evaluation.

"There's a lot of work on the subsystem components," adds Hadfield's GM colleague, Schultz. "When we understand the basic fundamentals of the battery, that gives us confidence that we can put this entire system in a vehicle, then crash test it, and correlate that work with our analysis."

Volvo safety manager, Ivarsson, concurs: "We did component tests, including penetration and deformation of the battery. It's sort of a buildup type of analysis using tests and calculations. Then we added new sign-off tests designed for this type of installation."

Makowski says Ford also 'tweaked' some internal testing procedures "to give us a more comparable setup, as we would be evaluating gas-fuel setups".

It seems that regardless of whatever powertrain a vehicle might have, the numbers still need to be crunched, and all teams agree that crash-testing battery vehicles is a sustained learning curve.

"The expertise for interpreting results comes from two areas. One is traditional crash analysis of the vehicle," sums up Schultz. "The other is a highly specialized team that works hard in battery design and development, not only to contribute to upfront design, but also to contribute to post-crash analysis of battery and vehicle structure."

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WORDS: CHARLES ARMSTRONG-WILSON

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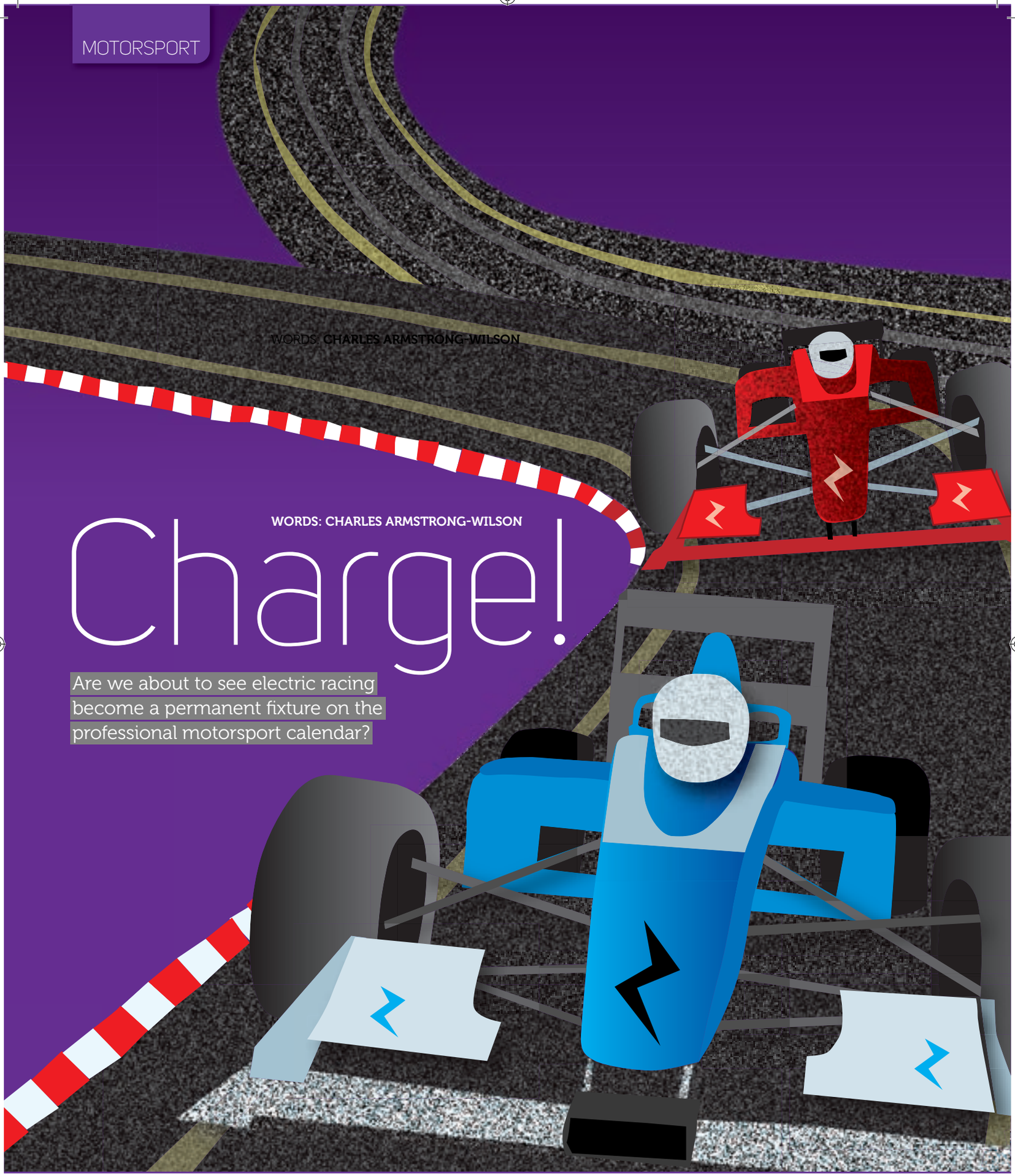
Charge!

Are we about to see electric racing become a permanent fixture on the professional motorsport calendar?



Electric racing cars; why would you bother? Well, there is a logical argument that while IC engines have dominated road cars, racing cars have also been IC powered. Therefore, as electric cars begin to emerge as a viable alternative, there should also be an electric race series.

However, one might equally argue that the arrival of electric road cars currently has as much to do with favorable legislation as their technical competitiveness. If you were to remove fuel duty and road fund licence for IC cars, electric vehicles would struggle to get a look in.

But the FIA believes that if EV activity on the racetrack is to survive, it has to have a beneficial input into road cars. This is why the governing body has invited tenders for the supply of a grid of electric racing cars to the new Formula E championship planned for 2013. The successful bid is due to be decided very soon and announced in April 2012. Of course, creating a championship is one thing; selling it is another altogether.

What, then, are the technical and commercial challenges in making an electric race series a success? The first question should perhaps be, can a credible electric racing car be built?

Eric Barbaroux, the man behind Formulec, certainly seems to think so. This is a project that began in 2009, long before the FIA proposal was announced. Segula Technologies was engaged to develop a prototype called the EF01, and what was then Brawn GP worked on the aerodynamics. An area of concern was the airflow around the battery packs and how to ensure they stay cool, and CFD was a way of tackling this.

By 2010, the EF01 was testing in the hands of Jules Bianchi and Alexandre Prémat to develop the final specification for a production race car and to promote the concept. The results of these tests were very credible and the aim now is to launch a 10-race series late in 2012.

Barbaroux says the biggest challenge has been power density. Hydrocarbons can produce an enviable amount of energy for a given weight and volume compared with other alternatives. "It struck me that, although chemically there was a lot more energy in one liter of petrol than in one liter of electrolyte, there are huge areas of electrical energy that have not been researched," he says. "At the same time, the petrol engine is still not very efficient, despite 100 years of constant development. As an engineer, I believe that the electric motor has just as much or even more potential."

NO MORE CABLES?

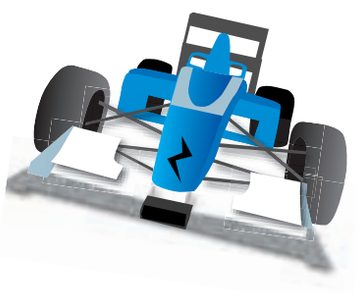
HaloIPT is developing inductive power transfer (IPT) recharging systems for EVs. The company's technology derives from industrial systems used for moving items around factories using electromagnetic induction. This has been evolved over the years to provide static charging of EVs: a pad on or under the ground provides a transmitter, while a pad in the floorpan of the car completes the magnetic field, and power is transferred across the air gap.

Halo is now working on a dynamic charging system. Similar to timing loops under a racetrack, a series of induction coils would be buried beneath the surface. The car is then charged as it passes over the top.

Paul Drayson, head of Drayson Racing Technologies, believes that racetracks could function as a testbed for the new charging technology.

"I think this is a tremendous opportunity for racetracks," he enthuses. "The Halo system could dramatically reduce the mass of the battery that you have in an electric race car, which would affect the handling dynamics of the car enormously and make the whole thing more efficient. I see it as a real game-changer for electric vehicle racing."

"I believe that the electric motor has just as much or even more potential"



Fondtech's usual Formula E design sees the batteries of the race car placed under the driver

Another company to have dabbled in electric motorsport is Zytek. It was one of the partners behind the successful Mercedes-Benz High Performance Engines (HPE) KERS system, but its involvement in electric racing cars goes back a lot further. There was the Panoz Q9 hybrid often nicknamed 'Sparky' in 1998, but the company also built an electric F3000 car in the 1980s.

Zytek's core business is electronics and electromechanical drivetrains for EVs and HEVs. It also happens to be a racing car manufacturer, so is very well placed to take on the FIA's Formula E challenge.

"Energy density really is the problem," says Pete May, senior engineer for motorsport applications at Zytek. "You can build a car that matches the performance of an IC-engined car, but the limitation is race distance." He cites the developments in battery technology that have been driven by KERS in Formula 1. "However, compared to motors and controllers, the rate of progress is steady," he says. "For example, if an engine delivers 13kWh of energy per kilogram of liquid fuel, suitable batteries are capable of supplying 0.25kWh per kilogram.

"However, only about a quarter of that energy from the IC engine is turned into mechanical power – say about 3.5kWh/kg. In contrast, the electric motor is more efficient, around 90%, and an electric car can harvest power under braking.

"So the reality is about a six-to-one ratio between the two energy sources per kilogram. That means that for a 10 to 15-minute race you could match the performance of a Formula BMW or a GP3 car."

"New technology is fascinating and the performance of electric race cars is electrifying"

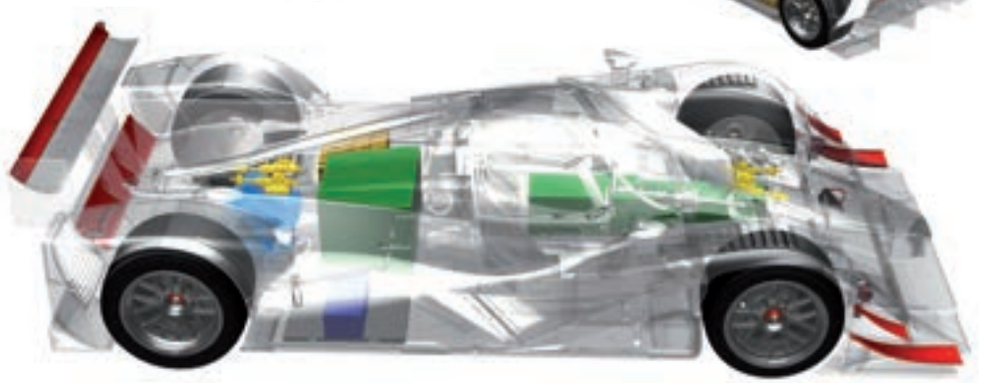
Above: Formulec EF01 testing at Circuit de l'Eure, France

Below: Halo engineers are working on a dynamic charging system that features a series of induction coils buried beneath the surface. The car is then charged as it passes over the top

Italian constructor Fondtech is taking the Formula E challenge very seriously, having a design already running in the wind tunnel. It has a distinctive high driving position forced by placing the batteries under the driver. This looks a little odd but designer Jean-Claude Migeot explains that this is for safety reasons, feeling that keeping the batteries deep within the car reduces the risk of them being damaged and rapidly discharging in a crash.

Another company that is serious about the future of electric racing is race car manufacturer Lola. It has recently collaborated with Drayson Racing on an electric version of the team's LMP1. The plan, however, is not to race, but to demonstrate the technology through setting circuit records for an electric car over a single lap. They say their main aim is "to prove that an electric powered LMP car can lap as fast, if not faster, than a conventionally powered car and to show how exciting an 850bhp, 200mph-plus electric car is on track."

The electric LMP1 is also planned to be a testbed for electric car technologies. The Lithium Nanophosphate batteries have been sourced from A123 Systems, which also supplies Mercedes-Benz HPE for its KERS, and Drayson is also working with HaloIPT to develop a wireless induction charging system for race cars.



Another electric race series about to launch is the EV Cup, which is planning two classes. The premier division will be for an electric Westfield sports car. Based on a derivative of the company's road car chassis, the electric racing version has been under development for around three years. Various layouts have been explored, including putting the motor up front and in the rear. It now has a pair of 60kW Oxford YASA motors in the rear of the car driving the wheels independently. Race director Grahame Butterworth says that this allows the control unit to be programmed with limited slip diff and stability control models that aid traction and handling.

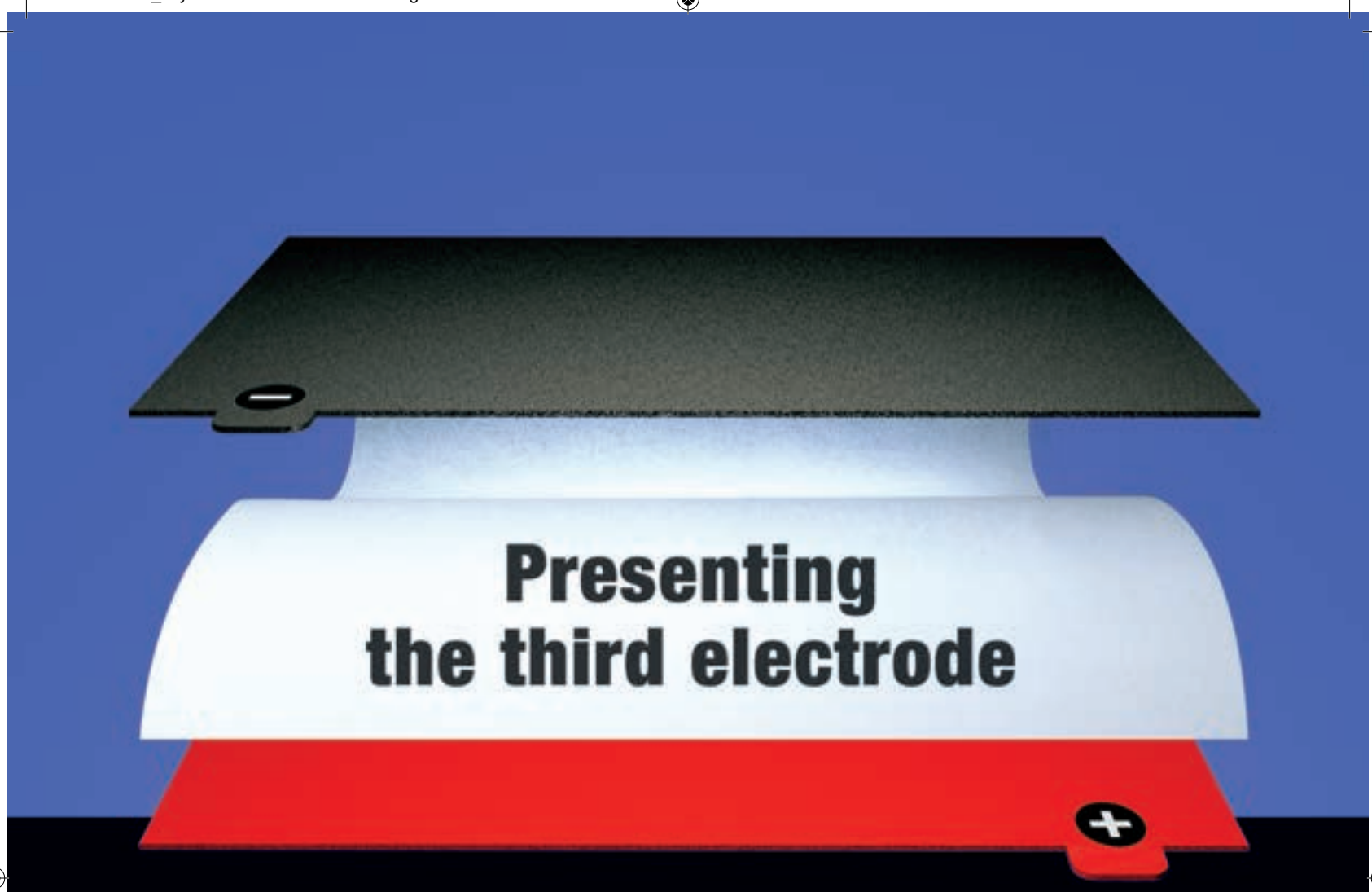
Currently, the car is projected to deliver 260bhp and up to 660Nm of torque, although the latter has to be limited at low speeds to maintain driveability. The other class is for near-standard Think City road cars.

Yet none of these series can claim to be the first as there have already been a couple of contenders for that title. The Trophée Andros ice racing series has been running races for electric cars since 2009. Formula Zero has also been there and done it. The brainchild of Godert van Hardenbroek, it challenged students to produce fuel cell-powered electric karts and compete in time attack events.

Unfortunately the series closed in 2011, but not without making an impact. Students who took part in the series revealed that the experience they acquired made them hot properties with the manufacturers.

But while there seem to be plenty of people keen to start electric race series, are they what the public want? Time and again the question of the sound – or lack of it – is raised.

"The public is smart and demanding of fresh, relevant experiences, aligned with the values of a sustainable future," says Timothy Collins, president of KleenSpeed, another Formula E hopeful. "New technology is fascinating and the performance of electric race cars is electrifying. Speed, sound, passing and pit stops are the traditional interest points of motorsport, and will continue to be so. In addition, the performance characteristic of the electric race car, with its instantaneous torque and burst of speed out of a corner, will capture the next generation of motorsports enthusiasts.".



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Moral fiber

High-tech batteries and electric motors alone will not get EVs to the masses. Materials, however – and particularly carbon fiber – just might. **Dr Klaus Draeger**, BMW's board member for development and purchasing, speaks candidly about project 'i' and the very clever LifeDrive concept

WORDS: **JOHN SIMISTER**

For BMW, an electrically powered future gets into its stride with the cars created under the Megacity banner, now known formally as 'i' cars after the 'i' electromobility project. So far, the industry has seen, in concept form, the i3 supermini and the i8 sports GT (*see page six*), both of them visions of material and engineering loveliness in their carbon-fiber passenger cells set within aluminum chassis structures. They represent how production versions of the 'ActiveE' prototypes, undergoing field testing as the next stage on from the electric Mini E project, will look.

In this ultra-lightweight construction, known as LifeDrive, lies the key ingredient of what can make an electric car viable for the masses. Reduce the weight, and you reduce the energy required to move that weight. So the same amount of stored battery energy can take a vehicle further. All that is needed is to make the weight-reduction process economically viable.

And this is exactly what BMW is working hard to achieve. "The i3 and i8 are an incubation," says Dr Klaus Draeger, BMW's board member for development and purchasing. "What we learn from the project will influence other model lines in the future, because our centers of competence can run across them all. The idea is to maximize the synergies, but also to optimize the differences between the lines so that the customer feels each line is unique.

"The Megacity LifeDrive module is unique, however. The two main structural components are split horizontally, and the aluminum frame is no real crash structure on its own. That's the job of the carbon fiber cell. Using this carbon fiber and aluminum construction saves 250-300kg compared with a same-size steel structure. That in turn means we can use a battery 50kg lighter, which is also cheaper." The current estimate of a lithium-ion battery's cost is about US$620 per kWh, so saving battery weight can save a useful amount of money.

1

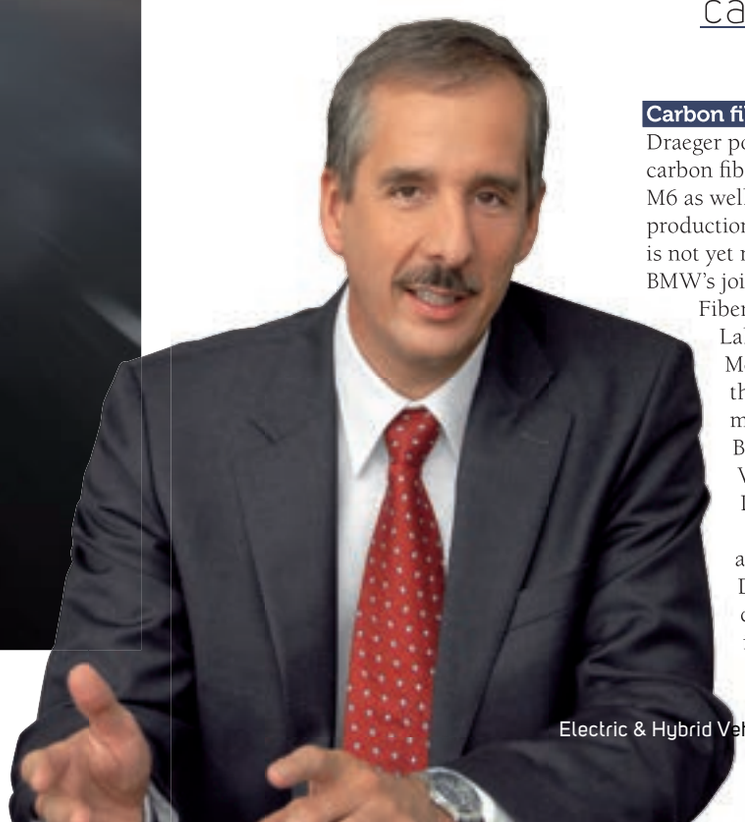
2

3

1 and 2: Both the i3 and i8 make use of BMW's LifeDrive technology to ensure a very light weight. The i3 tips the scales at 1,250kg, while the i8 comes in at 1,480kg

3: BMW has previous experience with carbon fiber. Shown above is the milling of the carbon roof of the BMW M3 at the Landshut plant

"It emerged that the real range on a full battery charge, in real conditions, was between 130 and 150km. So after a couple of weeks, the test drivers weren't worried any more and they charged the cars only every third day"



Carbon fiber experience

Draeger points out that BMW already has some form with carbon fiber in limited production, citing the roof of the M6 as well as the legendary M3 CSL. As a result, quantity-production resources for the 'i' cars are being readied. He is not yet revealing how many LifeDrive carbon fiber cells BMW's joint-venture partner, SGL Automotive Carbon Fibers, will be able to produce in a year at its Moses Lake, USA plant. However, the ultra-green Megacity factory in Leipzig is gearing up now for the launch of the i3 and i8 in 2013, with US$735 million invested in the whole project between BMW and SGL across four factories (Leipzig and Waldshut for the German car maker; Moses Lake and Wackersdorf for US-based SGL).

The 'i' cars are seen as zero-emissions vehicles, at least when running purely electrically, but Draeger accepts that electricity production can create its own CO_2 and that means, so far, there is no such thing as a pure green vehicle.

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PLANTING THE SEED

At the start of September 2011, SGL Automotive Carbon Fibers – a JV of SGL Group and BMW – opened its new, state-of-the-art carbon fiber manufacturing plant in Moses Lake, WA. The facility, which is key to BMW's EV plan, will manufacture ultra lightweight carbon-fiber reinforced plastics (CFRP) for use in the new BMW 'i' vehicles.

The two parent companies will invest approximately US$100 million in their Moses Lake plant and create 80 new local jobs by 2013. In order to prepare the large-scale production start of BMW 'i' vehicles, SGL says it is important to start carbon fiber manufacturing now.

As well as helping to manufacture eco-friendly vehicles, all the electricity needed for the production of carbon fiber at the plant will come from readily available clean and renewable local hydropower, and this was a key factor in why the two companies chose the Moses Lake location, especially as the state of Washington leads the way in offering clean, renewable hydropower and competitive energy costs.

The plant itself covers 60 acres of land, and there is the option to purchase additional land for future growth. It will initially run two carbon fiber lines, each with an annual capacity of 1,500 metric tons.

Commenting about the plant – and the tie-up with BMW – Robert Koehler, CEO of SGL Group, says: "The manufacture of carbon fibers is a core business for SGL Group and together with our partner BMW Group, we will ensure that carbon fibers play a ground breaking role in lightweight automotive construction. This new greenfield facility in Moses Lake is a milestone in the use of carbon fibers for large-scale production in the automotive industry."

1

1 and 2: BMW Group engineers are undertaking further development of electric drivetrain power electronics as part of the electromobility project

In fact, BMW takes a holistic approach to the reduction of emissions, and this means it continues to develop IC engines. "There's another 10-15% fuel saving yet to come with IC engines," notes Draeger, "especially with HCCI in the longer term. All our new engines are turbocharged now, including the three-cylinder that has no need for the twin-scroll turbocharger used in the larger engines."

"Using this carbon fiber and aluminum construction saves 250 to 300kg compared with a same size steel structure. That in turn means we can use a battery 50kg lighter, which is also cheaper"

2

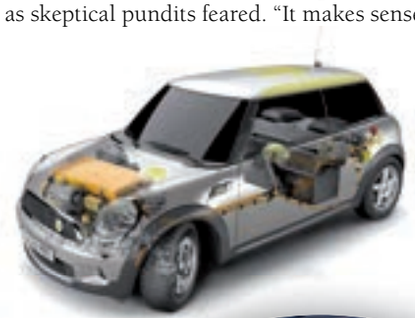
That three-cylinder engine is used in the i8 as a range extender, while the production i3 – unlike the electric-only concept car – will also be available as a range-extended model using a version of the flat-twin BMW motorcycle engine. So BMW is covering both bases, but Draeger is confident that buyers will find pure electric cars practical for longer runs than what they might have originally expected. In the Mini E test program, for example, the BMW board member says that range anxiety turned out to be less of a problem than the experts predicted.

"Our Mini Es covered 11 million test kilometers [worldwide]. The average distance driven was 60km a day, and most drivers on the program had more than one car in the household. Each journey averaged 9-10km.

1

2

"It emerged that the real range on a full battery charge, in real conditions, was between 130 and 150km. So after a couple of weeks, the test drivers weren't worried any more and they charged the cars only every third day." Used in the right way, then, an electric car can indeed be a viable mode of transportation for commuting and local errands, and is not as demanding of attention as skeptical pundits feared. "It makes sense for us to propose a lease idea," suggests Draeger, "in which as well as your electric i3 you can also have a BMW with an IC engine for a few days a year." Or a large BMW with range-extender technology? "Well, let's see what happens later," he hints.



1 and 2: Draeger says the Mini E field tests were a success, providing BMW Group with important data on every day usage of EVs

THE UK MINI E TRIAL IN NUMBERS:

40 Mini Es

12 months

138 drivers (32 women, 106 men)

258,105 miles

33,345 journeys

80,282kWh electricity

Highest mileage by an individual driver over six months: **7,954** miles

Average mileage per vehicle over six months, including fleet pool cars: **3,226** miles

Average cost to charge over six months: US$**96**

New approach to hybrids

Away from pure electric vehicles, BMW is pressing ahead with hybrids, with the ActiveHybrid 5 about to go on sale and others to follow. But BMW will move beyond regular hybrids: "By 2020, 5-15% of new-car sales could be of electric vehicles of some sort, either plug-in hybrids or pure EVs, but legislation will affect that and you never know what the legislation will be.

"But one idea we have for plug-in hybrids is never to charge the battery to 100%, but to make it 60% so there is room for extra charge from regenerative braking. Then, with the route entered into the satellite navigation, it's possible to plan the charge strategy as you drive so that when you come to a town, the charge is up to 100% ready for electric-only driving."

But doesn't that mean that the customer's movements are then restricted to the pre-planned route if best efficiency is to be achieved? Isn't that rather prescriptive? Tellingly for the future of driving freedoms, Draeger thinks not. "I believe customers are ready to accept this control," he says.

HYBRID HIGH FIVE

BMW's 'i' vehicles might have taken center stage, but the Bavarian company has not forgotten about the premium hybrid market, which Lexus pioneered and has been a leader in for the past few years.

By the second quarter of next year, Lexus will not only have a raft of Audi hybrids to deal with (*see page 104*), it will also have the ActiveHybrid 5 to tackle, a petrol-electric sedan based on the 5 Series.

The most striking thing about BMW's foray into this segment is that its hybrid exec offering delivers similar performance to a 535i, but with 16% lower fuel consumption and CO_2 emissions.

The drivetrain consists of a 306bhp 3-liter TwinPower petrol engine plucked from the 535i, with a 54bhp electric motor and an eight-speed automatic gearbox. This is the first time an in-line six-cylinder engine has been part of a BMW ActiveHybrid system.

Together, the engine and electric motor can generate a maximum 340bhp and 450Nm of torque.

At speeds of up to 37mph the ActiveHybrid 5 can travel up to 2.4 miles on electric power supplied by the lithium-ion battery stored in the boot, between the wheel housings. The electric motor, also integrated into the gearbox housing for the best packaging efficiency, delivers a maximum 210Nm of torque from rest.

The IC engine – featuring a twin-scroll turbocharger, high-precision direct fuel injection and Valvetronic variable valve timing – comes into play only when the driver needs more power or the energy stored in the battery is exhausted. When accelerating, the electric motor assists the petrol engine by providing an additional boost, hence why this hybrid offering can literally keep up with its speedy 535i sibling.

On the road, the BMW ActiveHybrid 5 sprints to 62mph in 5.9 seconds, has a limited top speed of 155mph, emits 149g/km of CO_2 and boasts a fuel consumption rating of 44.1mpg in combined mode.

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Frankie says relax

Now reaping rewards from a blossoming electric vehicle fleet, it is little wonder why Audi's head of electromobility is so composed when discussing the future. In a media exclusive, Frank Van Meel reveals the many strands to Audi's sustainable transportation plan

WORDS: **JOHN SIMISTER**

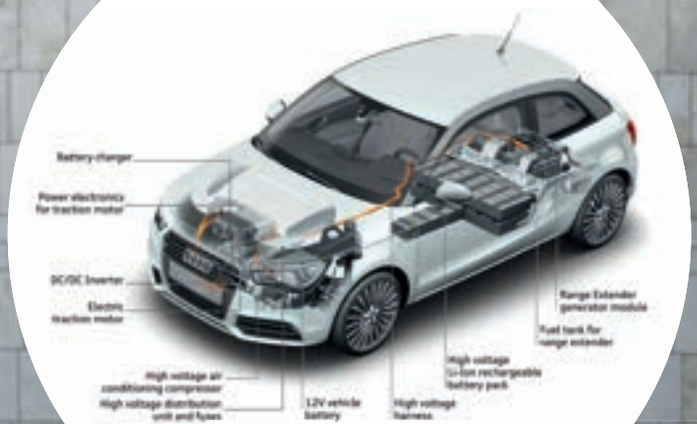
If one of your brand cornerstones is a visible strategy for a future likely to contain a lot of electric vehicles, then you have to make sure that the whole world knows all about it. International motor shows are the obvious place to showcase such plans, or at least the 'sexy' parts of them that will bring the buying public on side. At the 2011 Frankfurt Motor Show, Audi certainly obliged, bringing to life an EV funfair that received plenty of attention from both the international press and the general car-buying public.

Here were clear signals from VW Group's ever-successful premium brand: two four-wheel scooter-like 'urban concepts', in Sportback and open Spyder guise, plus an A2 concept, all of them electric (*see page 23 and 24*). The latest e-tron electric sports car was there, too. But how important are they to Audi's future? Is Audi anticipating an all-electric future? And what happened to the hydrogen fuel cell dream that would ultimately realize true sustainable transportation?

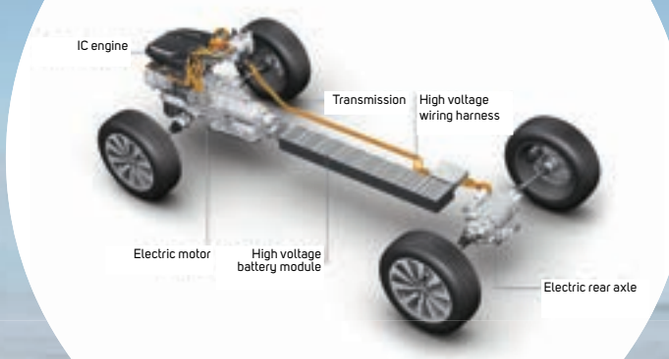
Answers to questions

Audi's head of electromobility strategy is Frank Van Meel, who was at Frankfurt to answer these pressing questions. He began outlining the short term and hinted at the longer term, but the message from Van Meel was clear: despite Audi's growing support for the electric powertrain, IC engines are far from dead.

Aside from the all-electric concepts, Audi has plans for full hybrid versions of the Q5, the A6 and the A8. Next year, too, the electric R8-based e-tron enters limited production – fleet cars are already on test. But the problem for Van Meel lies with the infrastructure for charging



The pure electric A2 will form a central strand to Audi's EV offering in the immediate future. The concept weighs just 1,150kg and the production version will stay true to this lightweight ethos



The Audi e-tron quattro in cold climate testing. Van Meel says plug-in hybrids form one part of Audi's electrification future .

electric cars, and getting buyers used to the idea of driving a vehicle that runs on electric.

"It's a chicken-and-egg situation," says the Audi man, "so we back it both ways. We have an A1 range-extender ready to go, a quattro hybrid with the motor driving the rear wheels, and we have an A2 that's purely electric. The urban concepts, however, are just a trial, a testbed for future mobility along with other concepts. These won't include two-wheelers – we are no fans of those. We are a four-wheel company.

"There are four pillars for the long run of the company. They are not an either/or situation: we shall use them all. They are the TFSI and TDI engines we have now, biofuels including biogas, and electrification. The last of these goes in two directions. Battery electric vehicles will be a top-down strategy, meaning that they will start as premium vehicles but not necessarily big ones, while plug-in hybrids will be cars such as the A4 e-quattro and the production A2."

Well-to-wheel

Up to now, Audi (and the rest of the industry) has been concerned with tank-to-wheel efficiency, but Van Meel insists the future is with well-to-wheel. This immediately reveals that electrification, rather than being an end in itself, is just part of a bigger picture in which hydrocarbon – or pure hydrogen – fuels still play a major part. The challenge is to make all the processes work with each other in a coordinated fashion: something that is easier said than done.

"Fuel cell vehicles will just be for certain fleets at first. They won't be for customers in the next 10 years. By 2020 they will still be under 1% of sales, maybe even just 0.1%"

Van Meel points to e-gas, which can allow OEMs to build their own, energy-efficient fuel from coal, and to the electricity available from turbines powered by North Sea tides. "What do we do with the electricity generated but not needed at the time? We can use it to make hydrogen, or to make methane that we put into the infrastructure. This will happen by 2014; it's less efficient than using electricity directly, but it's up to 66% better than doing nothing."

Panasonic
ideas for life

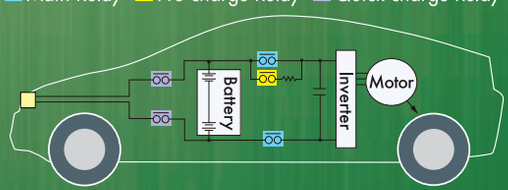
A vital piece to the EV and HEV puzzle.

EVs and HEVs are forerunners of the eco age. Essential to their development are relays that combine compact design with cutoff at high DC voltages – something that Panasonic has achieved through contact technology with sealed capsules containing hydrogen gas.

Compact, lightweight, high-voltage cutoff	Hydrogen gas with high arc cooling capacity used in contact points for short gap cutoff at high DC voltages. Relay also made more compact and lightweight.
Safety	Contact points encased in ceramic for anti-explosive structure to prevent arc from leaking and ensure higher degree of safety.
High contact reliability	Contact points sealed in hydrogen gas to prevent contact oxidation; also dustproof and waterproof as a result.

Relay Key Application examples

Main Relay Pre-charge Relay Quick charge Relay



Panasonic EV Relay

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Here, then, is a possible hydrogen supply for future fuel cell vehicles, and a potential solution to the chicken/egg conundrum that the industry faces. But this won't have much of an impact initially: "Fuel cell vehicles will just be for certain fleets at first," Van Meel predicts.

"They won't be for customers in the next 10 years. By 2020 they will still be under 1% of sales, maybe even just 0.1%. A fuel cell vehicle is just another sort of range-extended electric vehicle, and if we can produce fuel for existing IC engines then the fuel cell doesn't make sense. The urgency has gone."

The cleverer approach, Van Meel contends, is to store the surplus electricity produced at night. As well as using it to power gas or hydrogen production, he suggests – slightly fancifully – that it could be used to pump water back into the lakes that feed hydro-electric turbines in countries such as Austria and Norway. More realistically, the obvious solution is to use electric cars to store the energy by charging them at night. And if they are not being used during the day, they can feed their energy back into the electricity grid. Van Meel is quick to point out that this already happens in the USA, where adding a million battery electric vehicles would use just 0.5% more energy.

The 1+1 Urban concept (above) shows a new EV direction for Audi. The 480kg EV has a 90kg Li-ion battery and two electric motors producing 15kW of continuous power output and 47Nm of torque

MUNICH STREETWISE

In early November, some 20 Audi A1 e-tron models hit Munich roads as part of the German car maker's ongoing EV field trials.

"Audi works relentlessly on comprehensive approaches that maximize benefits to customers. In this era of electric mobility, we will offer our customers a wide range of services that go beyond driving itself," explains Van Meel. "For example, the networking of vehicles with their surroundings and with infrastructure as well as new concepts of mobility will be important. We want to use this fleet trial to learn more about our customers' usage of electric cars, and their expectations in this regard. We are planning additional fleet endeavors in strategically important markets."

The Modellregion Elektromobilität München project is sponsored by Germany's Federal Ministry of Transport, Building and Urban Development. Audi's trial partners include energy company E.ON, the public utility Stadtwerke München (SWM), and the Technische Universität München (TUM). E.ON and SWM are in charge of expanding and maintaining the charging infrastructure in the Munich metropolitan area, and as such have installed a demand-oriented charging infrastructure.

The A1 e-tron is Audi's take on the range extender phenomenon that is being led by GM with its Ampera/Volt offering. A1 e-tron's output of 75kW enables it to reach a top speed of 130km/h. If the battery runs out of energy, then a compact IC Wankel engine that has been co-developed by AVL recharges the battery as needed to boost the vehicle's operating range to as much as 250km. As such, A1 e-tron is a zero-emissions vehicle for the first 50km when it is running in pure electric mode. The battery comprises a package of lithium-ion modules mounted in the floor assembly in front of the rear axle.

"The Urban concepts are just a trial, a testbed for future mobility along with other concepts. These won't include two-wheelers – we are no fans of those. We are a four-wheel company"

A2 poster child

Returning to the nearer-term, Audi's head of electromobility strategy expands on the role of the A2, which is the accessible banner-waver for Audi's part-electric future. Some aspects of the concept car are not yet practical, or indeed legal, for production, such as brake-by-wire technology and, more controversially, the steer-by-wire system that allows the concept A2 to be driven in semi-autonomous mode in slow-moving traffic.

HYBRID – EXEC STYLE

Scheduled to launch in 2012, the Audi A8 hybrid combines a 2-liter TFSI engine with an electric motor to develop peak output of 180kW and 480Nm of torque. The luxury hybrid sedan, which will sit side-by-side with Audi hybrid derivatives of the Q5 and A6, can travel at a speed of up to 100km/h on electric power alone, and covers around 3km with zero local emissions at a speed of 60km/h. In the standard test cycle, it consumes around 36.5mpg, which corresponds to CO_2 emissions of less than 148g/km.

The layout of the parallel hybrid drive system sees the TFSI engine and electric motor mounted directly behind one another. For use in this model, the TFSI unit underwent modifications in several areas. The alternator as an ancillary unit has been dropped, while the crankshaft bearing and the fine-tuning of the turbo were adapted to new requirements. A secondary air system at the cylinder head makes sure that the exhaust gas treatment cuts in particularly fast. Integrated in the ECU, the hybrid manager controls the efficient change and smooth transitions between the operating modes. An extensively modified eight-speed tiptronic serves as the power transmission, without the aid of a torque converter. Its place is taken by the disk-shaped electric motor.

The permanent magnet synchronous motor, which also functions as a starter and – during deceleration – as a generator, has a peak output of up to 40kW and 210Nm of torque. The electric motor is integrated in the cooling circuit of the TFSI engine.

The motor is combined with a multiplate clutch operating in the oil bath and joining or separating it and the TFSI. A lithium-ion battery system, weighing only 36.7kg, serves as the energy store for the electric motor of the Audi A8 hybrid. The compact battery has a volume of 26 liters and is located in an area beneath the luggage compartment that is protected in the event of a collision.

However, it's the A2's innovative construction and use of materials – almost a homage to the original A2 – that's the real noteworthy feature here. Using an aluminum frame and carbon fiber panels is not only viable for a production car, it also keeps total weight down to 1,150kg – an impressive feat for a four-seater electric car that measures 3,804mm in length, 1,494mm in height and 1,693mm in width.

"The A2 brings together three main Audi assets," explains Van Meel. "These are 'e-tron' for the electric powertrain, 'ultra' for the lightweight construction [as portrayed on myriad posters at this year's Le Mans 24 Hours] and 'connect' [an evolution of existing Audi multimedia and telematics systems]. It has a system of mood lights using LEDs along the sides, showing normal driving, braking, turning and an emergency."

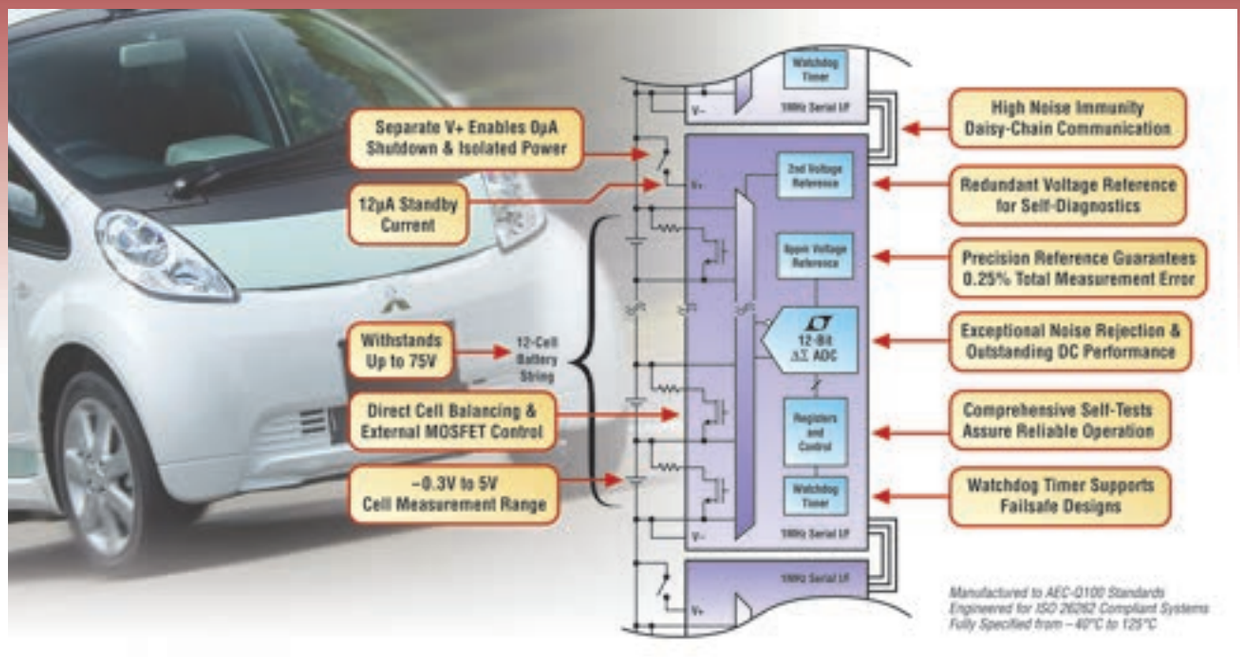
1. The latest version of the e-tron Spyder, a plug-in hybrid vehicle that also features a V6 diesel engine

2 Assembly of the R8 e-tron takes place in preparation for the vehicle's launch next year

These LED strips, extending from headlights to tail lights, shine blue as the driver approaches, intensify as entry is gained, turn orange when driving, pulsate in brighter orange when turning towards that side, and glow red under braking. Further lighting technology includes five laser diodes to act as a rear fog light. Normally their output is invisible, but they create a visible floating triangle of light in fog or fine rain.

As for the A2's electric powertrain, it produces 116PS and 270Nm of torque, with energy stored in a 31kWh lithium-ion battery pack located in the sandwich floor. A single-speed transmission channels power to the front wheels of the vehicle. Expected driving range on a full charge (four hours via a standard European domestic voltage) is 200km, which is spot-on for an 'around town, city car' that the production A2 will become, but don't be surprised if the production version of the A2 has an even better driving range when launched, which, along with the R8 e-tron, will set Audi well on the road to its particular electric future.

Road Proven Battery Stack Monitor



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LTC6803-3	2nd Generation Stack Monitor	Now
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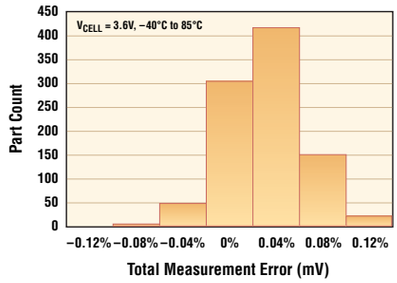

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LINEAR TECHNOLOGY

First rate

Akasol Engineering has designs to be the number one battery developer in the world. *E&H* takes a trip to Germany to find out just how such an ambitious plan will be realized

WORDS: **DEAN SLAVNICH**

With 20 years' experience in the development of high-tech battery systems for mobile and stationary applications, Akasol Engineering has found itself in the right place at the right time to take advantage of the blossoming electric and hybrid vehicle sector.

And this clever positioning can in no better way be reflected than in an announcement in September 2011 that confirmed a tie-up with Continental that would see the two suppliers co-develop a new generation of lithium-ion battery systems. "The strategic cooperation with Continental is very important to us," explains Sven Schulz, Akasol Engineering's managing director.

"We're able to supply Continental with our standard battery system solutions for small batch series as well as prototypes, and we can support the experts from Continental concerning development projects for mass production battery system solutions.

"Besides that, our clients have the possibility to buy Akasol technology from Continental, if they want a Tier 1 supplier for a reasonable production capacity."

The agreement with Continental represents a big win for Akasol. The next-generation Li-ion systems that the two partners are developing will use innovative fluid cooling technology that ensures uniform cooling of all battery systems. This essentially means enhanced battery life, easier modular expansion and a flexible and scalable approach, allowing for a wide variety of applications ranging from small city cars and high-end sports sedans through to SUVs and even buses.

AIBAS² has been optimized to include numerous new and further developments, which have arisen from field tests and customer projects, says MD Sven Schulz

"Our mission is to supply one of the world's best battery systems that's made in Germany for mobile applications. This is what our clients and the market expect from us and what we will keep on focusing in the future"

Since its formation in 2008, Akasol Engineering has been a subsidiary of the Schulz Group, which consists of five other companies, 10 global manufacturing locations and 250 employees. At the core of Akasol's expertise sits the company's AIBAM² (Akasol Intelligent Battery Module) and AIBAS² (Akasol Intelligent Battery System) technologies. The modular design realizes a battery module equipped with 53Ah Li-ion/NMC cells, featuring a positive and negative terminal, a data connector and connections for fluid cooling. The modules can be connected easily and within just a few steps with the use of the AIBAS², as Schulz

explains: "It meets all requirements for mobile storage solutions and has already proved its value in many high-performance applications such as sports cars, motor yachts, municipal buses and other commercial vehicles with hybrid or electric drive.

"AIBAS² has been optimized to include numerous new and further developments, which have arisen from field tests and customer projects. The high energy density of AIBAS² ensures a high range, with maximum safety, reliability and durability. The highly integrated modules form the basis of the modular scalable battery system. These modules were subjected to different crash tests to check the safety requirements of the battery in case of accidents. The advanced battery module passed the different crash tests with flying colors and fulfils important safety requirements for electrical vehicles."

The highly integrated AIBAM² modules form the basis of the modular scalable battery system

Active thermal management

What is more, the battery system provides powerful passive and active thermal management using liquid cooling – even at high loads. As such, the temperatures of the cells are always within the recommended range, which in addition to high performance ensures a long lifetime of the cells. "By the integration of a redundant battery management system, an even higher level of safety is achieved," continues Schulz. "The battery management evaluates at all times the current, voltage, temperature and internal resistance of the cells, as well as their state of charge, to bring the system into a safe condition in the event of errors."

With such a focus on engineering, Akasol is not a company that stands still. For future client projects, engineers are developing a wide portfolio with special cell chemistry for each application and a capacity range from 6-53Ah. "With this strategy, we will be able to offer standardized Akasol battery systems for the most common hybrid and electric vehicle applications with high performance needs," proudly explains Schulz.

Schulz's astute business acumen – and engineering background – has helped Schulz Group become a global force, boasting a turnover of more than US$43 million

Made in Germany

Akasol's underlying ambition is clear: "Our mission is to supply one of the world's best battery systems that's made in Germany for mobile applications. This is what our clients and the market expect from us and what we will keep on focusing on in the future.

"To accomplish this mission we will invest a lot of research and development efforts in cutting-edge technology concerning battery chemistry, thermal management, battery management system, safety and reliability."

Schulz, who is credited as being the driving force behind the expansion of the Schulz Group since 2001, growing turnover from US$5 million to US$43 million, is proud of the company's German R&D footprint. He adds: "The design and the engineering of Li-ion battery systems is very complex. It's much more than installing many Li-ion battery cells in a metal box and connecting them with cables and battery management hardware.

"As a German automotive company we employ many experienced engineers, who have been extremely familiar with automotive standards and automotive requirements for years and even decades. Those engineers are part of the success of German car manufacturers today and they know exactly how to develop a battery system, which is supposed to run in electric and hybrid vehicles not only for one or two years but for up to two decades. Besides that our engineers are focusing on long-term solutions with technically elegant and valuable properties. More clearly: installing more than 6,000 battery cells in a system like Tesla is not a solution that meets our expectations."

It's plain to see that 2011 was a key year for Akasol, but 2012 will at the very least be just as important. In the next 12 months, the Darmstadt-based company will start to supply the first small batch serial production, with up to 200 battery systems per year. "Beside that, at the end of 2011 we employed an R&D staff of almost 30 engineers and 10 staff in the workshop. In 2012 we expect to employ 40 people in Darmstadt, mainly in the R&D and project management department." With so much innovation taking place, it is hard not to take Schulz at his word.

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WORDS: **KARL VADASZFFY**

A unique combination of service from management consultants through to technology experts is available for the automotive, aviation and telecommunication industries from P3 Group. The company, which last year achieved a turnover of US$200 million and operates on a global scale with bases in North America, Europe, South Africa and Asia, has a staff of 1,400 consultants and engineers, 400 of whom focus exclusively on the automotive sector.

The company's North American operations are led by Dr Samit Ghosh, a 38-year-old German native who is based in Detroit, Michigan, where P3's regional headquarters are located. P3, whose client list includes Audi, VW, Ford, Continental, Bosch and Detroit Diesel, offers a service that spans from strategy through to implementation, says Ghosh, focusing on three primary practices: strategy consulting, professional management services and engineering solutions.

The strategy consulting part includes business plans, market analysis, product strategy, restructuring, cooperation and partnerships, including M&A strategy. Professional management services implement strategies through process improvement, cost reduction, program management, technology roadmaps and benchmarking, involving the management of quality, cost, programs and suppliers. Finally, engineering solutions, one of P3's USPs, cover vehicle systems integration, energy and storage, and production and quality. Ghosh explains the setup further: "We have technical domain knowledge, so we are able to thoroughly execute the work, from specification to systems integration, as well as testing and validation. So, with P3, customers get the strategic solution as well as the execution and technical understanding."

P3 offers a whole suite of instruments and services to define, evaluate and decide on the underlying business strategy of a company or individual development projects

"There'll be more OEM/OEM partnerships, OEM/Tier 1 partnerships, Tier 1/Tier 1 and I think it'll extend to Tier 2 level"

E-motor benchmarking

A current project being undertaken by P3 focuses on benchmarking and product strategy for e-motors. The work is being carried out for a North American Tier 1 supplier, as Ghosh explains: "We're suggesting how to reach a larger target market, as well as what changes are needed to the design and specifications. Our experts went on-site and worked directly with the head of engineering, as well as reporting to the decision makers. In the first step, we analyzed their current system specification requirements. Through our marketing and technology knowledge of the landscape, we assessed what they were targeting and if that market was lucrative. Then we told them what their target market segment should be, and what changes would be needed to refocus their product on it."

A typical next step on such a project, after a strategic decision has been made, would be to develop a plan to help the company execute the strategy. Ghosh adds: "We

would develop a program management work package, which could be for the duration of the product development. We use different people for that, but because our staff base includes so many skills, if we need to bring in a technical expert or strategy expert again, then we can."

Another of P3's recent projects involved exploring cost status and target price validation for a North American Tier 1 supplier. Says Ghosh: "First, we looked at the bill of material and validated all the costs of the parts. Then we did an analysis of the supply base, considering raw material prices and the value-add suppliers put on parts. Finally, we concluded what the designs should cost and whether the OEM's target was fair." Benefits for the client, as a result, included a cost target they could fulfill, an understanding of their own cost drivers, and a potential saving of millions of dollars.

A further project Ghosh is keen to highlight is the successful hybrid development cooperation that P3 North America implemented between four major automotive OEMs. "The challenge," Ghosh explains, "was to find a way for these four powerful players to have the utmost commonality in parts and development, while maintaining the flexibility to enable individuality when it was wanted.

"The next step was to come up with a complete redefinition of the processes on the engineering, business and operations sides. We moderate and facilitate while providing technical and management input, and we drive companies to the best solution to the issue we're exploring, and that's what we did here."

P3's North America HQ in Detroit. As a management consultant company, P3 offers a range of solutions to help clients successfully meet their end goals

Believing in partnerships

Cooperation, it seems, is a current trend that P3 is dedicating much of its time to. Partnerships and joint ventures, Ghosh believes, are a way that OEMs and Tier 1 suppliers can succeed in challenging economic times. He says: "We're working a great deal on electrification and alternative powertrains. In doing so, we're helping international OEMs and Tier 1 suppliers focus on developing reliability as well as cost-effective methods of processing and management."

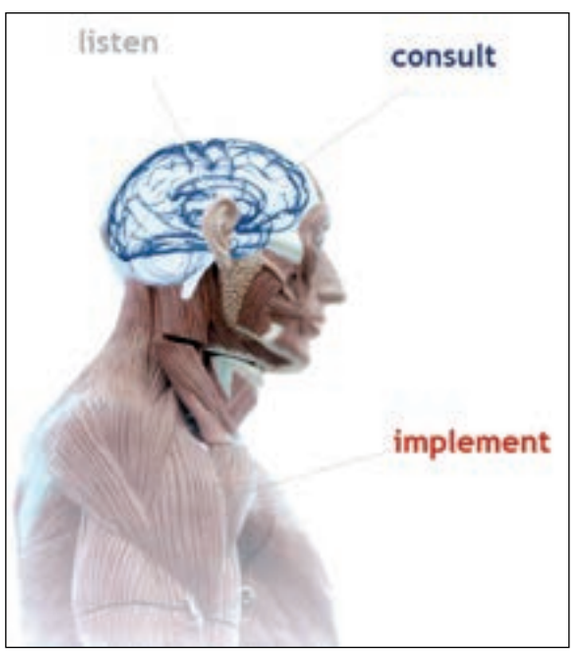
A core strategy to do this is the introduction of integrated systems, which Ghosh says will become increasingly crucial in years to come. "As technology becomes more complex and needs more resources," he explains, "it's going to be costlier to develop, so risk sharing and cooperation are a promising solution." There are different forms of partnership, including a development agreement, a joint venture or a company acquisition/merger, and Ghosh say P3 has the expertise to assist clients in deciding on the most suitable option for them.

"Partnership is popular, whether you're talking about batteries, motors or inverters, and this will increase. There'll be more OEM/OEM partnerships, OEM/Tier 1 partnerships, Tier 1/Tier 1, and I think it'll extend to Tier 2 level. At the moment, with Tier 1 suppliers for electrification, their core driver for M&A activity is survival, which will likely be the case for the next two to three years. But, after this, we hypothesize that partnership activities will be launched as a way to make businesses thrive."

By tackling electrification in partnerships, members of the automotive industry have given Ghosh and his team much time to consider the future of electric vehicles. The CEO concludes: "There's a lot of hype about alternative powertrains, but it's not all focused on full electric vehicles. Hybrids, mild hybrids and parallel hybrids currently account for a lot of the volume, and the micro hybrid that's coming will add to that.

"So, for us, it's clear that the majority of business for Tier 1 suppliers is not the full electric vehicle. As global car makers and Tier 1 suppliers give electrification their full attention, the smartest of the bunch will have their minds securely on all different types of alternative powertrains."

"We're working a great deal on electrification and alternative powertrains. In doing so, we're helping international OEMs and Tier 1 suppliers"



P3's listen, consult, and implement motto has helped the company grow since its formation in 1996

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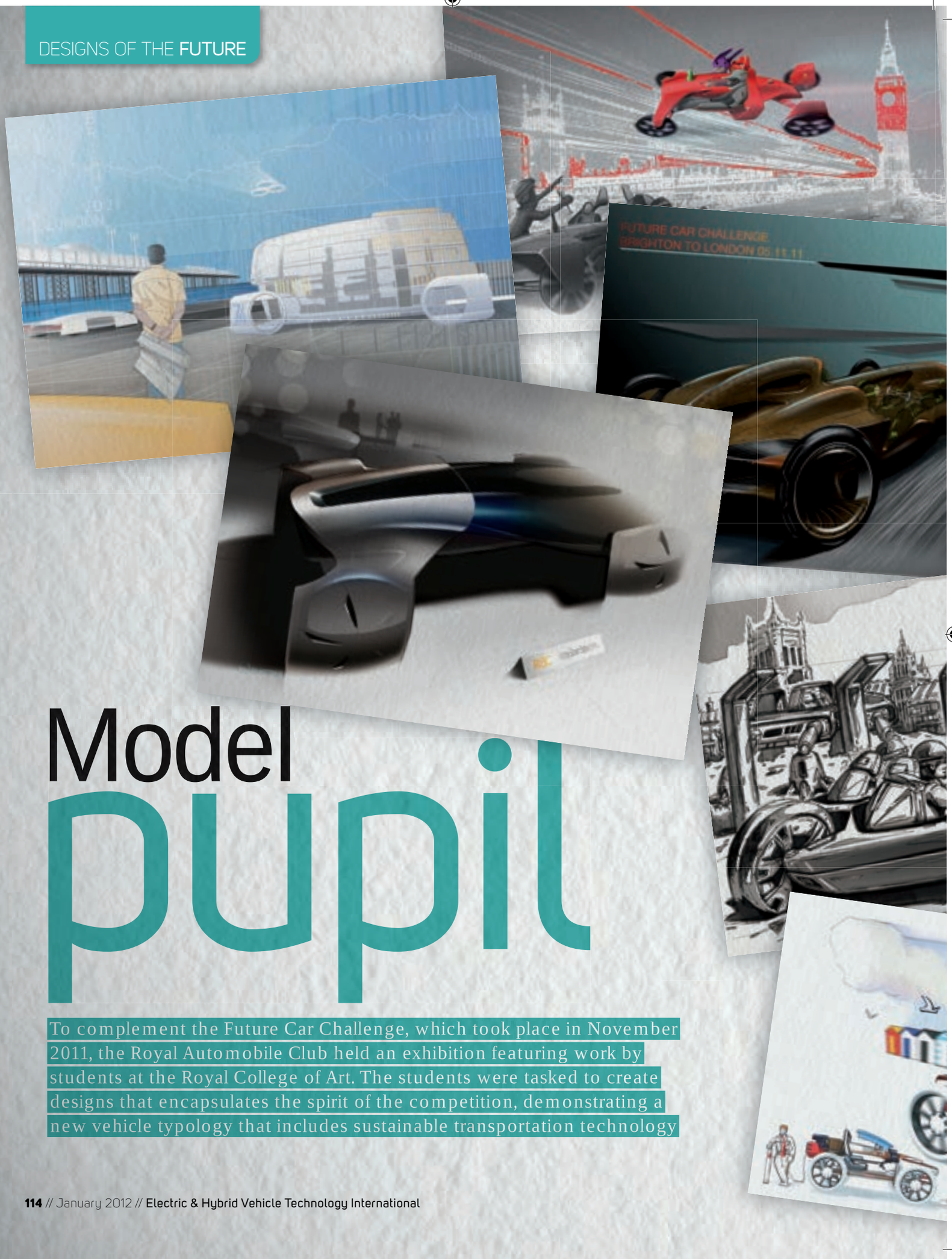

Model pupil

To complement the Future Car Challenge, which took place in November 2011, the Royal Automobile Club held an exhibition featuring work by students at the Royal College of Art. The students were tasked to create designs that encapsulates the spirit of the competition, demonstrating a new vehicle typology that includes sustainable transportation technology

1. SAMUEL JOHNSON

Image: This thought provoking concept is based around tomorrow's Future Car Challenge becoming a testbed for manufacturers to develop alternative drivetrains. Each OEM entry is allocated an amount of energy that they can use in the most economical way possible, thereby promoting new technologies and motorsport not around speed but efficiency.

Artist: Johnson graduated from Coventry University's transport and product design course in 2009. Having spent a number of years in the industry working within a wide range of application areas, he is now studying at the RCA.

2. KI DUK KIM

Image: A hybrid – solar and human-powered – race car that is lightweight and environmentally friendly, Kim's vision combines a nano solar-cell spraying technology and electricity-chargeable composite that reduces the car's total mass.

Artist: Originally from South Korea with a background in automotive design, Kim is interested in the styling of cars, specifically using new technology and materials.

3. SIDUO ZHANG

Image: A new type of electric vehicle is depicted here: an open structure electric car with a transparent cabin bodyshell.

Artist: Originally from China, Zhang studied illustration in London and worked as a freelancer for two years before coming to study at the RCA.

4. JUNGWOOK LEE

Image: Powered by a lithium-ion battery, Lee's design is sleek and compact, with the car's low profile making it even more efficient.

Artist: Born and raised in Seoul, South Korea, Lee always wanted to be a vehicle designer. He came to London to study, and is fascinated by the city's traditional heritage and its cutting-edge designs.

5. IAN SLATTERY

Image: Slattery's design focuses on the EV future, where the vehicle strives to emulate the emotional connection drivers have with their vintage cars. In this 'tomorrow's world' scenario, EV owners grow and develop their own batteries.

Artist: Slattery studied at the National College of Art and Design in Dublin in 2010 after which he went on to work in the Miele design center in Gütersloh, Germany. Now at the RCA, Slattery is interested in envisioning the future of mobility.

6. NIR SIEGEL

Image: This image portrays a future for lightweight kit vehicles that are self-assembled at the competition site. Consisting of a collapsible lightweight skeletal structure that is held together by highly tensioned stretched textiles, this kit car is very eco-friendly thanks to its electromagnetic motors.

Artists: A 29-year-old industrial designer born and educated in Tel Aviv, Israel, Siegel has spent the past few years in the design sector in his home country. Siegel is passionate about transportation design and is pursuing a Masters at the RCA.

7. MICHAEL HEVERIN

Image: The frame, electric motor and limited battery storage are standard issue here, while the seats, weather protection and storage are sourced individually. The limited battery power and range will require competitors at the Future Car Challenge of tomorrow to stop and recharge, encouraging gamesmanship.

Artist: Heverin started his career as a video game designer, but interestingly, he's also a qualified London cab driver, and finds the latter to be a source of inspiration for his artwork.

8. KYOUNG SOO NA

Image: The Future Car Challenge is all about using energy resources efficiently, so with this in mind, Na's design does not have a roof and the body of the vehicle is made up of only two parts, thereby ensuring the car is very lightweight. The vehicle is charged by a wireless electricity transfer system.

Artist: Na has a long-standing interest in moving objects, having taken industrial design classes before joining the RCA.

9. FERRAN MESTRES BLANCH

Image: Blanch's image depicts a scene from the Future Car Challenge in the year 2021. The car is powered by four electric motors – one for each wheel – and a tank of compressed air for extra power when overtaking.

Artist: Aged 27, Blanch grew up in Barcelona. Before attending the RCA, he studied transportation design at the Istituto Europeo di Design in Barcelona.

10. MARIANNA MERENMIES

Image: This car is powered by algae-derived fuel and constructed using recyclable algae-based plastic composites. Solar panels in the bonnet-roof shield capture the sun's rays for power.

Artist: Prior to pursuing a Masters in vehicle design, Merenmies gained several valuable years of experience in the automotive industry, working for VW's advanced design center in Potsdam, Germany, as an exterior designer, and at Fuore Design International in Barcelona.

11. EDWARD STARKEY

Image: Starkey's vision is of an electric vehicle whose power is supplemented by solar panels.

Artist: After studying interior architecture, Starkey worked in custom yacht design before moving to the RCA to complete a Masters in vehicle design.

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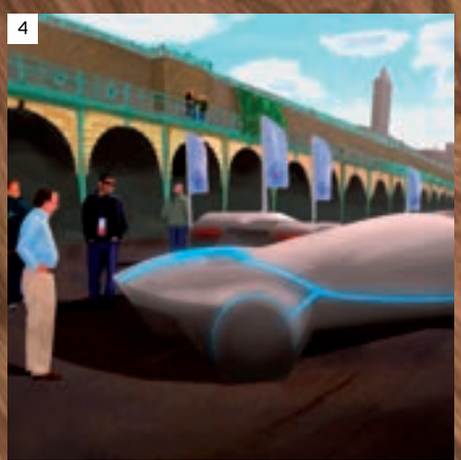

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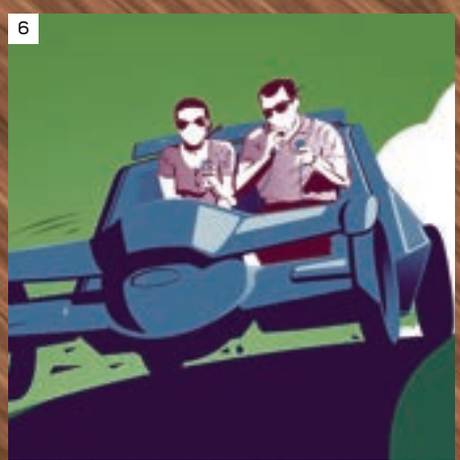

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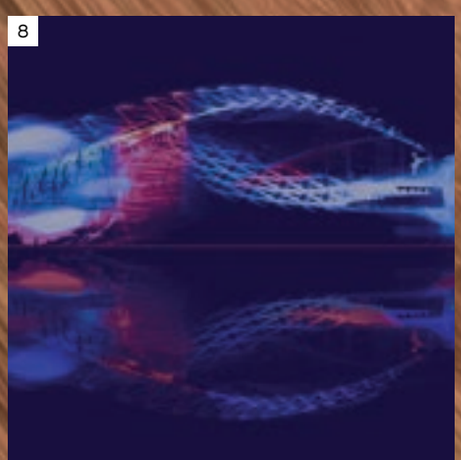

BEST OF THE REST

1. Michal Vlcek
2. Qiannan Wang
3. Shihan Pi
4. Josep Ferroil
5. Marcus Classen
6. Anthony O'Sullivan
7. Ewan Gallimore
8. Henry Cole

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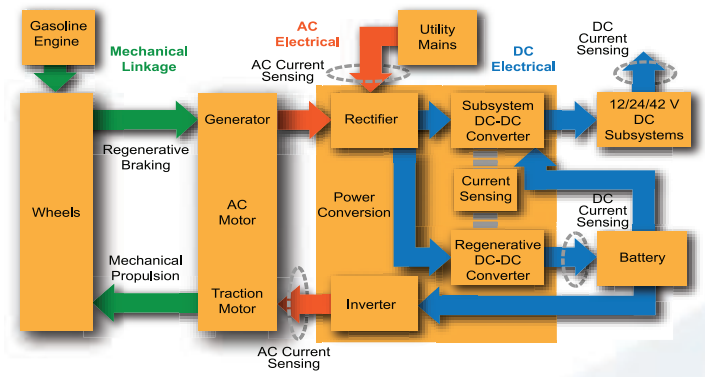
Consumers are embracing environmentally friendly "green cars" as a result of the rising cost of fossil fuels and a growing concern for the health of the environment. Hybrid electric vehicles (HEV), quickly becoming the most popular green car, employ complex power electronic circuitry to control the flow 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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One-stop **shop**

The testing community is charging ahead with new, state-of-the-art technologies, so we here at E&H have gone shopping on your behalf, seeking out the latest must-have systems, technologies and processes for your EV program

WORDS: **ADAM GAVINE**

ON A MOTORCYCLE MISSION

Here's something for those investing in developing EVs that feature only two wheels. Mission Motors has been using electronic load technology to create the Mission R, which the California-based company claims is the most advanced electric racing motorcycle in the world.

The cornerstone of the bike's technology is a lithium-ion battery pack that has been tested rigorously to determine performance and lifetime characteristics. Mission Motors chose Chroma's 63208 DC Electronic Load system for accessing the bike's EV battery modules. The 63208 technology is capable of pulling a 15.6kW continuous load from the battery modules – enough power to propel the Mission R bike to a continuous speed of 80mph.

The 63208 Electronic Load plays two main roles for Mission. Firstly, it acts as a research tool. For example, the Mission R requires high power and energy from its packs, while keeping the form factor small and lightweight, and in order to meet these specifications, tests must characterize electrical and thermal properties throughout a module's lifetime. The 63208 Electronic Load's second focus centers on the fact that Mission uses power versus time profiles from its vehicles to simulate power loads. Chroma's software enables Mission to take these loads and test their modules on the bench as though they were in a Mission vehicle.

When it's not being used for R&D, Chroma's load acts as a qualification tester in Mission's module production. It first verifies each module's capacity with a constant rate of 1C discharge. If a module's energy capacity passes this test, it is then assessed for power capability. At three different states of charge, Mission engineers test each module to verify that it will meet its performance requirements.

HIGH-TECH CHAMBERS

ESPEC has introduced a new range of temperature chambers for testing Li-ion batteries. The advanced chambers have been engineered to offer safety features to protect users from harmful explosions, and ensure the operator is protected. Safety features are selected based on the clients' individual testing needs and safety plan. Integral to most safety systems is a gas monitor, which can automatically activate protective features. Low-temperature heaters for the chamber protect from ignition of noxious gases if a battery vents, and a locking door latch and pressure vent are helpful if a battery explodes. ESPEC says that these features help enable the safe testing of batteries, as well as ensuring safety of the final product.

DEDICATED FACILITY

MIRA has opened a new, state-of-the-art facility dedicated to optimizing battery technology. This latest US$720,000 outlay is part of a planned US$1.6 million investment in battery testing capability at MIRA's technology center in Essex, UK. The company says that the investment recognizes that battery use in the automotive world is increasing in line with the growth in popularity of EVs, but also has the problem of limited range.

Featuring a Bitrode FTF 1-400-500 unit (for testing batteries of up to 500V/400A), a Bitrode FTV4-300-48 unit (for testing up to four modules at once from 0-72V/300A), plus a Prosig PS8048 150-channel data logger that can log both voltage and temperature with each voltage channel isolated, the new facility has already helped the company secure a major multimillion-dollar program with a premium European car maker.

"Our new facility offers state-of-the-art battery pack, module and cell testing alongside full environmental simulation capability," says Eamonn Martin, MIRA's environmental test services manager.

"It really is one of a kind, and expands and enhances MIRA's existing offer in power electronics, battery management strategy and functional safety. It enables us to analyze factors such as the variable effects of extreme weather."

RANGE REVOLUTION

Do you think it's acceptable for EV manufacturers to rely on driving range data developed for the IC engine when assessing a new EV? TÜV SÜD, one of the world's leading experts on product testing, doesn't, and as such, wants a new international standard to be formed. The company says that as the driving range of EVs is considerably lower than that of IC engines – and because range depends to a great extent on the outside temperature and the use of electrical equipment within the vehicle – EV makers need to be able to test against and work with a set of measurements that are as close as possible to real-world use.

So, in preparation for a possible new standard, TÜV SÜD experts have formed the E-Car Cycle (TSECC), a new method for determining the driving range of EVs. According to TÜV SÜD, one of the main concerns when developing this standard was to measure range under conditions that were as realistic as possible. As the industry already knows, the winter is a particularly testing time for batteries, a fact that was further highlighted during a comparative test undertaken by TÜV SÜD engineers that showed driving range of EVs under standard conditions of 23°C and wintry conditions of -7°C diverged by more than 50%.

Further testing also uncovered that the range of EVs, based on the NEDC, diverged from those based on TÜV SÜD's TSECC standard. The results from the NEDC test showed that the range of one Japanese EV was 133km; however, using the TSECC, the range dropped to 113km. Then, at a temperature level of -7°C, and with power consumers such as the heating turned on, the range dropped further, to a mere 64km.

TÜV SÜD says that the results of this independent test show clearly that the standard information on EVs provided by manufacturers, using data that is comparable to that for petrol-driven vehicles, is not sufficient to measure their range.

DESTRUCTIVE LI-ION TESTING

Looking for a new lab that offers complete lithium-ion battery assessment, including destructive testing of cells? Well, look no further because TÜV NORD together with CETECOM has developed the first functioning system for testing lithium-ion batteries. In creating the new battery test lab in Saarbrücken, Germany, TÜV NORD says it is expanding its activities in the electromobility sector, with the main focus being on battery packs and charging safety.

Axel Richter, the man responsible for EVs at TÜV NORD, explains further: "Through our work with CETECOM we can link know-how with hardware in order to create a complete and functioning battery test system – an important step for the further development of electric vehicles. But the high energy density in lithium-ion accumulator batteries can mean danger in the event of malfunction, so it's even more important to continue development work in this area."

Both the test equipment and test procedures that have been developed by TÜV NORD and CETECOM for battery systems meet unified standards so that results can be reproduced all over the world, a point that Gerhard Schirra, CEO of CETECOM, says is vital. He adds, "Our test benches are complete and have been validated, and our laboratory infrastructure means that we are also able to perform so-called destructive testing of lithium-ion batteries safely. This means that we can fulfill the requirements set for us by the automotive industry while promoting a high standard for battery safety across the world."

The lithium-ion batteries are tested in Saarbrücken for their resistance to mechanical, electrical and climatic stress. In addition, their reaction to misuse – caused by a short circuit, for example – is also assessed. The rigorous test procedure calls for the batteries to be subjected to a crash test in order to establish if they meet the UN rules for battery transportation.

COMPLETE LIFECYCLE

In need of a product that covers development, calibration, certification, end-of-line and repair and maintenance testing of EVs? In that case, the latest offering from Mustang Advanced Engineering (MAE) is just the ticket. The MAE-AC-4000 Series Universal Automotive Test Stand is an advanced independent-wheel-control AC motor dynamometer and ABS/ESC tester that is capable of reproducing an unlimited array of testing and simulation conditions for full product lifecycle testing of EVs and EV subsystems.

For vehicle development, calibration, and certification applications, MAE says that the AC-4000 Series provides a cost-effective design and enables quick development cycles for performing initial EV calibrations. It also covers such aspects as traction system motoring and ABS/ESC testing with skid simulation, regenerative braking and limited traction condition simulations using road load and federal drive cycles, electrical power systems analysis, efficiency testing, fuel consumption testing and repair and maintenance services. MAE offers a number of lab-grade software and data acquisition packages for hardware-in-the-loop and R&D environments.

The AC-4000 uses four independent AC motors, one coupled to each set of rollers, to control the load to each wheel independently. A moveable wheelbase enables the AC-4000 to accommodate both 2WD and AWD vehicles. An automatic vehicle restraint and safety system reduces the test cycle time and ensures that vehicles remain safely in position on the tester.

A NEW DIMENSION

Now, here's something from the academic world that might help future EV programs: the University of Illinois research group, led by professor Paul Braun and supported by the US Army Research Laboratory and the Department of Energy, have developed an innovative three-dimensional nanostructure for battery cathodes that enables faster charging and discharging without sacrificing energy storage capacity.

"This system gives capacitor-like power with battery-like energy," explains Braun, a professor of materials science and engineering. "Most capacitors store very little energy. They can release it very quickly, but they can't hold much. Most batteries store a reasonably large amount of energy, but they can't provide or receive energy rapidly. This does both."

Braun's group wraps a thin film into a three-dimensional structure, achieving high active volume, high capacity and large current. The group claims it has demonstrated battery electrodes that can charge or discharge in a few seconds, which is up to 100 times faster than equivalent bulk electrodes, yet (and here's the amazing engineering part) it can perform normally in existing devices.

Braun is particularly optimistic for the batteries' potential in EVs: "If you had the ability to charge rapidly, instead of taking hours to charge the vehicle, you could potentially have vehicles that would charge in a similar amount of time needed to refuel a car with gasoline," he explains. "And if you had five-minute charge capability, you would think of this the same way you do an IC engine. You would just pull up to a charging station and fill up."

Braun's development features a bicontinuous electrode structure with small interconnects so the lithium ions can move rapidly, a thin-film active material so that the diffusion kinetics are rapid, and a metal framework with good electrical conductivity. The group has demonstrated NiMH and Li-ion capabilities, but the structure is of a general type, so any battery material that can be deposited on the metal frame could be used.

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 imminent investment in 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.

FAIL TO PROGRESS

Forget about today's batteries that last just a few years – some R&D scientists are looking at how to create a battery pack technology that can power an electric vehicle for decades.

And realizing that kind of longevity in lithium-ion battery systems – while simultaneously trying to increase storage capacity – has become the mission of Daniel Abraham, material scientist at Argonne National Laboratory. But to extend the working life of a battery, researchers need to understand how and why batteries fail, says Abraham. "I think of it as solving a series of mysteries," he adds. "How did it happen? How can we prevent it from happening again? To find out, we often take apart the battery and examine its contents for clues using an array of diagnostic tools."

As the industry knows, there are many ways in which a lithium-ion battery can fail. For example, when both the cathode and anode are composed of tiny particles glued together with a chemical binder and painted on over a metallic sheet, sometimes the binder fails and the composite comes apart; and at other times, the entire layer peels off the sheet. In rare cases, lithium batteries can catch fire or even explode.

Abraham and his team say that quality control matters more in lithium-ion batteries than in other battery systems, especially because battery packs contain individual cells that are electrically linked together, and if one cell is faulty, the system becomes inefficient and much more dangerous.

"Say the faulty cell has only half the capacity of the others," Abraham explains. "When I plug in to charge, that one cell will fill up faster than the others, and it begins to overcharge."

He continues: "If I keep adding energy, the electricity has nowhere to go, and it's transformed into heat. The heat eventually exceeds the flammability threshold of the electrolyte, and the cell bursts into flame."

Abraham adds: "The arrangement of atoms within the crystal structure plays a role in how the battery performs. What we are doing now is looking at batteries in situ: that is, actually watching the battery as it charges and drains, using powerful x-rays from the Advanced Photon Source and electrons from the Electron Microscopy Center. That's the cutting edge of battery diagnostics."

SOUND ADVICE

Away from the testing arena, silent-running EVs pose major challenges for NVH teams. The sounds made by IC-engine vehicles mask high-frequency and low-level noise, and as a result, over the years there's been less concern when designing cabin acoustics and exterior sound profiles for IC-engine vehicles. But for EVs, the sounds from the switchgear and motors become prominent inside the cabin, and the exterior noise is much lower than the levels consumers are used to.

However, even though NVH engineering for EVs is a relatively new discipline, the need to investigate high-frequency noise

at low levels is not. The experts at Brüel & Kjær have long been pioneers in the field of sound and vibration measurement and the company has a portfolio of proven tools for exploring higher frequencies at lower levels, such as the Pulse Array Acoustics Suite, a post-processing environment for array acoustics across all methods and applications, including beamforming, spherical beamforming, and acoustical holography.

The Pulse Array Acoustics Suite is a single platform that ensures full interoperability between methods. This means that data from one method can be accessed from a database for display and comparison with any other method. Combining acoustical holography methods with phased array methods gives accurate, high-resolution maps in the full audible frequency range, which is just the ticket for those investigating the sound quality of tomorrow's EVs.

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Trash treasure

A research team at Tulane University is looking into ways to float discarded newspapers down the Mississippi River and turn them into a viable substitute for pump gasoline. Could this be the sustainable transportation solution that the industry has been searching for?

WORDS: **JIM McCRAW**

Okay, so running cars on old newspapers sounds like wacky stuff, but a determined researcher at the highly regarded Tulane University in the USA thinks he has come up with something big, if not different.

Most of us know that butanol (chemical symbol CH4H9OH, also known as butyl alcohol) has been around for a long, long time, but never in all that time has it been used as a motor fuel on any sort of large scale – a situation that Dr David Mullin of Tulane University's department of Cell and Molecular Biology hopes to change in the near future by using a microscopic tool.

Butanol is derived through various fermentation processes from cellulose, most commonly using the acetone-butanol-ethanol (ABE) fermentation process that utilizes bacterial fermentation to produce these three liquids from starches. The process is anaerobic, performed in the absence of oxygen, usually using a strain of bacteria from the Clostridia family.

The production of butanol by biological means was first performed by Louis Pasteur in 1861. Industrial production of ABE fermentation started in 1916 with Chaim Weizmann's isolation of Clostridium acetobutylicum, leading to a US patent. In order to make ABE fermentation profitable, many product recovery systems have been developed, including gas stripping, pervaporation, membrane extraction, absorption and reverse osmosis. However, none of them has ever been implemented on a large scale.

Two years ago Mullin found himself in flood-ravaged New Orleans, looking around for a new project after the hurricane ruined all of the department's existing ones.

"One of the projects I wanted to get involved in was biofuels, because of the rising price of gasoline, and sporadic shortages of oil. I'm a microbiologist, and fermentation technology is something that I have always been closely attached to. When I looked into biofuels, I found just one, ethanol, and the energy content is about one fourth less, whereas butanol is only about 4% less than unleaded gasoline in terms of energy content. As a microbiologist, I knew about the butanol fermentation pathways, so I thought we'd get involved in this, starting with some bacterial strains that would be more desirable than the strains currently being used."

Old news is good news

So Mullin, his staff and his students started looking for a bacterium that could make butanol from cellulose in the presence of oxygen, which would be far simpler and less expensive than the traditional anaerobic process. Their first targets as feedstocks were newsprint, a very highly refined version of cellulose, and cotton gin waste, both of which

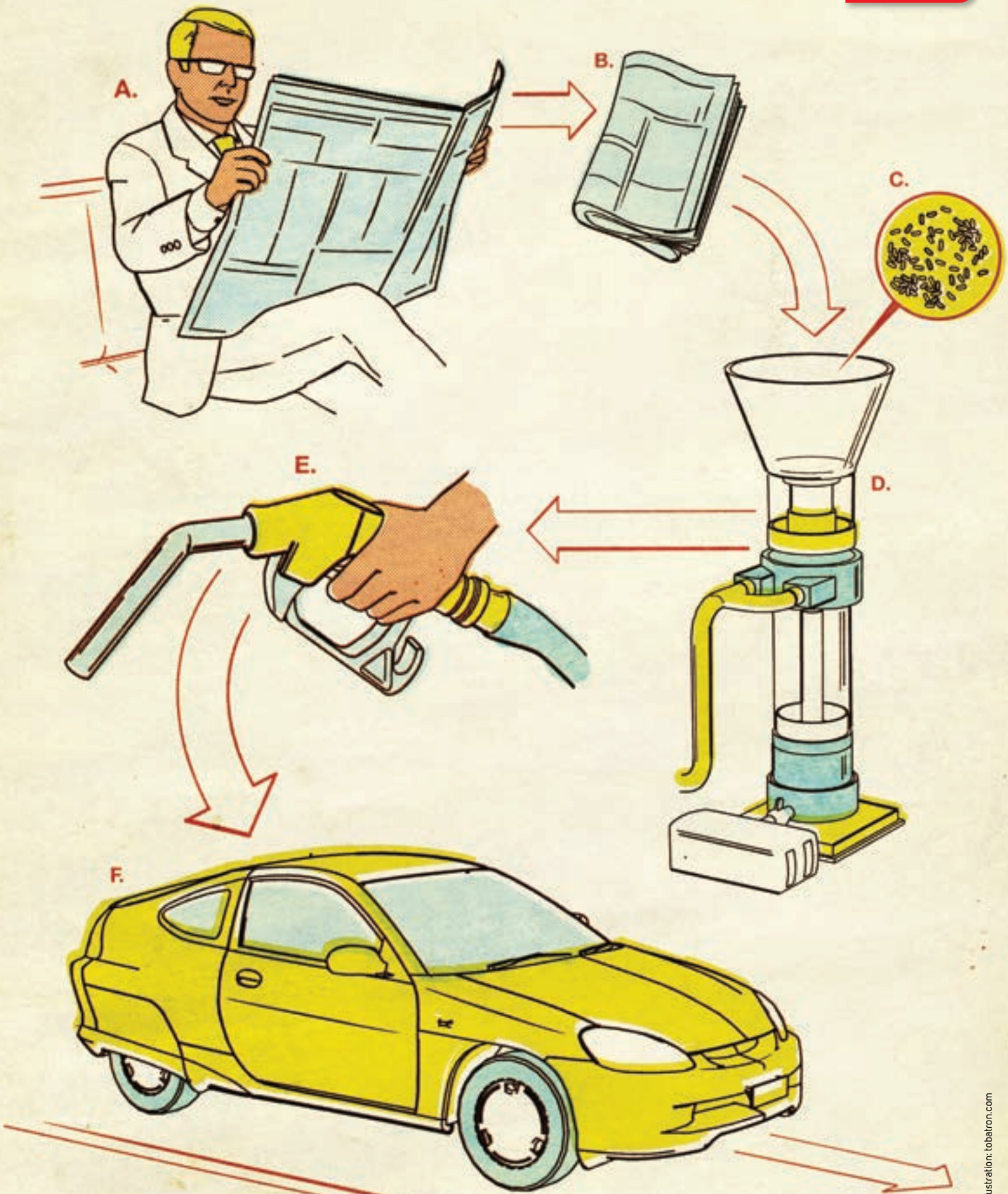


Illustration: tobatron.com

are normally thrown away after use. Mullin says that cotton gin waste, which is about 82% cotton, amounts to about two million tons per year, but that newsprint – essentially yesterday's newspapers – amounts to the staggering total of 323 million tons per year in the USA alone. The team also looked into using sugar cane leftovers or begasse, because of the local availability of begasse from the Louisiana sugar cane fields.

"We knew what we wanted to find," recalls Mullin. "We wanted a bacteria that makes butanol from cellulose that could grow in air. Cellulose is a polymer of glucose, so with glucose molecules linked together, our bacteria, TU-103, is a clostridium that produces an enzyme that cleaves or chips off the glucose units, one at a time, off of the cellulose. The glucose that gets chipped off is then converted into butanol. The bacteria know how to make butanol once the glucose is available, and the enzyme and cellulase combined is able to accomplish the breakdown of cellulose to produce glucose."

So where did the patent-pending TU-103 bacterium come from? Mullin's group, with grants from the Department of Energy's Clean Power and Energy Research Consortium, found it first in animal droppings generated by animals that eat grass, another form of cellulose.

"We looked at insects, we tried to look at animals that eat grass or cellulose, looking for bacteria that can turn cellulose into glucose. If you look at the total cellulose biomass produced in the USA each year, including newsprint, corn stalks, corn cobs, wheat stover, sugar cane begasse, and the like, it's more like about 1.3 billion tons per year, according to Department of Agriculture and Department of Energy figures."

With yesterday's newspapers already being collected for recycling in thousands of communities, Mullin is quick to point out that if it's just thrown away in landfills, it tends to break down over time and generates methane, one of the least desirable outcomes in terms of greenhouse gases, so it would be much better used to generate butanol fuel.

But the key question for those working in an automotive sphere is, how does butanol compare with pump gasoline? "Very favorably," states Mullin, "especially when contrasted to some other potential gasoline substitutes such as ethanol."

Mullin says butanol is nowhere near as corrosive as ethanol, which means that fuel systems could be used with minimal changes

For starters, its energy content is 110,000 Btu per gallon, versus gasoline's typical 115,000 Btu. Butanol has a motor octane number of 87, equivalent to today's regular-grade American gasoline. The burning of butanol, unlike gasoline, produces no oxides of sulfur, no oxides of nitrogen, and no carbon monoxide. It has about 25% more usable energy than ethanol. It has a much lower Reid vapor pressure number – .33psi versus 2.0 for ethanol and 4.5 for gasoline – and so it is cleaner from an evaporative emissions standpoint and generally safer to move and handle.

Another important aspect is that butanol is nowhere near as corrosive as ethanol, which means that current pipelines, fuel tanks, fuel pumps and fuel lines could be used with minimal modification or substitution of materials. It's a big plus point. Further more, it also contains four more hydrogen atoms than ethanol, making it more viable and appropriate when reformulated for use with hydrogen fuel cells.

A commercially viable option?

"The price of butanol as used in the chemical industry varies between US$5 and US$7 per gallon, so there is a lot of profit to be made selling butanol on the chemistry market," explains Mullin.

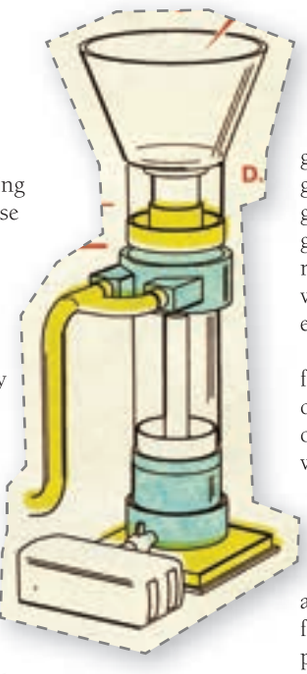
"The market for butanol right now is about seven billion gallons per year. Once that market gets saturated, you can start selling it for fuel. If you could sell butanol as fuel for two dollars a gallon, why would you do it if you could sell it for seven dollars a gallon to the chemical industry? So I think what has to happen is that, if you can produce it at a high enough yield, you can probably make money selling it to both markets."

As to the yield in large-scale production of biobutanol, Mullin's small-scale fermentation process has yet to produce reliable numbers in terms of gallons of fuel per ton of newsprint or cotton gin waste or sugar cane begasse. In the R&D laboratory he uses a 10:1 ratio of newsprint broth to TU-103 bacteria to make biobutanol.

Yes, but will it work?

Fuels and lubricants specialist for Ford, Pete Misangyi, says that biobutanol offers an attractive alternative to ethanol and gasoline. "Butanol is normally made or converted from ethanol, so you could almost consider it a refinement of ethanol. It has very high octane, 105 to 110 RON, similar to ethanol. The benefits of butanol over ethanol include its non-affinity to water – its material compatibility is more similar to gasoline, so you don't need to modify fuel system components, and you can blend up to 16% butanol with gasoline and get the same air/fuel ratio shift, so it's basically compatible up to 16% without any disadvantages. As a blending compound it's probably a much better compound than ethanol would be. It's similar to ethanol in terms of emissions."

Misangyi adds, "It would be similar to running 100% ethanol as we do in Brazil, but you'd have to recalibrate the vehicle to run on it, and change some of the materials in the fuel system to accommodate it. Newsprint, as long as there is any around, considering the internet, would be an excellent source, because it's a similar process to making cellulosic ethanol, with an additional step. I don't know what the well-to-wheels cost would be compared to gasoline, but if societal issues of cost, land use, water use and raw material were resolved – and if it is cost-competitive and environmental friendly, it could be an excellent source."



"If you look at the total cellulose biomass produced in the USA each year, including newsprint, corn stalks, corn cobs, wheat stover, sugar cane begasse, and the like, it's more like about 1.3 billion tons per year"

"We've determined the nucleotide sequence of the genome of this bacterium, TU-103. We know every single gene that's in it now, so it will let us take a directed genetic approach toward overproducing butanol. We can go in and tinker with genes, change the way that they are regulated and remove some genes that we don't want, so we are refining TU-103 itself so that it can become more efficient and create higher yields."

In the near future, says Mullin, the team will be looking for bacteria that can take cellulose and convert it instead of butanol into pentanol and hexanol, C5 and C6, instead of C4, which would contain a great deal more energy than what butanol currently offers.

As always with motor fuel, there are economic considerations and governmental regulations that can determine the future of biobutanol. In the USA there is a production limit of 14 billion gallons of ethanol per year, a rule intended to keep corn in the food chain and not in fuel tanks. After that limit the ethanol has to be exported, probably at a loss. The US government might also subsidize biobutanol production because of its strategic value, adds Mullin.

"Butanol is a drop-in fuel that could directly replace gasoline, or it could certainly be blended, but there are two other types of fuel that you could use butanol to make. One is butene, which can be converted in turn into Jet A, JP5, or JP8, for use in commercial and military aviation. It's also possible to convert butanol into dibutyl ether, which can be used as a diesel fuel for over-the-road trucks."

Is there a downside to using biobutanol as a motor fuel? Mullin says that one unknown is whether or not the combustion residue of biobutanol will react, away from the laboratory and in the atmosphere, to create harmful emissions. A major upside is that each year in the USA, fully one quarter of all the grain produced is in turn used to produce ethanol – a huge amount of food grains that never reached the American dinner table. In light of that, cellulose is crucial, says Mullin. "It's renewable, it's a waste product that nobody wants. It can be turned into fuel."

In the blue-sky world, Mullin envisions all of the waste newsprint in the USA being sent to various ports on the Mississippi River, floated down to Louisiana, and then processed in former ethanol plants that can be converted very easily and cost-effectively to biobutanol production, and located next to existing petroleum refineries, where it can be blended with gasoline or shipped directly to fueling stations.

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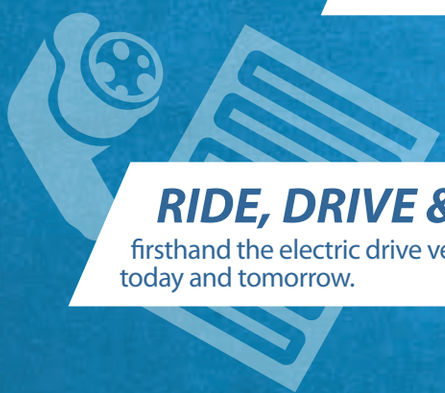

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Lasting

London is getting ready to become the first summer host city to have sustainability at the very heart of the Olympic Games. The plan includes the use of electric vehicles and the creation of a charging infrastructure

WORDS: **FARAH ALKHALISI**

LONDON 2012

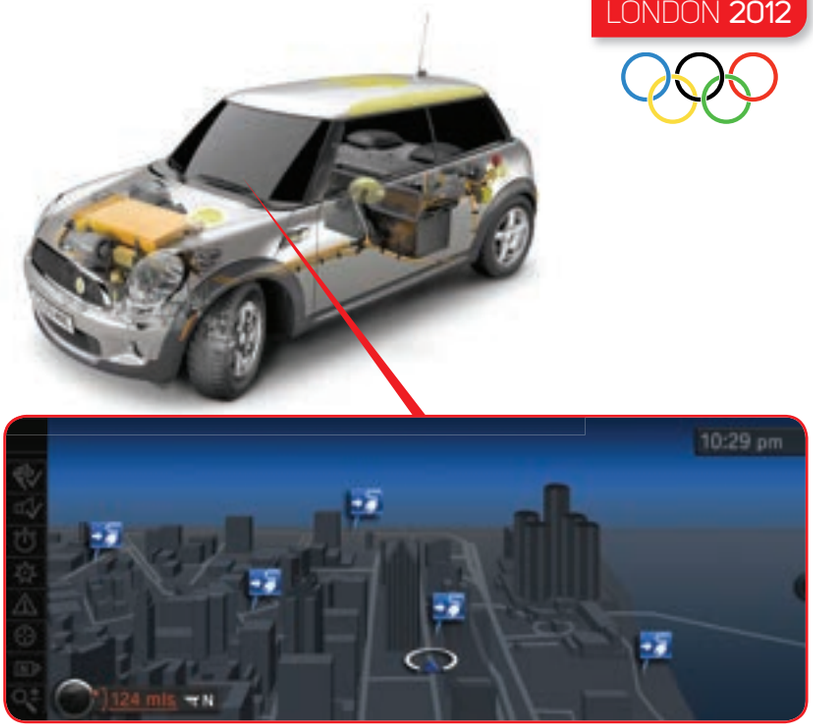
acy

The London Organising Committee of the Olympic Games (LOCOG) has some ambitious targets to meet for 2012. The UK's capital city has promised to host "the first sustainable Olympic and Paralympic Games", and while it has been acknowledged that the Games cannot be entirely carbon-neutral, some strict benchmarks for waste recycling, materials sourcing and energy consumption have been set. These extend to the fleet of support vehicles: the passenger cars are to have an average carbon dioxide output of less than 120g/km (logistics vehicles, buses and coaches will have a separate target). BMW, a Tier 1 partner for the event, is supplying LOCOG with nearly 4,000 cars, and of these, 200 are to be all-electric.

"The year 2012 is an amazing opportunity to showcase a wide range of sustainable transport solutions," says Michelle Roberts, BMW's UK manager for London 2012, "and EVs will undoubtedly play an important role, together with many other technologies."

The EVs will be deployed for tasks that can be carried out within their range. "The fleet provision is being made to support the transportation requirements of a diverse audience, including athletes, technical officials, media, LOCOG operational teams, national Olympic Committees, international sports federations, the IOC and marketing partners," she adds.

The electric fleet that BMW is to supply will comprise 160 ActiveE and 40 Mini E hatchbacks, 30 of which will be seconded from the fleet currently leased by EDF Energy, the official energy utilities and sustainability partner for the Olympics. While neither the Mini (which has its rear seats replaced by its battery pack) nor the three-door, 1 Series-based ActiveE are going to be able to transport teams, vast amounts of sports equipment or even a camera crew, there will be runaround duties that they can perform.



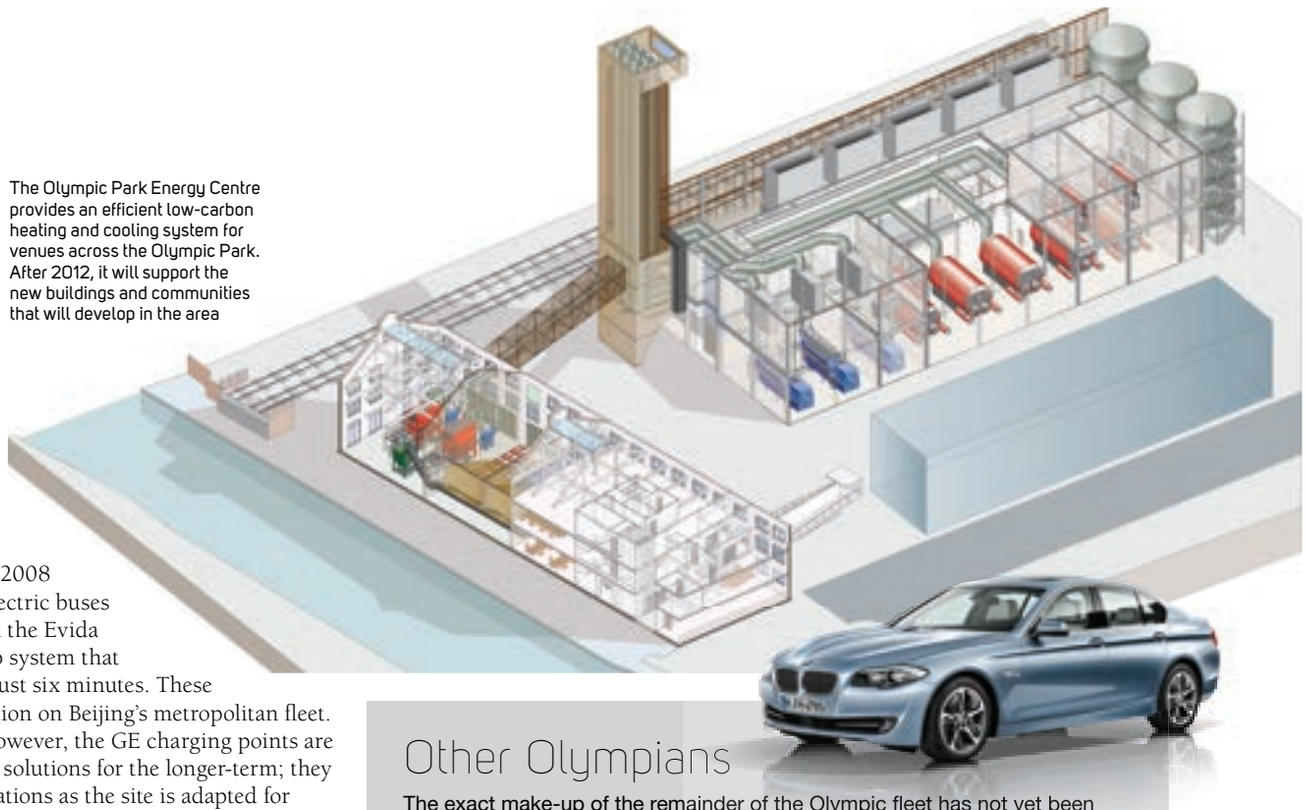
Above and below: BMW will supply 40 Mini E vehicles for the Olympic Games. However, a fully integrated charging infrastructure will be vital to ensure that the EVs will have enough power to perform their duties

Recharging batteries

LOCOG, which declined to comment for this article, has to ensure that the infrastructure to support the EVs is adequate. It is working with Transport for London and a specialist electric vehicles consultancy team from EDF Energy, which is also the official electricity supplier to the Olympics, to set up a network of recharging points. These will be supplied by General Electric, a partner at the previous Winter and Summer Olympics in Turin (2006), Beijing (2008) and Vancouver (2010).

"The project scope is to install 100-120 charge points," states EDF Energy spokeswoman Phillippa Coates. The points will be located at five fleet hubs, and will be GE's 32A Durastation fast-chargers, which can give a full recharge in as little as one to two hours, depending on the battery specification of the vehicle being charged. This should minimize the downtime the EVs will need; for while they will not necessarily be covering a high mileage on-site, they will need to be on constant call for shuttling around as needed. "Concurrent charging of this large number of electric vehicles in the UK is unique and complex," notes Coates. "The challenge is to maintain quality of electricity supply, while ensuring the fleet operational requirements are met."

Coates is not alone in her thinking. "The cars are going to be out of action for at least some of the day," explains Dr Ben Lane, director of Ecolane, a consultancy that has recently worked on schemes including a technology assessment for the Abu Dhabi Department of Transport and a vehicle technology strategy for Heathrow Airport. "You will need a lot of fast-chargers if you're going to keep a 200-strong EV fleet on the move all the time. Essentially, it's going to be down to the recharging regime in terms of what they can stand." Lane warns that there is a risk to the battery longevity from repeated fast-charging. The main challenge, however, is going to be logistics rather than technical constraints. "You need a good maintenance team," he advises, "keeping track of all the vehicles, which ones are available, and their state of charge. But it all sounds doable."



The Olympic Park Energy Centre provides an efficient low-carbon heating and cooling system for venues across the Olympic Park. After 2012, it will support the new buildings and communities that will develop in the area

While a high-pressure, high-profile event like this is not necessarily the best place to try out emerging ideas, an Olympic fleet can be a proving ground. At the 2008 Beijing Olympics, 50 electric buses were trialed, along with the Evida automated battery-swap system that exchanges batteries in just six minutes. These buses are now in operation on Beijing's metropolitan fleet.

Post-London 2012, however, the GE charging points are practical and accessible solutions for the longer-term; they will remain in their locations as the site is adapted for residential and business use, and become part of the ever-growing Source London public charging network. "The five fleet hubs sit outside the park and are owned by third parties who are hosting the fleet during Games time," explains EDF's Coates. However, this situation means that, "while EDF is the official supplier of electricity to the Olympic Park and will be providing a low-carbon mix, individual hub owners will be selecting their own electricity supplier, so there is no guarantee that they will choose a low-carbon or renewable mix".

There is clearly a substantial degree of thought – and financial investment – going into supporting this EV fleet for the duration of the Games, especially given its rather limited capabilities. Yet in the context of the entire fleet, the role of these cars is probably more symbolic than practical anyway, both as a preview of BMW's future plans and as a demonstration of electrically powered vehicles at work.

Other Olympians

The exact make-up of the remainder of the Olympic fleet has not yet been confirmed, but it will include the soon-to-be-launched BMW ActiveHybrid 5, which is based on the 535i sedan model, as well as the economical, low-emissions 320d EfficientDynamics and 520d EfficientDynamics diesel sedans and the Mini Countryman Cooper D. The 68.9mpg 320d EfficientDynamics, which emits just 109g/km, will make up at least a third of the fleet, says BMW, and its 520d counterpart (62.8mpg, 119g/km) will also feature significantly. The BMW fleet will support both the Olympics and Paralympics, and thus a proportion of the vehicles will also be specially adapted for use by disabled people.

However, "there are no plans to include hydrogen vehicles", says a BMW insider, nor the Rolls-Royce 102EX experimental electric prototype, which could perhaps have performed a ceremonial role. BMW will instead supply 400 bicycles as well as a number of different motorbikes – the R1200RT, R1200GS and F650GS – which will support the road- and mountain-biking events in particular.

And there is a further electric vehicle to be seen in action: the Pedelec, which will go on sale next year. The 18mph bike is equipped with batteries for electrical assistance and is intended as an urban commuting machine. It's ideal for London, not least because it can be folded up and carried on the Tube.

Center of competence

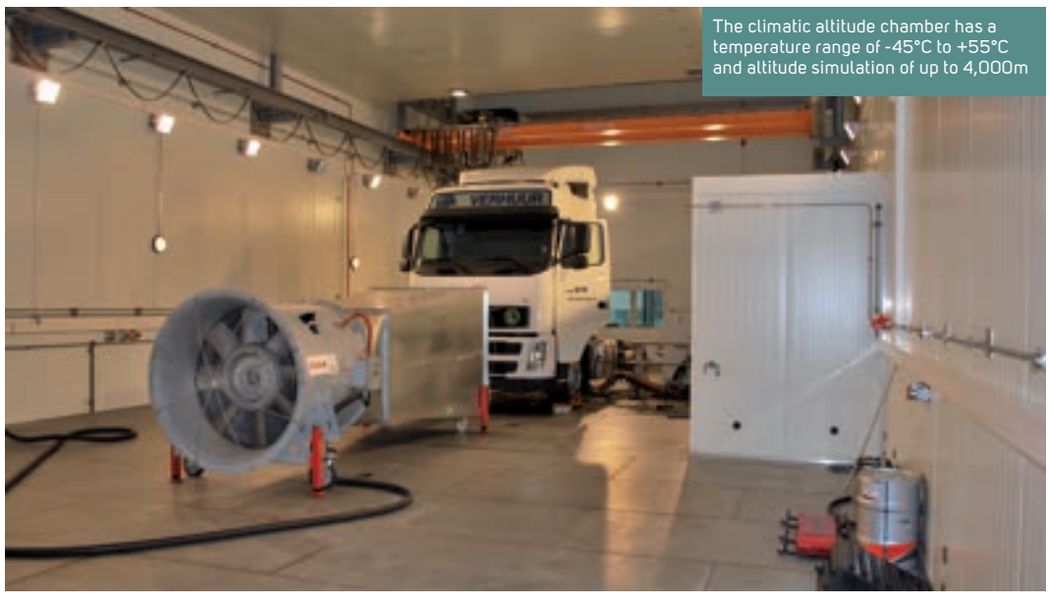
A new, high-tech EEMC facility is offering the automotive industry advanced development, testing and certification of hybrid and electric vehicles, subsystems and components

The electrification of vehicles is a global trend, but fully electric transportation is still a relatively new technology; it's essentially a bowl of technological ingredients – battery, inverter, electric traction engine and power electronics – all developed and produced by the traditional automotive industry. Given this mix, integration is an essential aspect of vehicle development. The European Electric Mobility Centre (EEMC) is now able to respond to this need by offering a comprehensive range of testing, development and certification services for hybrid and electric vehicles, systems and components.

The EEMC is located at the High Tech Automotive Campus in Helmond, the Netherlands. It is a partnership between TNO and TÜV Rheinland that bundles together from both organizations internationally acknowledged know-how in hybrid and electric transport, thereby creating a unique clustering of state-of-the-art expertise, facilities, and services under one roof.

The result of this clustering is a unique range of services at three levels within the hybrid or electric vehicle: battery, powertrain and vehicle. At each level and each stage of product development (from the drawing board to homologation) the EEMC offers OEMs and suppliers the solutions of an independent and experienced institute.

Amongst the extensive test equipment technology available at the EEMC is a high-tech battery climatic chamber



The climatic altitude chamber has a temperature range of -45°C to +55°C and altitude simulation of up to 4,000m

If fully electric vehicles are to make a real breakthrough in the consumer market, the automotive traction battery has to undergo powerful development, with performance, lifetime and safety being the key focal areas. The EEMC is able to provide the whole EV industry with the following solutions and services: research into battery pack performance in different climate conditions; development of charging and discharging cycles based on real-life vehicle data; development of battery models for SOC and SOH estimation; and research into battery-aging mechanisms as well as quantification of aging. In addition to this, the EEMC also offers battery abuse testing on pack level (mechanical, thermal and electrical in line with SAE J2929 and FreedomCar), and a postmortem analysis of battery packs in general.

In the case of electric or hybrid vehicles, the powertrain is decisive in terms of the ultimate energy efficiency. The proper integration of components such as the battery pack, inverter, motor(s) and the transmission is a prerequisite to gaining maximum range, performance and lifetime within the regulations governed by legislation, especially for safety. EEMC's expertise on IC engine controls and exhaust aftertreatment controls is combined with expertise on hybrid/electric powertrain controls. This results in an extensive package of services on a powertrain level, meaning it's possible to characterize the performance and energy efficiency of e-motors or complete powertrains, as well as developing and calibrating inverter controls for maximum performance and energy efficiency. Furthermore, the EEMC also enables customers to develop exhaust aftertreatment systems, specifically for hybrid vehicles, and integrate exhaust aftertreatment, hybrid powertrain and combustion engine controls for optimal efficiency.

Electric and hybrid vehicles cover all types of applications, from passenger cars to heavy commercial vehicles – and every niche in between. A key aspect for every OEM and supplier during product development is finding the right balance between performance and safety. The EEMC and its founders have internationally acknowledged expertise in the field of optimizing vehicle safety and vehicle performance as well as vehicle certification – and this is something that applies to both heavy- and light-duty applications. This comprehensive approach toward vehicle safety and performance in all the services provided by the EEMC generates important added value for customers. For manufacturers of all types of electric and hybrid vehicles, the EEMC offers the following

A 4WD roller bench features four individual controllable rollers with a maximum load per roller of 3,000kg

services specifically regarding safety: full-scale crash testing in a crash lab accredited for homologation standards worldwide, covering EuroNCAP; advice and engineering for the passive safety of vehicles; and vehicle crash simulation.

In the field of vehicle performance, the EEMC offers range and energy-efficiency testing in varying extreme climate conditions, ranging from -45°C to +55°C, with both light- and heavy-duty vehicles. Furthermore, it's possible to calibrate powertrain and vehicle controls for the optimization of energy efficiency and robustness of systems, such as exhaust aftertreatments, development, validation and testing of strategies for regenerative braking and torque vectoring, development of precise range estimators for electric and hybrid vehicles, and certification according to type approval legislation.

To support these wide-ranging services, the EEMC has numerous highly advanced test facilities, such as a high-tech battery climate chamber measuring 4 x 6 x 2.2m, with a temperature range of -45°C to +100°C and charge and discharge at maximum 300kW (750V, 400A). Humidity can be controlled up to a level of 95%.

The EEMC also features a battery abuse facility that's fire- and explosion-proof. This offers engineers washing installation on exhaust gases and is suitable for mechanical and thermal abuse at pack level.

There are four engine testbeds, all of which are suitable for e-motor testing. All four are operational in four quadrants with maximum values at the lowest order being 9,000rpm, 220kW and 230Nm; maximum values at the highest order are 4,500rpm, 670kW and 3,500Nm. A water cooling circuit is available for e-motor and inverter cooling, and a 300kW DC supply is available for inverter input power.

The EEMC has a climatic altitude chamber with dimensions of 25 x 10 x 7m, making it suitable for light- and heavy-duty vehicles. This climatic chamber has a temperature range of -45°C to +55°C and altitude simulation up to 4,000m.

A direct driveshaft with a dyno connection for dynamic testing is another key equipment feature of the EEMC. This dyno is well suited for light- and heavy-duty conventional, hybrid and electric vehicles. A 4WD roller bench features four individual controllable rollers with a maximum load per roller of 3,000kg. The bench's maximum horizontal force per roller is 4,290N, and the maximum speed is 250 km/h. The minimum wheelbase of the bench measures 1.8m, the maximum wheelbase is 4m, and its mass simulation is rated between 800kg and 3,500kg.

The indoor facility of the EEMC totals 160 x 20m, with a 150m track. The speed ranges from 5km/h to 110km/h with a speed tolerance of +/-0.2km/h.

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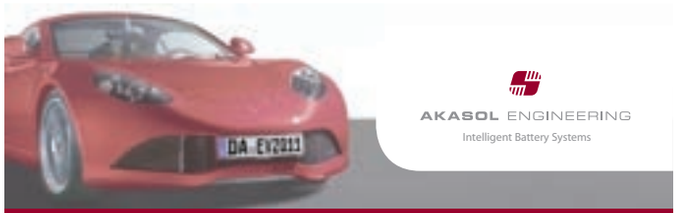

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Electric drivetrain control

New control methodologies for three-phase AC motors are enhancing safety of electric parts

Electrical three-phase AC-motors, such as permanent magnetic synchronous motors (PMSM) and induction machines, have a long history in industrial control systems. In automotive applications, however, they are relatively new, and are now emerging as an addition to or replacement for the IC engine.

Three-phase sinusoidal distributed and mechanically displaced windings are the main characteristic of PMSMs. Three-phase sinusoidal and time-displaced currents result in a rotating magnetic field, and this rotating field turns the motor and is caused by current switched in the motor windings via MOSFETs/IGBTs. The field-oriented control (FOC) algorithm generates the PWM pattern for the current control of the motor. The rotor position and current are continuously sensed. Efficient FOC systems, based on high-performance microcontrollers, lead the path to safe and highly efficient solutions to drive electric and hybrid vehicles.

Infineon's 32bit AUDO MAX microcontroller family is equipped with a main core (TriCore CPU) and also a fast co-processor, called PCP (see Figure 1). This asymmetric architecture allows for the efficient handling of the peripherals using PCP without interrupting the processing of the main algorithm that runs on the TriCore CPU. As such, the PCP takes care of the real time and critical interrupt loads, and therefore offloads the CPU.

For generation of the PWM to drive the inverter, two options are possible. The GPTA enables every sophisticated PWM pattern generation. As a result, this includes asymmetric dead-time generation or customized patterns. As a lower-end option, the peripheral module CCU6 can be used for generation of center-aligned and edge-aligned PWM. Compared with the GPTA, the generation of the PWM signals is directly supported with low software overhead and does not require the configuration of multiple timer cells.

Both modules – CCU6 and GPTA – offer trigger functionalities that allow latency-free, time-equidistant synchronization between the PWM-signal and the A/D current measurements. As an additional safety feature within the system, every GPTA module is equipped with an emergency mode stop signal that can be used to set up a safety switch. In addition for all TriCore AUDO MAX microcontrollers, a safety platform (based on PRO-SIL) is available that covers hardware (safety watchdog CIC61508) and software (SafeTcore driver) for scalable ASIL B-D requirements.

Two motor phase currents are measured in the given example and converted by use of an A/D converter. Based on Successive Approximation Register (SAR), the analog/digital conversion offers high precision (12bit resolution) and a conversion time smaller than one microsecond. Out of two known phase currents, the third can be derived by calculation. For increased safety requirement levels, the redundant measurement of the third motor phase current is recommended. In such a case a microcontroller with a third A/D module is available.

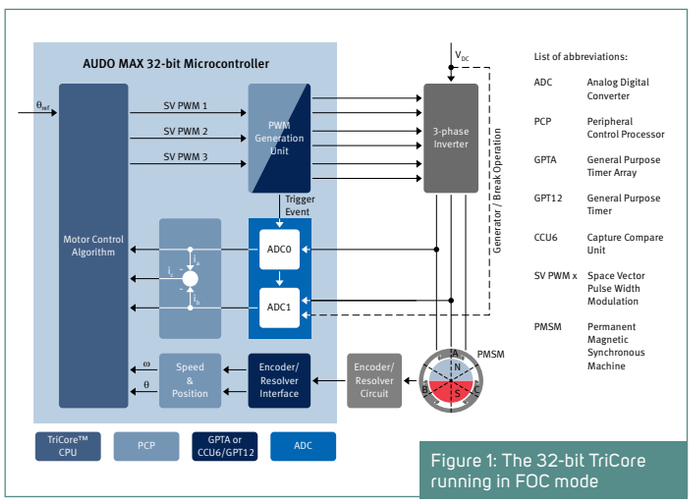

Figure 1: The 32-bit TriCore running in FOC mode

A resolver converts the angle position of the PMSM rotor into an electrical value. Essentially, the rotor angle is derived from two signals (sine/cosine) with the use of an additional circuitry that applies tangent function. The signal of the resolver circuitry is given to the SPI bus. Alternatively, the resolver sine and cosine signals are directly read by the microcontroller. Another alternative is the encoder signal that is then conditioned in the encoder interface that runs on the GPT12 of the microcontroller and is fed back to the control algorithm.

Over the last few years, both automotive software and communication has been standardized via OSEK, AUTOSAR, and FlexRay. Besides standardized

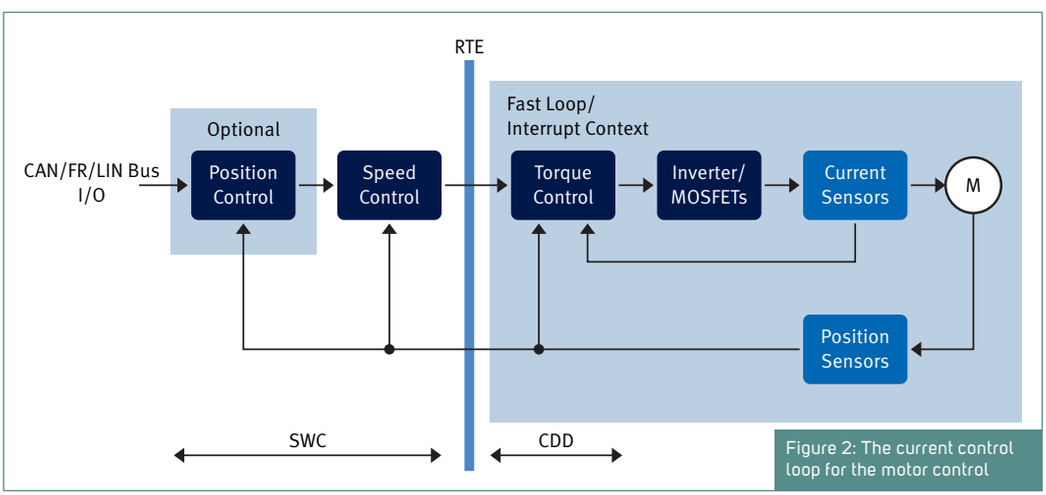

Figure 2: The current control loop for the motor control

		AUDO MAX
Basic features		▪ Control up to 4 PMSM motors via FOC ▪ Control up to 4 BLDC motors via block commutation
FOC mode	Sensors	▪ Incremental encoder / Hall sensors ▪ Resolver ▪ Direct resolver mode (without resolver IC) ▪ Sensorless FOC
	Current measurement	▪ 3-Phase ▪ 2-Phase ▪ DC link
Block commutation mode	Sensors	▪ Hall sensors ▪ Sensorless back EMF
	Current measurement	▪ DC link

Figure 3: The MC-ISAR eMotor operation modes

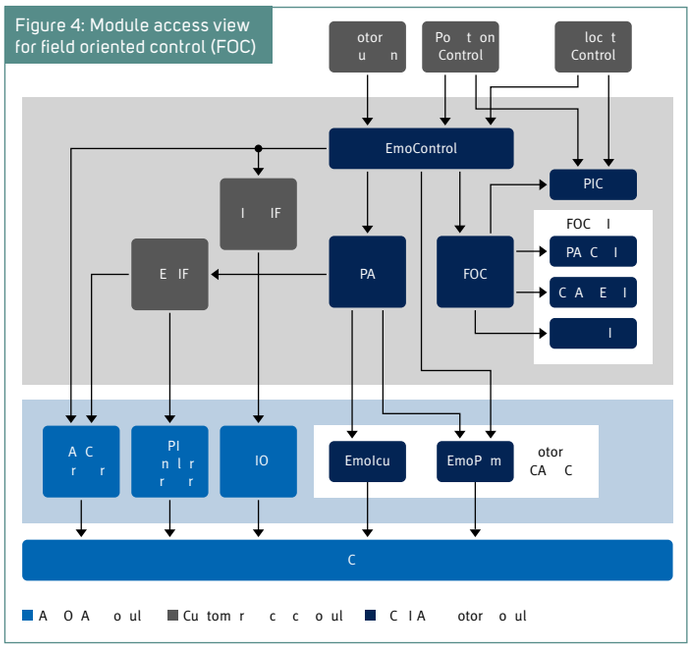

Figure 4: Module access view for field oriented control (FOC)

software components, automotive systems are using control algorithms that can be reused amongst a variety of applications. The control of electrical motors is increasingly handled within ECUs located within the powertrain.

The MC-ISAR eMotor driver is abstracting the common feature of current control for three-phase electric motor applications. It has been designed to support multiple-position acquisition modes and inverter-control devices.

Infineon's AUDO MAX family is highly suitable for the control of electrical motors. The TriCore architectures and MC-ISAR eMotor driver provide the power to control multiple three-phase motors, with their sophisticated control strategies for block commutation of brushless DC (BLDC) motors and FOC of PMSM.

Even the mixed control of BLDC and PMSM motors from one microcontroller device is supported. The advantages of FOC controlled PMSM motors in comparison to other motor types enables more energy efficiency levels, shows less attrition and enables exact control and positioning. It's important to remember that the support for linear torque control is the baseline for its use in the hybrid and electric drivetrain technologies.

Figure 2 shows the current control loop of the MC-ISAR eMotor driver on the right side as complex device driver (CDD). On this occasion, the time-critical current control loop is handled in an interrupt context manner within a range of 50 microseconds. On the left side there are additional software components for position and speed control that are provided from the application code.

To further support the precise positioning requirements, the MC-ISAR eMotor (Figure 3) applies the typical high-resolution sensor modes via hall sensors plus incremental encoder and resolver. In addition to this, the sensorless FOC may be used for failsafe modes. For cost-sensitive implementation, the direct resolver mode is provided for the AUDO MAX family via software implementation and discrete components to avoid the need for external resolver ICs. Such a setup enables a cost reduction of around US$2 per control unit – a key point during a time when budgets and cost reduction are playing an important role in the automotive industry around the world.

The software partitioning in Figure 4 is split into hardware-independent and hardware-dependant components. Hardware-independent modules are for EmoControl, position acquisition PA and FOC. Therefore EmoControl is the main module to control the direction and the current via FOC. The currents given to the motor defines the torque. Towards the application, the MC-ISAR eMotor driver returns position and speed information of the motor. The position acquisition PA module captures the angle form the resolver and encoder signals. The FOC with its park, clarke and space vector modulation is the main part to set the new current via sensing the current and position.

Hardware adaptation is provided via modules that are either reused from the AUTOSAR MCAL drivers, or dedicated models for PWM generation and encoder interface. The customer code for position and velocity control can be added as standard software components and subsystems, such as the ones provided by the AUTOSAR development package.

To further support safety-compliant applications, it is vital to consider all safety requirements from the beginning when designing software components. The application-specific requirements are to be defined during ECU development, and as such, they may differ from one application to another. For example, the MC-ISAR eMotor has been developed and based upon an ISO 26262-aligned software process and allows three-phase current measurement, which supports and enhances safety aspects.

The Infineon AUDO MAX family and MC-ISAR eMotor driver enables control of up to four PMSM or BLDC motors in parallel and provides performance for controlling the application task. Furthermore, the MC-ISAR eMotor is integrated with the standard AUTOSAR MCAL drivers under the same configuration tool.

As a result of such a setup, configuring the microcontroller resources for the AUTOSAR MCAL and MC-ISAR eMotor driver is supported within one user interface and enables seamless configuration of the different software modules. ECU developers can focus on the application that's relevant to the control of the electrical motor and do not need to reprogram the motor control algorithm. To reduce systems costs, the direct-resolver mode is supported and this function eliminates the need for the resolver IC. The AUDO MAX family and MC-ISAR eMotor driver are designed to support safety applications.

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Cost optimization

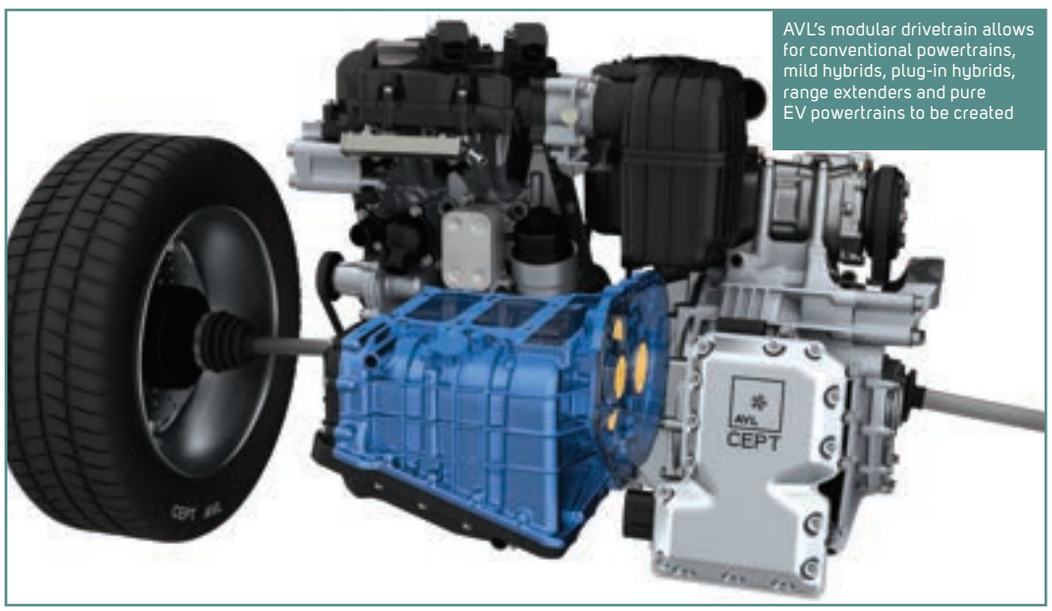
A high-tech modular drivetrain system has been created that enables automotive powertrain engineers to seamlessly integrate many functions in order to minimize development costs

The design of a modern powertrain raises the core issue of how to keep costs down for the variant diversity resulting from electrification. New electrified systems adhere to the existing module design, which has certain advantages regarding the development task of optimizing single components. But even in the case of economies of scale in the mass production of electric components, there still remain substantial additional costs over non-electrified powertrains.

The questions that need to be asked are, is this approach applicable for future modular drivetrains? And are the traditional interfaces the right ones to integrate the electrification systems, and at what cost?

The objectives of AVL's new modular drivetrain, called e-Fusion, are as follows: modular powertrain, ranging from the conventional powertrain to mild hybrid; plug-in hybrid; the range extender with mechanical drive as well as the pure range extender; and the pure EV.

It is important to note that the same driving performance and driving pleasure can be gained for all the above applications. Furthermore, decisive consumption reduction for all applications is critical, especially when covering automotive segments A, B and C. In addition, a 10-20% reduction of the average cost for the complete powertrain as compared with traditional solutions needs to be realized (depending on application); weight reduction of 10% is also an important target; and a minimal package needs to be designed.



AVL's modular drivetrain allows for conventional powertrains, mild hybrids, plug-in hybrids, range extenders and pure EV powertrains to be created

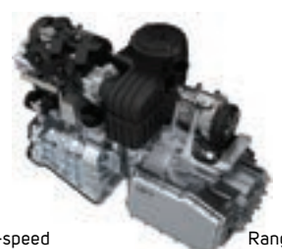
Customer expectations and compulsory regulations define the target catalog of vehicles in regard to driving performance and fuel consumption. Customers expect performance and driveability factors of electrified powertrains to be at least identical to that of IC-engined applications. Concerning the estimated boundary conditions defined by CO_2 regulations, the target value for vehicles without external recharging devices is 90g/km, and 50g/km for those equipped with such devices, such as plug-in hybrids.

The e-Fusion family consists of five different electrification concepts: The illustrations above and below provide an overview of the highly integrated but modular design of this technology.

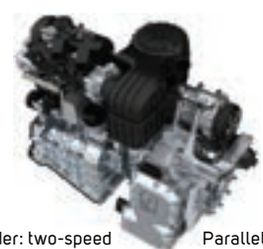
AVL's approach to cost reduction as well as long-term management of the weight and package targets comprises consideration of the overall system rather than mere subsystem optimization. This includes a high degree of integration of functions with controllable complexity, the reduction of parts numbers, and the critical questioning of known interfaces.

The integration of functions will not only be applied to the main elements of the powertrain, such as engine and e-motor, but innovative solutions had to be found in order to logically combine these elements in a powertrain design, starting with the overall powertrain function.

Electric drive: two-speed transmission and one e-motor rated at 40kW

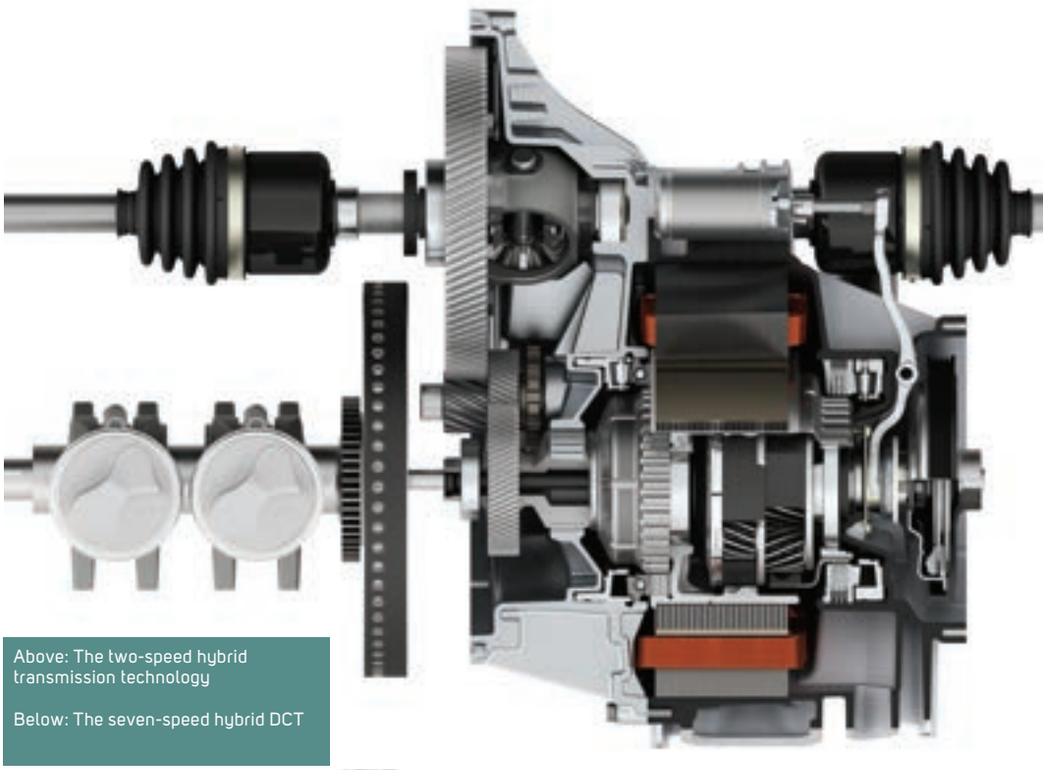


Range extender: two-speed transmission with two e-motors rated at 40kW and 25kW



Parallel plug-in: two-speed transmission with one e-motor rated at 40kW

Mild hybrid: seven-speed DCT with one e-motor rated at 10kW



Above: The two-speed hybrid transmission technology

Below: The seven-speed hybrid DCT

A two-cylinder IC engine design was chosen as a concept for all applications. For the high-power version of the mild hybrid, the IC engine is equipped with simple exhaust-gas turbocharging and DI technology. The aspiration variants of all other powertrain versions are less sophisticated.

Both IC engine versions include a mass balancer for the elimination of first-order mass forces. Through highest functional integration, a massive reduction of the total manufacturing costs was achieved compared with conventional engine architectures. All external pipes can be omitted, and compact dimensions are realized. Furthermore, assembly machining was avoided to the greatest possible extent.

Two transmission designs cover the requirements for these applications. For the mild hybrid, an advanced and electrified seven-speed DCT is used in combination with the TCI engine. All other variants are equipped with a two-speed hybrid power shift transmission. The NA engine completes this powertrain unit. Despite their completely different requirements, both transmission variants are characterized by their conceptional high similarity and functional integration. As a result, they offer high potential for identical components to reduce cost.

The two-speed transmission is designed as a double planetary gear with two ring gears and embedded e-machine rotor, a clutch and a brake. The torsion shaft is a common feature with the seven-speed DCT, as shown in the transmission illustrations above.

The high integration of functions allows for a very compact design compared with conventional solutions. The e-Fusion plug-in hybrid can be installed very comfortably, even in the smallest front-end area of an A-segment vehicle. This aggregate still leaves enough space for additional components, which will be required for higher electrification.

In addition to these compact dimensions, the weight of the e-Fusion plug-in hybrid also sets new standards. The powertrain, which consists of the IC engine, e-motor, transmission, power electronics, and all add-on parts, weighs only 165kg.

The e-Fusion mild hybrid offers less than 13% additional costs as opposed to a conventional non-electrified transmission, and is rated at about 14% below a conventional mild hybrid. This full functionality arrangement allows for a possible CO_2 reduction of a parallel plug-in hybrid in the e-Fusion design but with only 20% extra costs as compared with the conventional drivetrain. A direct comparison with a reference plug-in hybrid application even shows a cost advantage of up to 40%.

When it comes to the battery, the outlook shifts because the cost of the battery for the electrified version has a higher disproportionate share. Yet even then, a cost difference of about 10% arises when comparing a conventional mild hybrid with the AVL e-Fusion mild hybrid.

In addition to the current certification cycle (NEDC), overall fuel consumption calculations are also based on the current definition of the Worldwide Harmonized Light Vehicle Test Procedure (WLTP) cycle.

In comparison with typical non-electrified reference vehicles in this class, the consumption results of the NEDC cycle show a consumption reduction of about 12% for the mild hybrid, and about 70% for the plug-in and the pure range extender variants.

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ONLINE READER ENQUIRY NO. 503

Battery testing solutions

Automated end-of-line systems are ideal for evaluating battery packs at licensed assembly sites

Greenlight's control and automation software provides a flexible and convenient platform to integrate the necessary building blocks of a complete battery test system

In late 2010, Greenlight Innovation was approached by Corvus Energy – a leading lithium battery pack integrator – to supply an automated end-of-line test system to evaluate its range of battery packs.

Corvus manufactures and integrates energy solutions for commercial and industrial applications – ranging from airport ground handling equipment to truck APUs, marine hybrid and heavy industrial. The Corvus battery modules are assembled from prismatic lithium nickel manganese cobalt (NMC) cells supplied by Dow Kokam. The battery pack is fitted with a Corvus proprietary battery management system. At the end of the assembly line, the integrated packs need to be cycled and tested for conformance.

Greenlight's control and automation software provides a flexible and convenient platform to integrate the necessary building blocks of a complete battery test system, including a range of power sink and source devices, environmental chambers, air and liquid thermal management modules and data acquisition systems. These individual components are either supplied by Greenlight or are commercially available components that are sourced and integrated with the control software.

The Greenlight control software enables expansion to multiple independent test channels, and additional modules can be added for importing drive cycles, remote monitoring and data analysis. Greenlight's custom automation language allows users to quickly program dynamic test cycles, which can be saved in a library and routinely called to ensure repeatable results. Sub-routine capability enables the test station to detect abnormal conditions and automatically perform diagnostics, without operator intervention, allowing intelligent but safe continuous operation.

The requirement from Corvus was for an automated test system with a capacity of 100V, 250A and 32 channels of data acquisition for cell voltage and temperature monitoring. It was also necessary for the test station to communicate via CANbus with the battery pack controller, so a custom interface was written by Greenlight. The test system not only had to meet the existing Corvus pack specification, but the cycler was required to have the flexibility to accommodate numerous alternative pack configurations. Furthermore, the system had to be fully automated with multiple hard-wired and software safety interlocks for 24/7 unattended operation – all standard equipment in the Greenlight product line.

Prior to shipment to the Corvus site, the first test system was assembled at Greenlight's Vancouver, Canada, facility and extensively tested on multiple configurations of the Corvus battery pack. The unit met the performance targets and was deployed to the Corvus manufacturing facility, where it is now in daily operation.

According to Brent Perry, CEO and president of Corvus Energy, "Greenlight Innovation has provided Corvus with some of the most sophisticated battery testing equipment available, and has given us with the ability to qualify risk management through their unique machinery. We depend on their product and the quality they build into it for every battery we produce."

Corvus is currently in the process of establishing a number of international manufacturing licensing agreements to address specific geographical markets. The Greenlight end-of-line battery test station has set the standard for safety, reliability and unattended operation, and has thus been specified as the required end-of-line tester for these other facilities.

Greenlight Innovation offers end-of-line test stations, R&D test equipment, data acquisition systems, and software solutions for testing all types of electrochemical cells.

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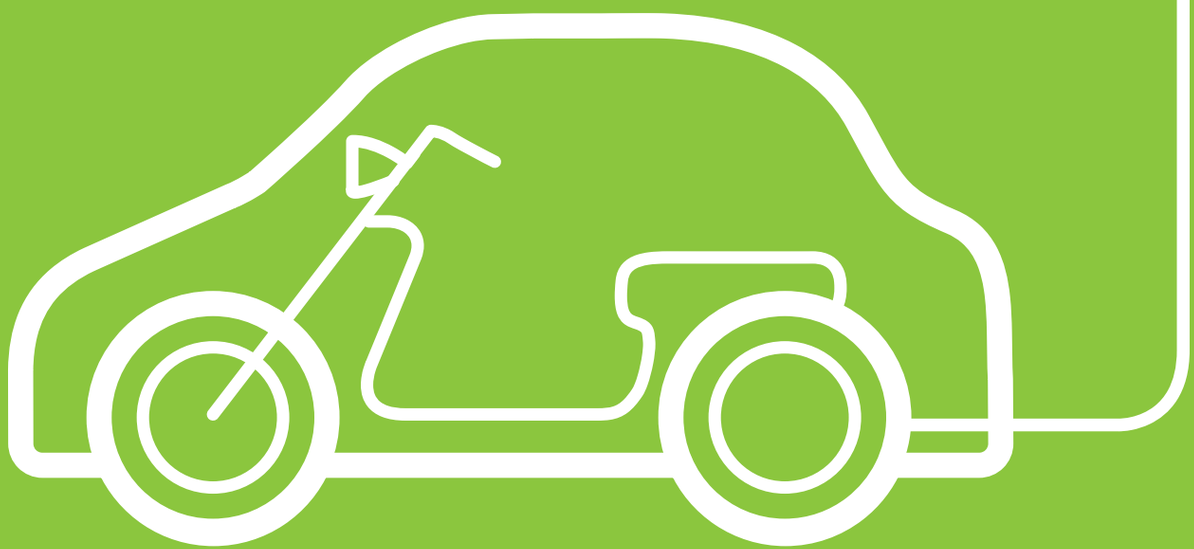

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Designs for a green future

Before electric vehicles can fully thrive, a decent charging infrastructure must be provided. Fortunately, advanced charging solutions are already available and aiding EV global growth

The growing EV industry faces a dilemma: vehicles will not attract buyers on a grand scale until there is a consistent charging infrastructure in place, but nobody wants to build one until there is a notable number of vehicles ready to use it.

This problem is now being addressed as numerous European governments, cities and other localities have started promoting EV use as a part of their sustainability strategies. Many are exploring their options and planning a charging infrastructure for their EV-driving citizens. Companies are also starting to realize the business potential embedded in the provision of EV charging.

Charging systems are already available from manufacturers across the varied sectors of the industry. Ultra-fast charging technologies are on their way, allowing for more extensive commuting with EVs in the very near future. Standardization of charging requirements and harmonization of the connections required is also underway in many countries and on an EU level.

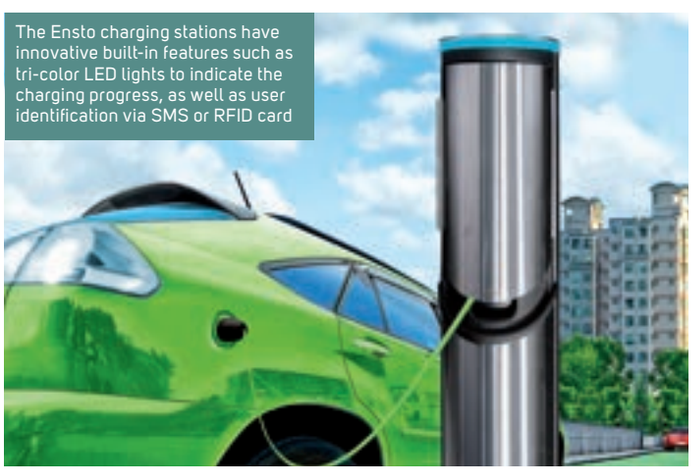
Finland-based company Ensto has a long history of developing and manufacturing high-quality electric equipment, enclosures and accessories for demanding environments. As a Cleantech member, sustainability and energy efficiency are part of its core values. Therefore expanding into the EV charging business has been a natural step for the company.

Ensto is one of the forerunners in the industry. It already offers a variety of high-quality charging stations for different environments. For example, the EVT Charging Station has been developed for non-profit charging at normal speed (single-phase charging at 16A) and is suitable for charging at home or during a working day in a secure environment such as an office. The EVC offers a solution for fast charging for a fee. With a possible 400V nominal voltage, it can charge a 40kWh battery in around an hour. This makes the EVC ideal for public charging in areas such as parking garages and in shopping centers.

EVT stations, created by Ensto, in use in a parking lot in Oslo, Norway

Safety is always an issue when dealing with electrical equipment, and the company has taken this to be a key priority. The acid-proof stainless steel structure makes the stations safe, durable and easy to clean. With a lockable hatch, the charging technology is protected from weather and vandalism. The stations are unpowered during plugging and unplugging, so there is no risk of electric shock.

In creating its charging stations, Ensto has focused on two important aspects: design and functionality. “One of the major features is the visual appeal,” says the company’s UK sales manager, Stuart Tolley. “The charging stations are stylish and visually appealing while blending into a wide variety of urban surroundings.” This is also the main reason why the Ensto EVT poles were chosen by the city of Oslo. “They were designed in cooperation with the local authority and key clients so they blend seamlessly into the environment,” adds Tolley.



The Ensto charging stations have innovative built-in features such as tri-color LED lights to indicate the charging progress, as well as user identification via SMS or RFID card

But internal features are also a selling point, as Tolley points out: “Unlike some charging technologies, Ensto stations contain software that gathers usage data, which can be used to charge the user when complemented with a PC-based system. Companies with a fleet of EVs can easily track drivers’ usage, and companies in the parking provision market can turn the charging of the electric vehicles into a competitive business opportunity.”

Ensto is supporting the building of an EV infrastructure by offering reliable and ready-to-install charging solutions from its base in Finland.

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Charge ahead

EV charge time continues to worry consumers, but now a leading systems supplier has developed an onboard fast-charging device that can recharge an EV in only 45 minutes

Range anxiety is a big concern for many people when it comes to driving an electric car. While statistics show that most drivers very seldomly exceed the range provided by modern electric cars, the time it takes to charge an electric car remains an issue for potential EV owners.

In the same way that the Toyota Prius started the hybrid revolution and introduced drivers to partial electric driving, range extender concepts will assist the current transition to pure electric cars. Range-extended or plug-in hybrid cars such as the Chevrolet Volt, Toyota Prius PHEV, and Volvo V60 PHEV are the first of their kind. These types of cars will help drivers to discover their true range needs, while becoming aware of the advantages of electric driving.

Even though charging times of range-extended cars are not a big issue due to the presence of IC engines and batteries that usually have small capacities, the amount of time to recharge a fully electric car remains an issue.

Swiss company Brusa Elektronik AG recently presented an all-new onboard fast charger at the eCarTec fair in Munich in October. The NLG6 22kW charger fully supports three-phase charging and will charge an electric vehicle six times faster than standard chargers with only 3.7kW. This would make it possible, for example, for a depleted battery with 16kWh to be charged to 80% in less than 45 minutes.

Simplicity is key to the NLG6 design. For example, the device is not reliant on costly DC quick charging stations, instead it allows for rapid charging through existing infrastructure

The beauty of this concept lies in the fact that it does not require bulky and costly DC quick charging stations, but instead allows rapid charging through existing infrastructure. For example, high-power AC supplies are readily available all over the world, and can be used without expensive initial investments.

The NLG6 is the high-power sibling of the sixth generation of Brusa's flexible and powerful onboard chargers. It converts alternating current from single, two or three-phase outlets to DC for charging the battery, thereby precisely controlling voltage and current flow. The charger is compatible with worldwide standards (such as SAE-J1772) on the mains side and therefore adapts to the given infrastructure.

The unit is controlled by CAN messages from a control unit, and sends live data, such as battery voltage or current levels, back to the control unit. Built-in protective features prevent damage to the charger or battery, while galvanic isolation between the mains and battery ensures personal safety.

A liquid cooling system and proprietary SoftSwing technology mean the charger is contained within a compact housing. With lightweight construction, robust design and high IP protection, as well as high conversion efficiency, low EMI, and CAN features, the NLG6 meets all the important requirements of the industry.

Brusa's win of the eCarTec award for the charger led to the announcement of the start of series production and introduction to market by the end of next year. Following one of the largest orders in the company's history, recently placed by a European OEM, cars equipped with the NLG6 will be available by the end of 2012.

Brusa Elektronik unveiled its new onboard fast-charger at the eCarTec fair, which took place in October 2011

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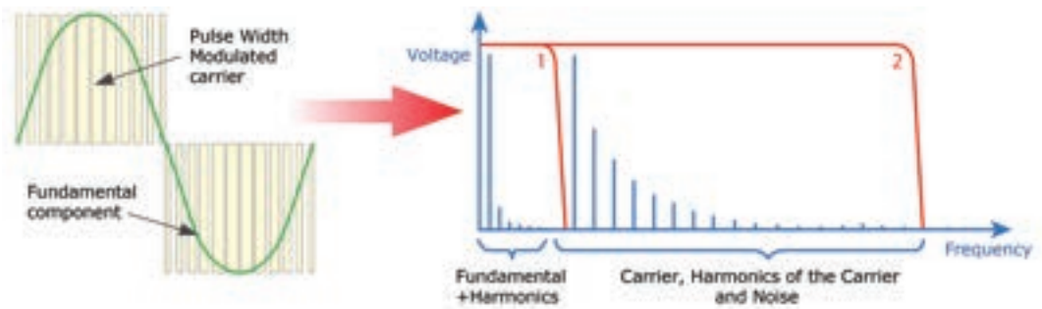
Shunt design innovation

Innovative design techniques are helping engineers to improve power measurement accuracy

Rapid developments in power conversion technologies combined with a need for better inverter efficiency places increased pressure on design and test engineers working on automotive power electronic systems to more accurately quantify the true value of electrical power.

This need focuses attention on the accuracy of power measurement instruments and it becomes clear that the complex power characteristics associated with modern power conversion techniques require high-frequency performance that is beyond conventional analyzer design.

To illustrate this need, it is important to consider the voltage signal associated with a variable speed PWM inverter drive. For example, if engineers wish to accurately quantify total power, they need to include all frequency components of the signal. This may at first appear straightforward as many power measurement instruments offer an appropriate frequency range, but in most cases high-accuracy power measurement is achieved over only a limited frequency range. This is illustrated by red response line 1 in the graphic (above right) and represents the typical high-accuracy range of many power analyzers; red response line 2 represents a power analyzer that maintains high accuracy over its complete operating frequency range.



The graphic above shows high accuracy voltage measurements being achieved over a wide range

The PPA5530 power analyzer data from Newtons4th is a compact, cost-effective instrument that offers high-precision internal shunts and superior accuracy to any external shunt design

Achieving high accuracy in power measurement over a wide frequency range requires great attention to the voltage and current input hardware design. For the voltage input, the frequency response is largely influenced by parasitic capacitance and for the current input where a low resistance shunt is used. The frequency response is largely influenced by parasitic inductance.

Usually, the greatest challenge for a precision AC power analyzer designer is to achieve a low inductance current shunt. This is particularly difficult in power analysis products because the shunt resistance needs to be low in order to minimize shunt power dissipation and burden on the circuit. However, because the parasitic inductance of a component is a function of its geometry, it follows that a shunt of any particular physical geometry will have a greater phase error as the shunt resistance is reduced because the same inductance will represent a greater proportion of the total impedance.

As inductive impedance increases with frequency, the error associated with parasitic inductance also increases with frequency. As a consequence, minimizing the capacitive reactance of the voltage input and the inductive reactance of the current shunt can optimize the wideband performance of a power measurement instrument.

An innovative power measurement instrumentation company in the UK has developed and perfected a shunt design that achieves field cancellation equal to that of the best coaxial shunt, while maintaining a manufacturing cost that is viable for use in commercial power analyzers.

This new shunt design combined with zero gap high-frequency sampling and wide dynamic range provides a solution for power measurement applications requiring high wideband power accuracy.

A complete shunt board illustration with parallel forward and reverse current flow for field cancelation

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Electric powertrain testing

A closer look at two new cutting-edge products that will aid engineers when undertaking durability testing of inverters and electric motors

D&V Electronics has showcased its innovative technologies in its newest line of powertrain testing products.

The EPT line of testers – as well as the D&V battery testing systems – feature full testing capabilities for e-motor inverter and battery testing. Each group of testers has been designed to support and enhance the capabilities for various applications, such as development, validation and end-of-line processes. D&V has been supporting EV markets all over the world with its EPT products for the past six years.

Specifically, the EPT-150 line of testers is being utilized in multiple customer labs to prove concepts in cutting-edge motor design. The EPT-150 system is designed to be a high-accuracy development platform for the e-motor, inverter and battery pack testing.

The main vehicle driveline can largely be tested on the EPT-150 because of its highly modular capabilities and functional characteristics. For example, inverters can be tested with proven motors powered by a D&V battery simulator, or optionally with a proprietary battery pack.

The EPT-150 enables D&V customers to grow and improve their products through high-quality and reliable testing because of the fidelity measurement equipment built in with the testers. Simulation features, vehicle network control and e-motor controller calibration options are available to provide a full testing suite and facilitate better component design.

When considering validation testing of inverters and e-motors, there are two products that can serve these purposes respectively: the EPT-120 and the EPT-350.

The EPT-120 data acquisition system measures and records all necessary data for test evaluation

The former has been developed specifically for e-motor durability and runs long-term drive cycles to prove product design, component integrity, and build quality. Supplied with an EPT-120 system are ancillary modules that support endurance testing, including thermal chambers and coolant conditioning systems. The purpose of the thermal chamber is to cycle the DUT e-motor with temperature and humidity changes throughout its testing period. During the lengthy test, the EPT-120 data acquisition system measures and records all necessary data for test article evaluation.

Similarly, the EPT-350 inverter durability tester can also cycle DUT inverters while being stressed with temperature and humidity changes. The EPT-350 is generally designed with two load motor systems, including a pump system for customer-controlled oil cooling.

The DUT inverter is tested by powering it with a preset DC current or voltage profile, and running its customer-specific control profile.

The DUT motors provided are customer-driven samples, known to be good, and will be loaded by the dynamometer system. Each tester can control multiple communication, power, thermal chamber, and coolant systems, depending on customer requirements. The number of testers being used simultaneously can vary from a few to double-digit numbers.

"It's paramount for our customers to iron out all bugs and component weaknesses before the product hits full-scale production. This makes it important to be able to test multiple units continuously over the course of months," says Michael Kelly, D&V marketing manager. "This is the level of testing that is required when proving a powertrain system is ready for production implementation."

In addition to general electric vehicle validation, at the cusp of the EV and HEV market is the need for reliable and safe batteries. D&V engineers have recognized this requirement and established that the field and technology are mature for capitalization.

Taking advantage of the company's expertise in sound electrical design, its new BTS (battery testing system) will boast an extremely fast switching time between charging and discharging, and the ability to ramp current faster and higher than conventional battery pack testing equipment.

The reliability and accuracy of the power electronics technology used in the BTS have already been established in D&V's EPT range. The BTS will be initially available to a select number of customers. The limited release serves as a demonstration period to finalize software and battery pack industry-compliant parameters.

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Electric mobility leadership

Innovation and strategic business partnerships deliver high-efficiency, cost-effective solutions to global markets

Major growth in the global market for electric powertrains represents a significant opportunity for GKN Driveline to develop and deliver high-efficiency and cost-effective systems for EVs and HEVs.

The company's ambitions are being realized through the design and production of its eAxle and eTransmission systems – already deployed in more than a quarter of a million vehicles. Furthermore, strategic JVs and business acquisitions are strengthening its capacity for research and innovation, widening the range of systems and solutions that it can provide to customers, and enhancing its ability to manufacture and supply in all world markets.

GKN Driveline is a leader in harnessing the potential of electric power in highly efficient systems that meet the performance needs of vehicle manufacturers and consumers. In addition, these cutting-edge systems are robust, versatile and cost-effective. The company's recent acquisition of the driveline products business of Getrag has further established it as a world leader in all-wheel drive (AWD) and eDrive systems.

The integrated eDrive Family 2 system with a two-speed eTransmission from GKN Driveline and an AF 130 eMotor from EVO Electric, as displayed at Engine Expo North America 2011

GKN Driveline has pioneered a family approach to the development of eTransmissions and eAxles, its two principal eDrive systems product lines. The rational design concepts it has created bring much-needed standardization and structure to a fast-changing market, and set the trend for the wider industry segment.

The eAxle is a compact and lightweight system that can provide secondary electric drive in a vehicle equipped with an IC engine. As well as enabling full hybrid and electric drive, it provides an on-demand AWD function, assisted by a proprietary disconnect clutch system. Compact, lightweight and with low NVH, this fuel-efficient technology has already been taken up by a number of OEMs, including Nissan and PSA Peugeot Citroën, with the latter using it in the HYbrid4 diesel-electric hybrid powertrain.

GKN Driveline's eTransmissions are designed for use in EVs and can transmit up to 300kW to the driven wheels, with a spread of ratios from 6.0 to 14.0. A modular design enables the system to be used with e-motors from different suppliers and for additional features such as an electric parking brake or limited-slip differential to be incorporated.

The single-speed eAxle Family 2, with a disconnect system feature

The single-speed eTransmission Family 2

Currently, GKN Driveline is working on eTransmissions for 15 vehicles due to be launched globally between 2012 and 2015.

To take advantage of the electrification trend, GKN Driveline is looking beyond transmission products and investing in additional areas, notably electric motors. Earlier this year the company set up a joint venture with EVO-Electric, a UK pioneer in advanced electric drive solutions. The new business, called GKN EVO eDrive Systems, will manufacture and sell drive systems and electric motors based on EVO's axial flux motor technology for use in hybrid and all-electric vehicles.

Dave Latimer, CEO of EVO-Electric, says: "This alliance with one of the automotive world's leading Tier 1 suppliers and a leader in electric-drive axle and transmission technology represents a major breakthrough for us. It will be pivotal in establishing EVO as a key player in the fast-growing global market for electric drive components."

John McLuskie, business development director of eDrive Systems for GKN Driveline, adds: "This is a further step toward increasing the total value that we are able to offer to customers and partners in eDrive systems. The joint venture brings us valuable additional knowledge and competencies in motors and power electronics, strengthening our ability to work successfully with OEM and Tier 1 partners on hybrid and electric vehicle programs."

GKN Driveline's strategy for eDrive technology and business development promises to deliver effective systems and solutions for its automotive industry partners and customers as the shift to electric power accelerates.

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ONLINE READER ENQUIRY NO. 509

Surging forward

It has been 25 years since Maccor was formed, and in a short period of time the international battery development supplier has come a long way

A pioneer of the modern battery test industry, 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, Maccor has experienced continued growth since then. As a result, it has come a long way in a short time.

In the past, the only commercial products capable of evaluating battery performance were designed and built specifically for lead-acid vehicle battery applications. These were high-power units without a great deal of accuracy. They had limited test programming capabilities and collected data slowly. In the mid-1980s, when there was a resurgence in battery systems, it became obvious that these battery test systems were inadequate.

The founders of Maccor conceived an entirely different design for a battery test system that provided extremely accurate results, collected test data at high speed, and would test large numbers of batteries simultaneously. The system could also be programmed to perform almost any test sequence required.

Over the past two decades, Maccor's innovative technology has enabled it to become the standard for most companies involved in the research, development, and quality control of cells and batteries for a wide range of products and cell chemistries. This solid foundation provides Maccor engineers with the knowledge, experience, and resources for the future.

Today, Maccor has earned a greater than 80% share of US business in its product area, and its share of the European and Asian markets is growing.

Maccor designs all its own hardware and software systems in-house

With nearly 1,500 systems in regular operation in more than 40 countries (including the first system ever built), there is no doubt that Maccor is a leader in the battery test industry.

The company designs all its own hardware and software – and this is an ongoing process. Most systems are customized to meet a client's specific requirements, and from time to time, customers request specific features. Over the years, this has provided Maccor engineers with a wealth of knowledge and experience in the design and performance of these systems.

This experience is being used to develop systems with even higher levels of performance and additional features and capabilities that harness new computer technology. For this type of equipment, Maccor is confident it offers the widest range of features and capabilities of any manufacturer. And, if its standard equipment does not meet the customer's exact needs, then the company's engineers will customize it.

In 2009, Maccor moved to a newer and larger facility to meet growing demand for its products. This facility has the capacity for expansion to handle any future increase in demand.

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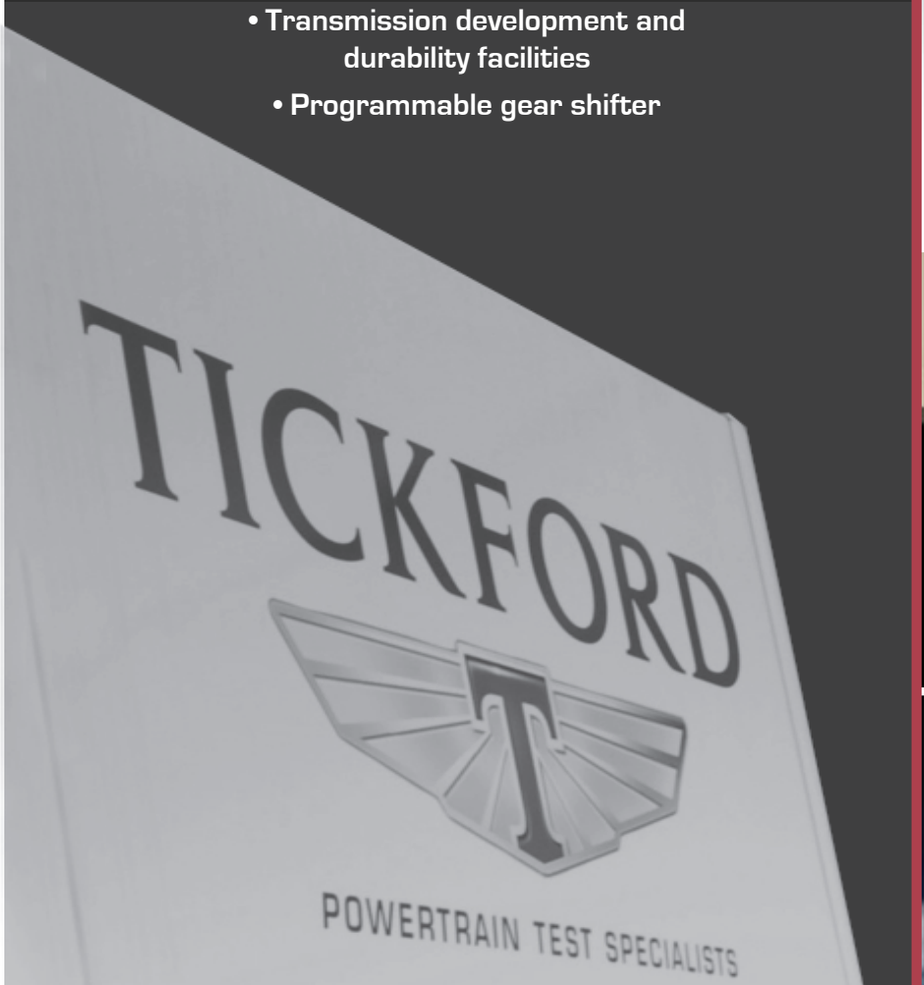

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Electric vehicle road map

Having had a false start in the 1990s, electric and hybrid vehicles are finally set to take the global automotive industry by storm, thanks mainly to new engineering breakthroughs

The Lotus Evora 414E demonstrates Lotus Engineering's electric and hybrid vehicle expertise

Lotus Engineering has been active in hybrid and electric vehicle development work since 1990, but looking back in time gives an indication that perhaps two decades ago, the world wasn't quite ready for new technologies. There have been many theories why this may be the case – some more controversial than others – but the new wave of activities together with a global focus on environmental issues suggest that now, maybe, the time is right.

Reinventing the hybrid and electric vehicle market is not without its challenges, however. There is a global aim to reduce the world's carbon footprint, and treaties and legislation are methods employed by governments to try to force this issue. The desire to reduce the carbon footprint is primarily for environmental reasons but there are associated factors such as energy security and reliance on fossil fuels. Probably the biggest challenge, however, is to develop lower carbon vehicles that are cost-effective, durable and to the level of quality demanded by the end user.

Governmental intervention is playing a part with incentives and taxation, and for the consumer there are grants to help with the purchase price of a new vehicle. Total cost of ownership (TCO) is becoming more important to the consumer, and taxation is helping in this area, with higher emitting vehicles being taxed more and lower or zero emitting vehicles being taxed less.

Government intervention applies to industry, too. In the UK, for example, the Technology Strategy Board (TSB) has funded the industry to develop and innovate new technologies, including the application of these technologies into demonstrator vehicles. The fuel cell London taxi and the Lotus Evora 414E are prime examples of TSB-funded projects undertaken by Lotus Engineering.

Lotus Engineering and Intelligent Energy have built a London fuel cell taxi for the 2012 Olympic Games

The fuel cell London taxi is a series hybrid vehicle, incorporating an electric motor driving the rear wheels, a lithium polymer battery pack, and a hydrogen fuel cell as the range extender. Lotus Engineering was responsible for the vehicle integration, design and build of the battery pack, and the complete build of the vehicle. The Lotus Evora 414E is a conversion of an Evora sports car to series hybrid drive. Each rear wheel of the vehicle is independently driven by an electric motor with each motor capable of delivering 150kW, ensuring supercar performance. The range extender engine is the Lotus unit, which has been specifically designed as such.

There are many configurations of H&EV drive systems and market research shows a number of interesting points. First, the market is large enough to support many different solutions, and second, people are thinking a lot more about vehicle usage and making an informed choice. TCO has become a key factor – certain usage patterns would not be as suitable for hybrid or electric vehicles as others.

The charging infrastructure is also an issue in the usage and TCO. Arguably, there is already a vehicle charging infrastructure – domestic charging via a three-pin socket. It is understood that this infrastructure may not be available for some but it's already there nonetheless. Higher levels of charging and smart metering are the subject of many schemes in the UK and Europe and these developments are now fitting in well with the availability of vehicles on the market, but there is still room for improvement.

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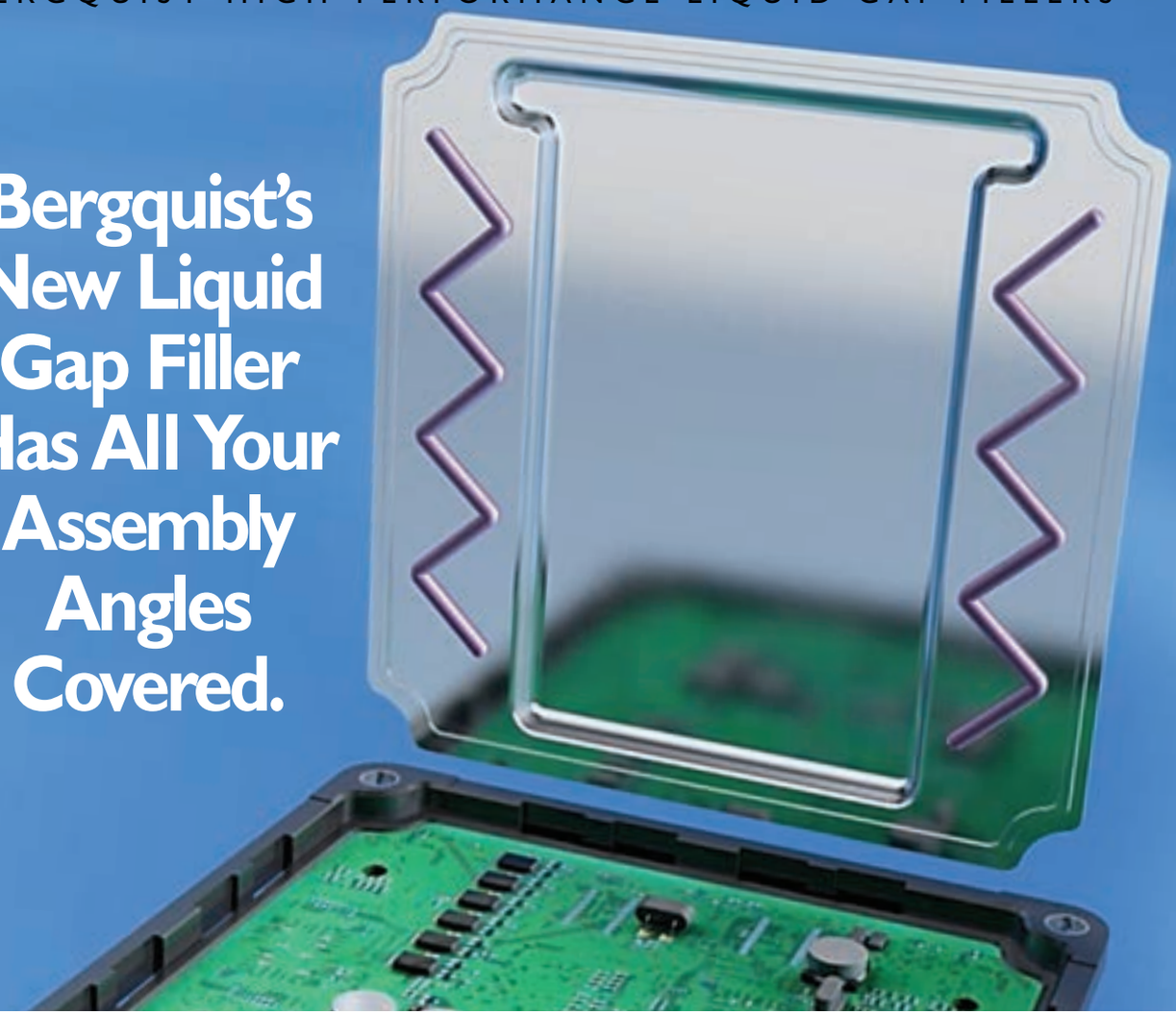

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Electric drive refinement

Two leading suppliers are applying simulation and analysis techniques to design a low-noise e-drive transmission system that offers high efficiency and durability

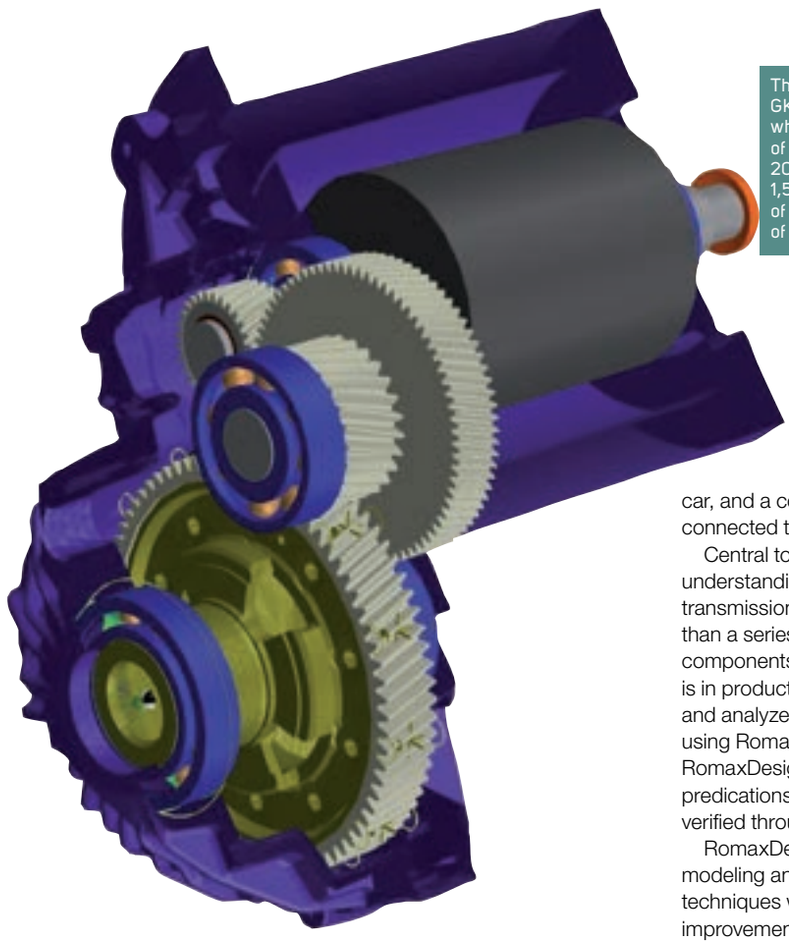
The evolution of EVs and HEVs is having a substantial impact on all areas of vehicle engineering. This is especially the case for transmission and driveline design, as recently highlighted in a project involving GKN Driveline and Romax Technology, which took on the challenge of improving the efficiency of an electric-motor-driven transmission without compromising durability or noise.

HEV transmissions are the systems that tie together complete hybrid drivelines. There is a vast array of different configurations that present a huge burden of analysis work to determine the best conceptual design and then optimize its performance.

Romax Technology is a leader for the provision of simulation and analysis tools that have revolutionized transmission design processes over the past 20 years. Fast and accurate system simulation represents the only practical solution for cost-effective evaluation of multiple transmission system concepts.

Romax's flagship product, RomaxDesigner, has gained an unparalleled reputation for accuracy in the prediction of transmission for system behavior, in terms of deflections, durability, noise, and dynamics. Some 13 out of the top 15 car companies worldwide are users of RomaxDesigner, as are most of the OEMs' Tier 1 suppliers, which has ensured that simulated results have been extensively validated in real systems.

By working closely with clients, such as GKN, Romax has been able to refocus its technology to the areas of EV and HEV transmission design, where many of the technical challenges are even more severe than for conventional transmissions. For example, in conventional transmissions, gear noise can be masked by engine noise that is absent in EVs. This area has now become a focus for Romax's noise reduction research.



The Romax model of GKN's e-Drive gearbox, which has nominal power of 20kW, input torque of 200Nm, output torque of 1,500rpm and input speed of 7,500rpm. The total ratio of the unit is set at 1:7.5

But it is in the area of carbon reduction and efficiency that there has been the greatest pressure for development. The transmission has two tasks: first to enable the sources of mechanical power to operate in the most efficient manner; second, to be as efficient as possible in transmitting the mechanical power.

Romax has developed innovative tools that enable engineers to investigate the questions of the design, such as, should the EV gearbox be single or multiple ratios? Where should the shift points be? And when should operation be in pure EV or HEV modes?

Conventional methods for achieving higher transmission efficiency can have adverse effects on gear durability and quiet running. The lack of engine noise in an EV makes the historically acceptable design compromises untenable. GKN Driveline and Romax took up the challenge of improving the efficiency of an e-drive gearbox on an all-wheel-drive HEV without compromising durability or noise. The e-drive gearbox connected an electric drive to the rear axle of a PSA Peugeot Citroën passenger car, and a conventional IC drive was connected to the front wheels.

Central to the project was understanding the behavior of the transmission as a system rather than a series of assembled components. The original gearbox is in production and was designed and analyzed as a whole system using RomaxDesigner. The RomaxDesigner NVH and durability predications had therefore been verified through testing.

RomaxDesigner's powerful modeling and optimization techniques were used to investigate improvements in efficiency from changes to the gear macro-and micro-geometries. GKN redesigned gear and carried out further testing.

The results were impressive, with overall efficiency improvements; in the all-important coast condition, a 1-2% improvement across the speed and torque range was achieved.

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EV interconnection

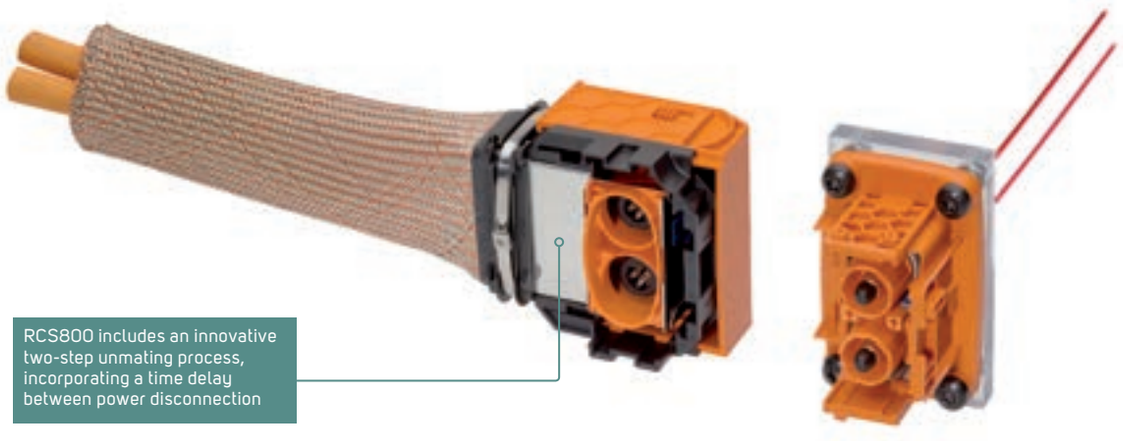
Collaboration is key in order to realize a new generation of sustainable transportation products and solutions

In terms of interconnection, EV applications pose significant engineering challenges. The most obvious include voltages and operating currents that are much higher than in conventional IC-engined vehicles. These bring with them serious safety risks, as well as problems associated with electromagnetic interference (EMI) and arcing. Voltages of up to 800V and operating currents up to 300A also mean bulky power cables, which can place considerable mechanical stresses on connectors, and therefore make mating problematic in the restricted spaces of an engine bay. Furthermore, as OEMs strive to make EVs and HEVs commercially attractive, build costs must be driven down.

In addition to characteristics specific to the EV sector, the broader requirements of automotive engineering still apply. Notably, these include the need to maintain absolute reliability over a long working life, in operating conditions that include vibration, extremes of temperature and the ingress of dust and moisture.

With virtually nothing in the way of industry standards to draw upon, the emphasis to date has been on connector manufacturers working in partnership with OEMs to create new solutions. With an extensive track record in the automotive industry, FCI has been at the forefront of these efforts. As a result, the company has established a production-ready portfolio of EV connectors and charge plugs.

Key elements of FCI's Power.S3 family include the high current, high voltage RCS800 range. Novel 8mm round pin terminals are employed, making more efficient use of space than conventional square designs and boasting higher like-for-like current carrying capacity. Other key features of these compact, robust products include an innovative two-step unmating process, incorporating a time delay between power disconnection and the interlock opening. Disconnection is impossible when the connector is live, eliminating the risk of accidental electrocution or arcing. In addition, a unique integrated electric interlock and Connector Position Assurance ensure 100% safe mating. A slider system provides a fast, easy, single-move connection process.



RCS800 includes an innovative two-step unmating process, incorporating a time delay between power disconnection

FCI applies two levels of sealing to these products: individual cable line sealing and global sealing when mated. Consequently, during maintenance operations, RCS800 connectors are sealed even when disconnected. These solutions provide for a combination of IP2xB finger touch protection and IPx9K, IP67 external sealing performance. Peripheral shielding combines rigorous control of EMI with ease and reliability of installation, leading to an efficient total applied cost.

The compact RCS800 range features novel 8mm round pin terminals allowing for more efficient use of space

Alongside the RCS800, FCI also recently announced the RCS890, a 90° version that will provide greater design flexibility to address the mechanical stresses created by 35-50mm^2 power cables. FCI's EV charge plug offering is similarly well advanced, with both Type 1 and Type 2 solutions available.

The EV market remains as fluid as it is dynamic. While the introduction of new models continues to accelerate, FCI will continue to strengthen its participation in the definition of future standards.

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ONLINE READER ENQUIRY NO. 513

Traction motor know-how

Multiphysics simulation is a valuable tool for optimizing the performance of e-drive systems

OEMs face the difficult challenge of designing a new generation of traction motors – which play a critical role in EV and HEV designs by transforming electrical energy into physical energy that is used to turn the wheels of the vehicle. The efficiency with which traction motors can perform this conversion is crucial because of its effect on the range and battery life of the vehicle. Another design challenge is the need to minimize rare earth metal content, since these materials are increasingly in short supply.

OEMs around the world face a huge number of possible combinations of the many design parameters involved in traction motor development. For example, at the highest level, they need to determine whether an interior permanent magnet, induction machine or switched reluctance machine design is the best fit for the vehicle.

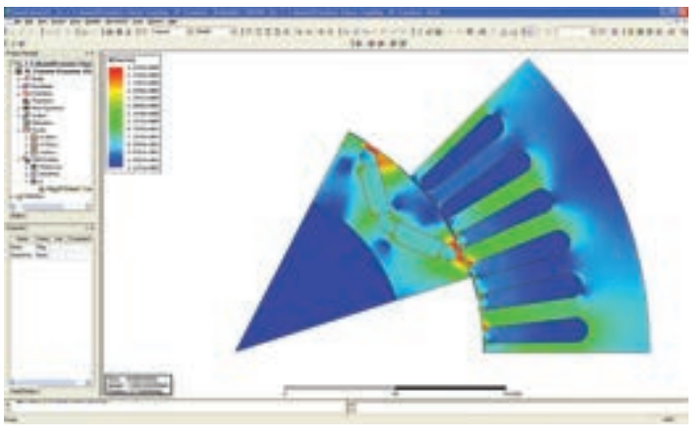
The traditional method of designing traction motors involves building and testing prototypes to evaluate each design alternative. The drawback of this approach is that the cost and time involved means that engineers can study only a few design alternatives; thus, they cannot optimize motor performance to its full potential.

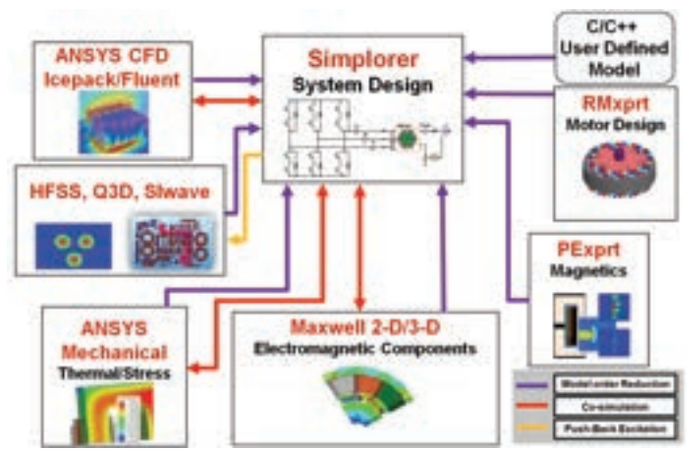
Simulation enables engineers to study hundreds of thousands of design alternatives so they can iterate to a traction motor design that will deliver a higher level of efficiency, while meeting constraints and requirements.

So, OEMs use multiphysics engineering software to develop virtual prototypes of traction motors that help them to understand how a particular design alternative will behave without having to build physical hardware. The first phase of the design process, typically, is to study the electromagnetics of the electric machine using electromagnetic field simulation. These tools compute the torque profile of the machine. Design parameters such as magnet size and geometry are varied to optimize the trade-offs between performance and efficiency against size, weight, and cost.

In the early stages, engineers gain an understanding of the performance trade-offs in each individual domain involved in traction motor performance, including electromagnetics, electrical, electromechanical, thermal, and controller. Later, they begin to tie together multiple domains into a single simulation so that they can simultaneously optimize different domains.

For example, traction motors can be a major source of noise in electric vehicles. As a result, the computed torque output generated by electromagnetics simulation is used in a structural mechanics solver for computing mechanical stresses, loads, deformations, and vibration of the powertrain. A fluid dynamics solver is used to study thermal management issues, mapping energy losses, and determining heat distribution in the motor/generator assembly.





Left: FEA accurately accounts for non-linearity and local saturation of a rotor and stator. Maxwell electromagnetics field simulation software from ANSYS uses the FEA method to solve static, frequency-domain, and time-varying electromagnetic and electric fields

Below: Systematic integrated simulation approach for motor and drives systems. Simplorer software from ANSYS is a multidomain system simulation program that is used for designing high-performance systems, such as electrical, thermal, electromechanical, electromagnetic and controller system designs

Another multiphysics simulation example calculates stress and deformation on the stator lamination and coils and uses the results to perform vibration/acoustic noise or fatigue analysis. The simulation predicts the amount of noise generated by the traction motor as well as its operating life.

Simulation-driven development provides the ability to rapidly evaluate many traction motor design alternatives and to predict their performance in a short amount of time. Engineers at leading EV and HEV manufacturers are using multiphysics-based simulation tools to produce superior traction motor designs and bring them to market ahead of their competitors.

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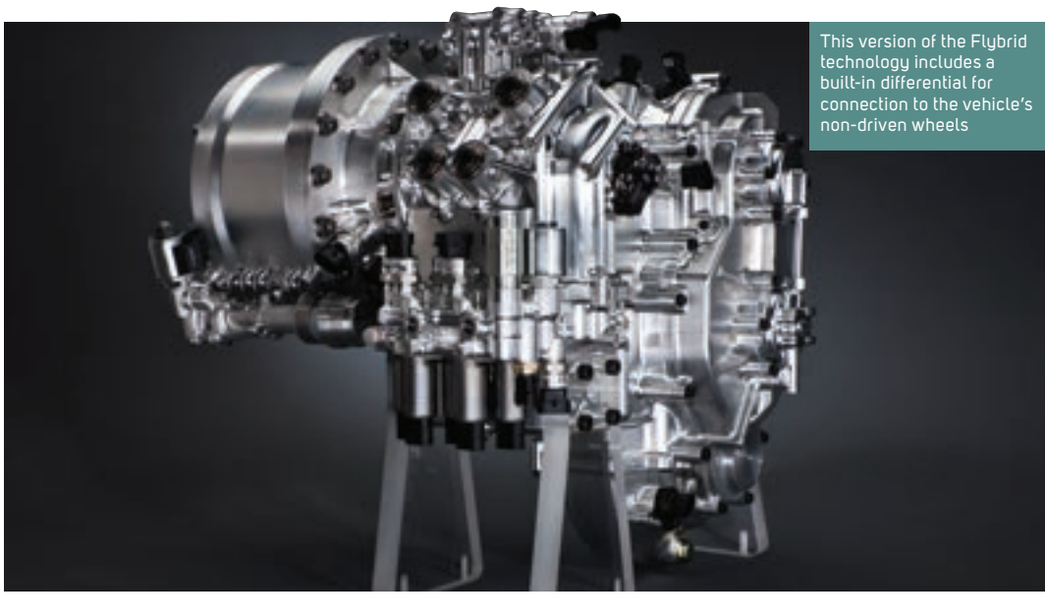
Positive spin for flywheels

More and more global car makes are investigating flywheel hybrid systems, with the technology demonstrating strong real-world benefits as it moves toward mass production



This version of the Flybrid technology includes a built-in differential for connection to the vehicle's non-driven wheels

UK-based flywheel hybrid specialist, Flybrid Systems, has reported a surge of interest in its proprietary fuel saving technology as a number of client demonstration projects have concluded with good results.

Demonstrator vehicles fitted with the 60,000rpm flywheel systems have been on test in many regions of the world, with such progress having been made that the company is now switching its attention to the industrialization of the product so that it's ready for mass production.

"We have seen huge growth in the past 12 months, doubling the size of the business to keep pace with demand for demonstration projects all over the world," reports Flybrid managing partner, Jon Hilton. "There are no longer any questions about whether the system works, runs reliably, or delivers the expected fuel savings. The most common question now is, can it be made for the target price that is about 25% of an equivalent electric hybrid system? We believe it can."

Among the recently completed programs is the Flywheel Hybrid System for Premium Vehicles project undertaken by a consortium of UK companies, including Jaguar Land Rover, Ford, Flybrid Systems, Prodrive, Torotrak, Xtrac and Ricardo.

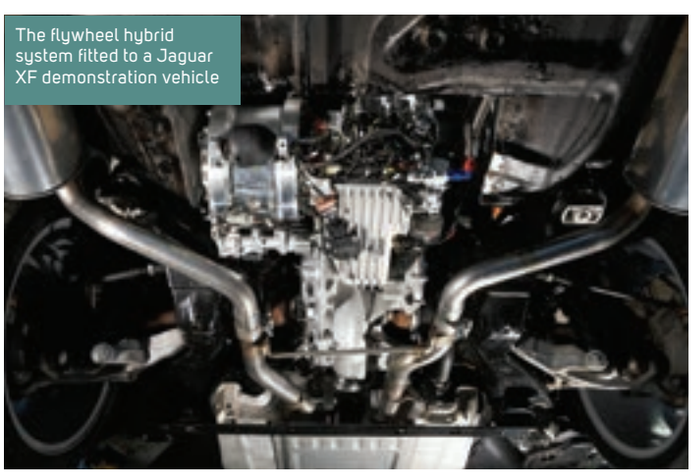
Published data from this UK government-supported project shows a CO_2 saving of 22.4%, including the benefit of stop/start when measured on the Artemis test cycle. This is considered to be a good improvement over the already excellent 3-liter diesel Jaguar XF sedan vehicle.

Interest in the technology is coming from a wide range of clients, covering every type of vehicle from B-segment to D-segment, as well as bus, truck, and off-highway applications. The technical benefits of the system, such as high power, low weight, and zero performance degradation are proving attractive, but the key consideration for most clients is CO_2 and cost savings.

"Most clients agree that a government subsidy can stimulate the market for hybrid vehicles, but they will not become true mass-market offerings until they make financial sense," adds Hilton. "Particularly for commercial vehicles, we need to achieve payback on the purchase price of the hybrid system within three years; with our device this is possible."

Across this range of projects, Flybrid has created systems that connect to the engine, the input shaft of the gearbox, the output shaft of the gearbox, and the rear differential, as well as a version that features a built-in differential for connection to the non-driven wheels of the vehicle. This wide range of connection possibilities allows a packaging solution to suit most applications.

Flybrid is now entering the industrialization phase, where the design of the system will be refined for low-cost volume manufacture in collaboration with an unnamed automotive Tier 1 supplier. The support of an experienced manufacturing partner is key to the company's ambition to deliver product to OEM car makers in true mass volume during 2015.



The flywheel hybrid system fitted to a Jaguar XF demonstration vehicle

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ONLINE READER ENQUIRY NO. 515

Exceeding standards

The importance of meeting the relevant regulatory standards to certify electric and hybrid vehicle supply equipment for sale into North America

Components for hybrid electric and plug-in electric vehicle supply equipment (charge stations) are required to meet relevant regulatory standards. To achieve North American market access, OEMs have a responsibility to get their equipment tested and certified to electrical and mechanical safety standards by an independent third-party – preferably one that has multiple accreditations across international markets to help achieve global access.

In North America, manufacturers must depend on an independent third-party organization that is classified as a Nationally Recognized Testing Laboratory (NRTL). An NRTL functions to provide independent evaluation, testing and certification of any electrically operated or gas- and oil-fired product, recognized by the US government's Occupational Safety and Health Administration (OSHA). Manufacturers have choices when it comes to selecting the third-party NRTL that best fits their needs.

A testing provider should empower manufacturers to make the best choices concerning certification to optimize their process and speed time to market. In the newly released White Paper, *The Q&A Guide to Electric Vehicle Supply Equipment Certification in North America*, authors Rich Byczek, technical lead for electric vehicles and energy storage at Intertek, and Dave Vanderlin, senior project engineer at Intertek, outline manufacturers' most frequently asked questions about North American product testing and certification.

It's critical to choose a testing and certification partner based on a comparison of key purchasing drivers versus the services that each NRTL provides.

Intertek has been helping manufacturers to meet national and international standards for more than a century

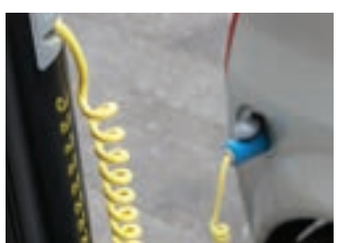
Responsiveness, reputation, local offerings, and the ability to provide global market access can easily trump the value of cost savings, as a strong and effective partnership between a manufacturer and a testing lab is what drives electric vehicle supply equipment to market in this ever-evolving industry.

An efficient test cycle is powered by an active and involved partnership between the manufacturer and testing lab. A certification partner will identify which tests can be done for the greatest number of markets to save time, cut costs and increase distribution channels. A component may be no more than a test or two away from meeting requirements for additional markets, so guidance from an NRTL can ensure manufacturers catch every opportunity to maximize their global approvals.

Full certification assists with market entry and communicates compliance to Authorities Having Jurisdiction, buyers and consumers. Listed equipment that bears a certification mark signifies that it is in compliance with national safety standards, having been tested by a qualified, independent testing laboratory. This mark of product verification enables installers, retailers, electrical inspectors and city code officials to put confidence behind the product's compliance with industry standards. It should also certify that the manufacturer's production site conforms to a range of compliance measures and is subject to periodic follow-up inspections to verify continued conformance.

When selling and/or installing electric vehicle supply equipment, manufacturers must demonstrate compliance to Article 625 of the US National Electric Code (NEC). Depending on design, electric vehicle supply systems are subject to evaluation against several standards, including UL 2231-1, UL2231-2, UL2251, UL2594 and UL2202.

Intertek has been helping global manufacturers to meet national and international standards for more than a century. With unsurpassed expertise in this area, Intertek helps customers cut through the incidentals and provide the critical data they need. Intertek empowers customers to make the choices about testing, approval and listing that will help drive the product to market faster than the competition. Intertek is recognized as an NRTL in the USA, and in a similar capacity as a testing organization and certifying body in Canada, as well as being a notified body in Europe.



The new breed of electric vehicles, including plug-in applications, need to meet stringent international standards

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ONLINE READER ENQUIRY NO. 516

Safer connections

Increased power and voltage requirements mean designers of electric vehicles need larger, safer and more integrated connections

The increasing pressure for environmentally friendlier transport solutions is driving the development of EVs and HEVs toward ever-greater levels of safety, performance, and serviceability.

Today's EVs feature high-performance electric motors capable of approaching the performance levels of their IC engine predecessors in terms of acceleration, speed, and distance. These motors require high levels of current and efficient electricity distribution systems to achieve this capability. This places greater demands on every aspect of the vehicle's power management system, and one area that can benefit from attention is the energy lost in the various connector systems, especially those associated with energy generation, conversion, storage, delivery, and recovery.

Connector systems need to be able to transmit very high current levels – up to 1,000A – with very low voltage drops to achieve the required efficiencies. They must also be as small and as lightweight as possible, normally a conflicting requirement with the traditional bifurcated socket contact connector technology. Fortunately, an alternative socket contact design with superior electrical characteristics is available and is ideally suited to this requirement.

The design of bifurcated socket contacts allows for only a very small surface area to be in contact between the pin and socket of the connector. This concentrates the current flow and increases its density, creating higher energy losses through the generation of heat. Typically, this is improved by increasing the contact area by a higher number of bifurcations of the socket. The optimum solution is to enable the socket contact to transmit current throughout its whole length to the pin and around its complete diameter. The Hypertac Hyperboloid socket contact technology achieves exactly this, maximizing contact areas and therefore efficiency by minimizing current density, voltage drops, and heat generation.

The mechanical construction of the Hypertac socket comprises a number of wires arranged in a hyperboloid fashion that expand, wrap around, and grip along the length of a pin contact inserted inside its bore. This design offers substantial improvements over alternative technology capabilities in terms of insertion force, mating cycles and fretting corrosion resistance in addition to the key requirements of high current capability and low contact resistance.

Each of these characteristics can be optimized for the unique set of requirements demanded by the developing EV community. The number of wires, wire angle, entrance diameter, material, and finish are all carefully optimized to ensure not only the very best electrical performance, but also in the smallest and lightest of packages with the requisite reliability and in-service life that the public expects of all vehicles today.

The HBC range includes single, dual or triple pole, 300A and 500A, and options with plastic or metal ruggedized quick release shells, and straight or right-angle backshells

Hypertac has introduced a new HBC range of circular quick release connectors featuring IP2X safe contacts

What this means for EVs is that for any given power requirement, the Hyperboloid socket contact technology can offer a 30% reduction in size and 50% reduction in weight over alternative designs.

Commercial, off-the-shelf solutions that are very reliable are ideal for the EV designer, especially in the low-volume production phase. Hypertac has introduced the new HBC range of circular quick release connectors incorporating IP2X safe contacts specifically for EV and high-voltage/high-current applications. The HBC range includes single, dual or triple pole, 300A and 500A options with plastic or metal ruggedized quick release shells, and straight or right-angle backshells. When entering the high-volume phase of production, the connector shells can be optimized in each application for space, ease of termination, assembly into the vehicle and maintainability, ensuring that the lowest possible cost of ownership is achieved.

CONTACT

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ONLINE READER ENQUIRY NO. 517

Precise measurement

The AS8510's accurate current and voltage measurement helps extend the overall lifetime and driving range of electric and hybrid vehicles

In few areas of electronics is such precise and accurate measurement of current and voltage as important as in the management of lithium-ion batteries.

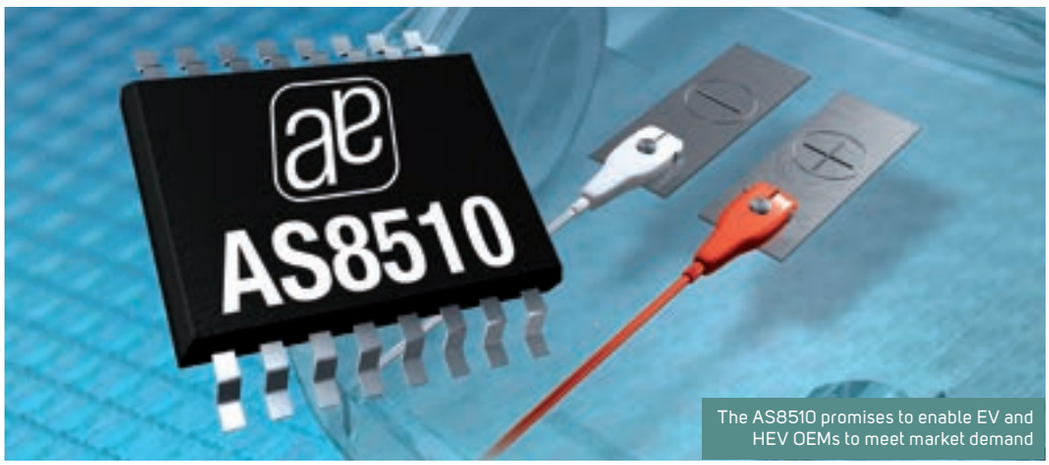
Li-ion is highly prized by the manufacturers of HEVs and EVs, as it offers better energy density, voltage output and charge/discharge efficiency than any other commercially viable alternative. But a Li-ion battery needs the most careful management if it is to be charged and discharged safely and efficiently, and without curtailing its useful life.

In the BMS of an (H)EV, accurate current and voltage measurements that are even just a few tenths of a percent are of critical importance. Insufficiently accurate measurements, and drift in those measurements over time or temperature, can lead to lower efficiency, reduced operating life and reduced energy capacity.

As (H)EV manufacturers compete to offer drivers lower running costs and cost of ownership and – crucially – longer range between charges, the call for accurate current and voltage measurement could not be more urgent.

Enter the AS8510 from Austriamicrosystems, which supplies advanced analog semiconductors to the automotive and other industries. Offering best-in-class accuracy for current and voltage measurement, the device has two independent data acquisition channels that can simultaneously measure current and voltage signals of both polarities, and with no offset.

In a Li-ion battery, SOC data is obtained through the accurate measurement of the current flowing in and out of the battery over time, with the help of calibration cycles based on similarly accurate measurements of no-load battery voltage and on the battery's temperature. Accurate SOC data capture requires precise current measurement over the entire signal and temperature ranges as well as an exact time base (provided by an external quartz-based clock). SOC data informs the remaining range indicator, and also enables the BMS to prevent the occurrence of damaging over-discharge events.

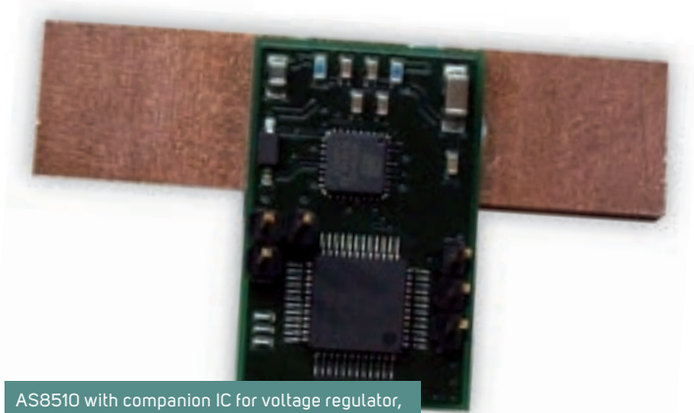


The AS8510 promises to enable EV and HEV OEMs to meet market demand

Current is measured through a 100µΩ Manganin shunt from Isabellenhütte, a precise and stable resistor. Features such as highly linear 16bit sigma-delta ADCs, a zero-offset architecture, and an ADC reference that is temperature-trimmed in the factory lead to a possible accuracy of 0.2% over the full temperature range, input range, and lifetime (when the shunt resistor is thermally coupled with the AS8510). The accuracy of the reference and gain over the device's lifetime has been certified as part of the device's AEC Q100 qualification.

Voltage is another key parameter that a BMS must measure. Accurate voltage measurement is required, in particular, for safe and efficient charging and for cell-balancing in Li-ion batteries. In the AS8510, the externally attenuated battery voltage is directly digitized, either simultaneously with the current measurement, or at a different sample rate if so configured. As with the current measurement function, voltage measurement accuracy of 0.2% is possible on the voltage channel (when software correction of the ADC reference's drift over temperature is implemented).

Offering better accuracy, stability, and lifetime than any other battery measurement, the AS8510 is set to enable (H)EV OEMs to meet market demand for vehicles that more closely match drivers' expectations for range between charges, while lowering the lifetime cost of owning an (H)EV.


AS8510 with companion IC for voltage regulator, precision attenuator and LIN transceiver packaged as AS8515 in a 32pin 5x5MLF

CONTACT

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ONLINE READER ENQUIRY NO. 518

Ensuring safe and reliable fast charging

As the EV charging market evolves, a requirement for fast, reliable, and safe charging is now evident. Although this brings obvious time benefits to users, the migration from single- to three-phase EV charging brings new challenges, not least the need for safe, high-voltage, and intelligent charging units.

Siemens has now delivered its first three-phase EV charging points in the UK. Fast-charging units have been supplied and installed at the University of Lincoln as part of the company's collaborative work program with the university to establish a new engineering school.

As part of a low-carbon transportation solution for the City of Lincoln, the fast-charging units will be primarily used by electric vehicles supplied by Nissan to transport staff, customers, and students between Siemens' Service business and the university. As the city's largest employer, Siemens is setting the standard for other local companies to follow and helping Lincoln to preserve its heritage and enhance its long-term sustainability.

According to Siemens, the company's solution for the UK market is built on four key components: industry-leading fast-charging technology; modular back-office management software; extensive contact center capabilities; and comprehensive service packages. All are tailored to meet individual customer requirements and ensure maximum system availability and safety.

Siemens is already engaged in major projects across Europe to devise and develop solutions and business models that will help to establish electric vehicles as a viable and attractive transport option for the long term.

Siemens
mark.bonnormoris@siemens.com

ONLINE READER ENQUIRY NO. 519

Water-cooled PM drive system

Kolektor's 50kW synchronous water-cooled PM drive system was specifically designed for EV, HEV, and marine applications powered by 400V battery packs. It combines high torque for enjoyable acceleration and high efficiency for economical transportation. The motor controller is suitable for running synchronous PM and asynchronous induction motors. It combines high-power performance within a compact package, and high levels of interconnectivity for comprehensive integration into the EV and HEV applications. It includes an external watchdog for microcontroller observation. Drives can be interconnected to master controllers in various applications over CANbus (SAE J1939). There is also an option for an additional module, which works as an electronics differential unit in case of multimotor application.

Kolektor Group
matjaz.potocnik@kolektor.com

ONLINE READER ENQUIRY NO. 520

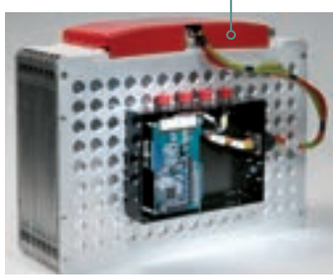
NCM electrochemistry breakthrough

Axeon has announced the results of a consortium project that it led, co-funded by the Technology Strategy Board in the UK, to develop a new battery for use in EVs, which aimed to reduce the size, volume, and weight of the battery pack.

The new, high-energy-density battery offers a 35% improvement in range over existing technologies, for the same weight. This increase is largely down to the use of nickel cobalt manganese (NCM) electrochemistry, which theoretically requires 50% less volume and 30% less mass than large-format lithium iron phosphate chemistry at cell level.

A key part of the project was to ensure that similar improvements would be achieved in the battery pack as a whole, which would take into account battery packaging, cell retention, cooling and interconnects, BMS components and overall system functionality.

The project has confirmed that it is feasible to replace lithium iron phosphate technology with a robust NCM solution and that most of the benefits at cell level are also seen at battery pack level.



A demonstrator pack has been created using NCM pouch cells – not yet widely seen in EVs – that have been packaged in modular blocks. These support a range of thermal management options and enable Axeon to support rapid prototyping into a range of other vehicle types with considerably reduced development lead times.

Axeon
www.axeon.com

ONLINE READER ENQUIRY NO. 521

Efficient power transfer in EV charging circuits

Volatile oil prices have expedited sales of EVs and HEVs across the globe. To accompany the surge of EVs and HVs on the roadways, the ever-increasing necessity will be an infrastructure of convenient commercial charging stations.

Charging circuits in EVs demand maximum efficiency for power transfer across a broad spectrum of temperature conditions and circuit configurations. Kool Mμ, Magnetics' cost-effective, distributed gap material, possesses ideal properties – high stable saturation, low losses, and no thermal aging – for charging stations and onboard power conversion equipment worldwide.

In high-current circuit designs, often the limiting factor is not the capacity of the core to provide inductance under load, but the availability of window area to accommodate enough turns of heavy gauge wire or foil. To address this requirement, Magnetics tooled up a family of blocks. Powder core blocks enable the designer to create a custom inductor of the size required and to adjust the window dimensions to accommodate the winding.

The advantage of a custom-built inductive structure from Kool Mμ blocks is the ability to achieve the target inductance and performance in the space allotted to the magnetic converter.

An easy-to-use spreadsheet is available to calculate the A_e, L_e, and A_L of the block structure to determine which size block is best for the high-current application.

Magnetics
www.mag-inc.com

ONLINE READER ENQUIRY NO. 522

Rechargeable power solutions

Lithium Technology Corporation (LTC)/GAIA Akkumulatorenwerke, a unit of LTC, is a leading global provider of large-format rechargeable power solutions for diverse applications. The company claims that it offers the largest cylindrical lithium-ion cells with the highest power of any standard commercial lithium-ion cell produced in the western hemisphere.

With more than 20 years of experience, LTC leverages its extensive expertise in high-power, high-energy, large battery assemblies to commercialize advanced lithium battery technology as a new power source in the global passenger and heavy-duty transportation markets.

LTC's large format technology has enabled the development of safer battery systems with a significantly lower number of cells. The weight of the battery is decreased, while performance and safety monitoring capabilities are increased. The BMS precisely monitors the fewer cells, keeping them in balance for optimal performance, and preventing damage to the battery.

The advanced, high-energy-density and high-power lithium-iron phosphate (LFP) product line is aimed at answering the need of the EV and the PHEV markets. The batteries will incorporate the largest cells of their kind in the world.

LTC's LFP product line will offer cells ranging from 8-40Ah, and joins LTC's existing high-power and high-energy line of nickel cobalt oxide cells that range from 7.5-485Ah.

Lithium Technology Corporation
+1 703 459 9976
www.lithiumtech.com
ONLINE READER ENQUIRY NO. 523

Next-generation drivetrain

Zytek has recently launched a new design of electric drive that targets the medium- to high-power end of the market. Designed for use as a traction motor for medium-sized pure electric passenger cars, as a part-time four-wheel drive assist system for heavier classes of vehicles (such as SUVs), or for use with high-performance electric sports cars where multiple motors per car can be installed, Zytek's new 120kW system has a variety of potential applications.

The new 380Nm motor operates at speeds up to 12,000rpm, enabling high gearbox reduction ratios to be used to give a very low powertrain weight to axle torque ratio.

It has been developed in close partnership with gearbox manufacturers to enable a variety of units to be used (both concentric epicyclic for space-constrained longitudinal applications and transverse with integrated differential for use in cost-conscious FWD applications). The water-cooled motor case, supplemented with a unique internal rotor cooling arrangement, generates a very high continuous peak power ratio, enabling the drive to replace larger and heavier drives that are normally needed to achieve high continuous power levels.

Zytek
www.zytek.co.uk
ONLINE READER ENQUIRY NO. 524

Protecting the environment

BorgWarner's strategy focuses on developing advanced technologies to improve fuel economy, reduce emissions, and enhance performance. From the products produced to where and how they are manufactured, the company aims to protect the environment by making vehicles more efficient.

The company's innovations help to reduce emissions and improve fuel economy for on- and off-road vehicles. Its products, such as turbochargers, exhaust gas recirculation valves, pressure sensor glow plugs, and electric air pumps are key technologies to reduce emissions, while turbochargers, DualTronic control and dual-clutch modules, variable cam timing, and tire safety systems are critical products to help OEMs improve fuel economy.

BorgWarner has one of the most diverse and strongest

portfolios of environmentally friendly products that help OEMs and thus countries around the world to meet their goals for reducing petroleum usage and emissions.

BorgWarner has also developed innovations engineered for EVs, such as eGearDrive electric drive transmissions and electric cabin heaters.

BorgWarner
www.borgwarner.com

ONLINE READER ENQUIRY NO. 525

The fifth International Advanced Mobility Forum

The International Advanced Mobility Forum (IAMF) was created five years ago to bring together scientists and key players from the motor industry to exchange knowledge and accelerate development in the framework of the Geneva International Motor Show.

Today, the event is one of the most important gatherings related to future transportation issues. For the first time, the IAMF takes place on the second press day and on the first public day of the Geneva Motor Show (March 7-8, 2012), instead of during the second week of the show as in the past.

This year, the forum is dedicated to technologies for more environmentally clean vehicles, but it also addresses human behavioral change issues related to these new developments, such as the increase of corrective actions against human errors, electronic devices multiplying communication technologies, and a population that is aging. Bernhard Gerster, the newly appointed president of the IAMF and head of the automotive engineering division at Bern University of Applied Sciences, points out the importance of these considerations: "In this context, human behavior needs to be analyzed when confronted with new alternatives in mobility. We have to understand how people accept technical ingression and how older generations deal with new technology."

This debate is an integral part of the program, which also gives an insight into cutting-edge technology and alternative energies for the mobility of tomorrow. A full program of speakers can be found on the IAMF website.

International Advanced Mobility Forum
www.iamf.ch

ONLINE READER ENQUIRY NO. 526

All-new 800V onboard battery charger

EDN Group, a power converter expert in high-frequency battery chargers and power supplies, has announced the introduction of its 800Vdc battery charger modules for battery-powered vehicles.

The new modules are ready to be plugged to three-phase or single-phase mains lines to permit useful recharging in any location. This feature is SAE J1772 compliant, and has a high degree of protection (IP67, IP6K9K), high efficiency, is water- and air-cooled, and offers safe and reliable operation in outdoor environments, thereby providing a highly usable charger module for onboard EV applications. A CAN v2.0B interface ensures excellent flexibility, compatibility, and parameter control for all BMS technologies and systems.

EDN Group has extensive competence in designing power converters such as battery chargers and DC-DC and AC-DC converters suitable for EV and HEV applications. Its know-how and core competency are to provide fast, cost-effective, customized solutions.

EDN Group
sales@edngroup.com

ONLINE READER ENQUIRY NO. 527

Electrical wiring protection

Delfingen, a global leader in electrical wiring protection and fluid transfer systems, has developed in recent years a wide range of products and systems to answer the new technical challenges of hybrid and electric vehicles.

The company's Nu-Guard SC is a self-closing textile sleeve that offers excellent protection against abrasion and other mechanical risks such as chafing or cutting. It is also made to protect and insulate high-voltage power cables. Gafmil (tapeless closeable tube), Oval Tube (for flatter bundles), and TwinVolt (dual-channel tube) are the company's convoluted tubes specially designed for high-voltage identification, wiring harness routing, and cable management.

Nu-Guard EMI-HV is a braided copper and PET monofilament sleeve that offers high levels of electromagnetic interference shielding between 10kHz and 1GHz. Nu-Sleeve fiberglass sleeves are available for higher dielectric protection due to the various silicone coating thicknesses.

The company's Fluid Transfer Solutions are custom-built and designed for thermal management in hybrid and electric vehicles.

All of Delfingen's products are easy to assemble over the wires and for safety reasons are identified by the color orange. These products are available in multiple sizes and materials.

Delfingen
delfingen@delfingen.com
www.delfingen.com

ONLINE READER ENQUIRY NO. 528

2012MIECF

Macao International Environmental Co-operation Forum & Exhibition
2012年澳門國際環保合作發展論壇及展覽

ufi Approved Event

Host / 主辦單位

Government of the Macao Special Administrative Region of the People's Republic of China
中華人民共和國澳門特別行政區政府

The Macao International Environmental Co-operation Forum & Exhibition (MIECF) is a major annual event and a highly effective platform to promote solutions for a low carbon future and sustainable urban development in South China. The exhibition and conferences are strategically positioned to nurture technology exchanges, and co-operation between the Greater Pan-Pearl River delta region and international markets.

According to a recent report from Pike Research, China will be the leading market for EVs in Asia Pacific by 2015. The cleantech market intelligence firm believes that the Chinese market will represent almost half of the region's total sales by 2015.

Register as an exhibitor now to showcase your EV solutions to more than 6,000 professional visitors across the region! Participate in the conference and seminars where you can learn from industry thought leaders who will discuss the key issues in the EV market today! Visit the exhibition to source for EV solutions from the region!

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Macao Trade and Investment Promotion Institute

環境保護局
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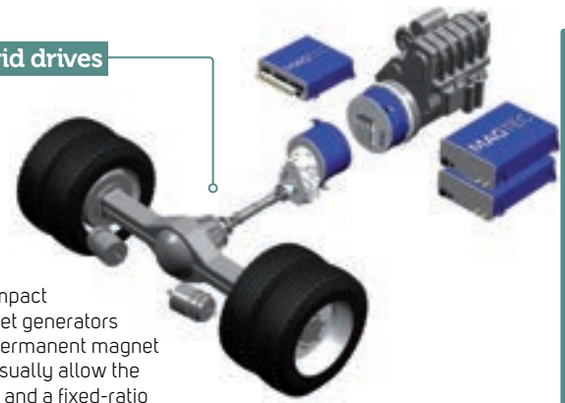
2012 MIECF Event Manager:

koelnmesse

Retrofit hybrid drives



Magtec's range of hybrid drive system components has been designed to enable easy retrofit into commercial vehicles. The compact permanent magnet generators and lightweight permanent magnet traction motors usually allow the generator, motor, and a fixed-ratio transmission to be accommodated in the space created by the removal of the original vehicle gearbox. This enables the system to be easily retrofitted into vehicles, or offered as an alternative drivetrain by OEMs without the need to redesign the chassis or engine installation.

The power electronic controllers for the motor and generator and the energy storage buffer can usually be accommodated in the vehicle chassis without significantly affecting the vehicle's load space or weight.

As the energy storage system is generally the most cost-sensitive component, selection of the right energy buffer technology and the size of the energy buffer is critical to ensure the customer gets a return on their investment; Magtec works with customers to ensure the installation is optimized for their application, and can offer ultra-capacitor and $LiFePO_4$ energy buffer solutions.

The company currently supplies retrofit systems suitable for vehicles up to 18 tons, and can match the vehicles' original hill-climbing capability and maximum speed, while providing sufficient fuel savings to justify the capital expenditure in a two- to three-year timeframe.

Magtec
www.magtec.co.uk

ONLINE READER ENQUIRY NO. 529

MES distributor

E-car Supplies is the distributor of MES products for electric and hybrid vehicles. With extensive experience in designing, developing and manufacturing innovative components for the EV market, MES is one of the most widely acknowledged centers of competence for EV development in the world.

One of the many components produced by MES is the vacuum pump. Designed to create vacuum for brake boosters of electric and hybrid vehicles, the MES pump is already the preferred choice of a number of leading EV manufacturers, including Tesla.

Although the vacuum pump was specifically designed for the EV market, due to its performance, compact design, and onboard pressure control, there is now an increasing demand from the sports and classic car arenas.

Specifications include relative and absolute pressure measuring, fully encapsulated electronics, and integrated one-way valve. The MES commitment to continuous improvement ensures the MES vacuum pump remains a market leader.

E-car supplies
www.e-carsupplies.com

ONLINE READER ENQUIRY NO. 531

Opportunity charging

When it comes to electric mobility, range is one of the top concerns. This is the case for both public and private transportation. Conductix-Wampfler already has 10 years' field experience with automated charging. This rich know-how means the company can help to extend the driving range of electric buses, for example, by factors of two and even four, if charging is considered properly in the planning of bus routes and time schedules.

Opportunity charging can be done with conductive as well as with non-conductive solutions. Positive experiences have already been realized with first-generation automated charging solutions in Italian cities such as Turin and Genoa, as well as from current testing taking place at the University of Tennessee, USA. From studying the experiences gained in public transport and first field testing in private transportation, it has become obvious that resonant inductive charging will become a key factor for future electric mobility, especially because on performance and cost levels it is absolutely comparable to plug-in hybrid vehicle solutions.

Conductix-Wampfler
www.wampfler.com

ONLINE READER ENQUIRY NO. 530

Options for wiring harness assembly routing challenges

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, but 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 has safe, reliable solutions that enable flexibility in system design.

Options are not limited by the device header; the same interface is used for 2-4mm individually shielded wires and multicore wire. Reduced size and mass are achieved through optimized packaging, an integrated HVIL, and floating two-stage latch.

With products currently in use in Asia-Pacific, Europe, and North America, TE's AMP+ headers and connectors are ready to help engineers around the globe.

TE Connectivity
+1 248 273 3317
ajay.bhargava@te.com

ONLINE READER ENQUIRY NO. 532

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www.tdipower.com

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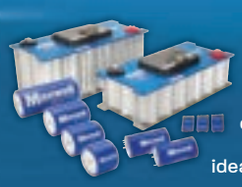


SMALLER, LIGHTER, LEANER, GREENER, Maxwell's industry-leading ultracapacitors are breakthrough energy storage and delivery devices that offer millions of times the capacitance of traditional capacitors. They deliver rapid, reliable power bursts for a million-plus duty cycles – even in extreme conditions. This makes them ideal for energy-use optimization in applications ranging from wind and mass transit to hybrid cars and industrial equipment. Maxwell. The leader in burst power delivery. Hands down.

maxwell.com

Maxwell® TECHNOLOGIES

Enabling Energy's Future™

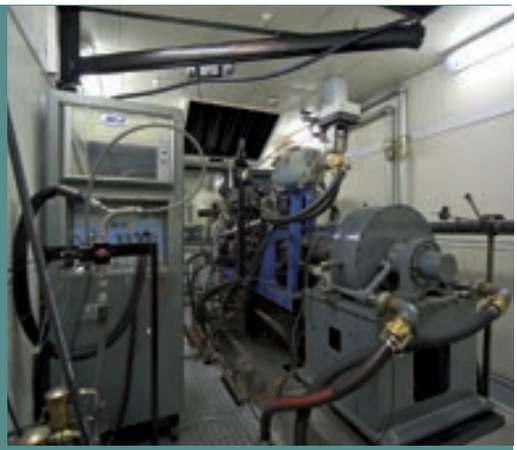
Independent test facility

Tickford Powertrain Test was formed six years ago by its management buyout team. The company's operational roots date back 30 years, when it was Tickford Engineering. Based in Milton Keynes, the privately owned business is one of the last truly independent test facilities in the UK.

Tickford has 21 engine test cells, an electric motor rig test area, and a vehicle chassis dynamometer. All facilities have both gasoline and diesel capability, and they are covered by ISO 9001 and, for specific fuel-testing-based activities, ISO 17025 quality accreditation.

The facility has many multinational blue chip customers, including vehicle manufacturers, fuel, lubricant and additive companies, and Tier 1 and 2 suppliers. To support this wide array of clients, the test facilities are continually evolving. Current market forces dictate two particular areas of facility development for Tickford: the management and use of alternative fuels; and adapting, applying, and developing the existing facilities to meet the requirements of testing hybrid technologies.

The complexity of hybrid driveline systems, including electric motors, high-voltage requirements, and associated transmission systems, dictates that the historical approach of a simple test system for mechanical component or subsystem development has been overtaken.



With further investment in transient dynamometers to support already existing electrical drive systems, gearshifter, and robot driver technology, Tickford has an integrated approach to testing hybrid drivelines. That capability continues to grow, and will support complete powertrain testing for the future.

Tickford Powertrain Test
tbraddon@tickford.eu
www.tickford.co.uk

ONLINE READER ENQUIRY NO. 533

EV Relay latest

Panasonic is one of the world's first companies to succeed in developing a technology that involves contacts in sealed capsules filled with hydrogen gas, which can instantaneously cut off high voltages. This function is now vital to the battery control of HEVs and EVs, which are spreading worldwide. In 1997, a Panasonic EV Relay employing this technology was adopted for the world's first mass-produced HEV. Having been adopted by many users since its release, in July 2011 the EV Relay had recorded total sales of 10 million units. At present, the Panasonic EV Relay line-up ranges from 10-300A, and will continue to evolve in line with user needs, focusing on achieving smaller, lighter, and safer design with higher contact reliability.

Panasonic Electric Works Europe AG
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info-eu@eu.pewg.panasonic.com
www.panasonic-electric-works.com/ev-relay

ONLINE READER ENQUIRY NO. 535

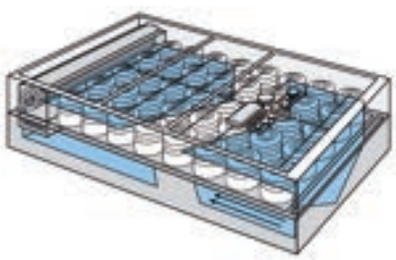
New cooling concept for hybrid drive

Tangential fans from LTG Aktiengesellschaft, based in Stuttgart, Germany, provide effective cooling in the electronic industry, such as supercapacitors, batteries, and hybrid drive components. This ensures a flawless function and long life expectancy.

The specific design of the tangential fan saves space and provides the designer with freedom in the layout of the electronic components.

Complicated additional air guidance systems, such as ducts or guide vanes, to optimize the air or temperature distribution are not required. The whole assembly can be made smaller and more compact, thereby saving a lot of space.

The bearings and the motor of tangential fans are outside the airstream. For this reason, temperature changes and humidity in the moved airstream cannot reduce the life of the fan. Tangential fans can be used in a temperature range from -40°C up to +800°C. The impeller diameter can be between 25mm and 1,000mm, and the length of the impeller between 40mm and 4,500mm. The air volume moved with this type of fan can be up to 300,000m³/h. Length and diameter can also be adapted to meet specific customer requirements.



LTG Aktiengesellschaft
info@LTG-AG.de
www.LTG-AG.de

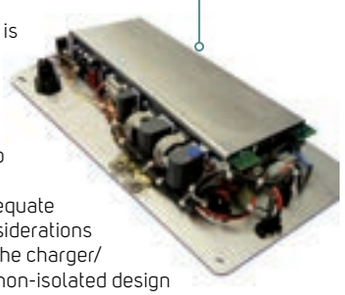
ONLINE READER ENQUIRY NO. 534

Considerations on power electronic isolation

The emergence of EVs and PHEVs has provided the opportunity to use energy stored in the vehicle's battery to power AC equipment from the vehicle, or to recycle power back to the utility grid. With these opportunities come new considerations for safety and cost.

It is possible to realize the battery charger and export inverter as a single converter that can operate in either direction. This converter may feature galvanic isolation between its AC and DC terminals, or the converter can feature a non-isolated design that provides a relatively low impedance path between the vehicle battery and AC power.

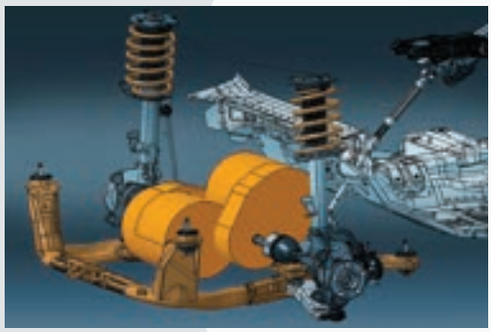
The general practice in EVs and PHEVs is to provide robust insulation between the battery's high-voltage terminals and the rest of the vehicle. Insulation integrity is often monitored by detecting the impedances from the battery bus. If a fault to ground is detected, a device in series with the battery is opened to prevent dangerous currents flowing into ground.

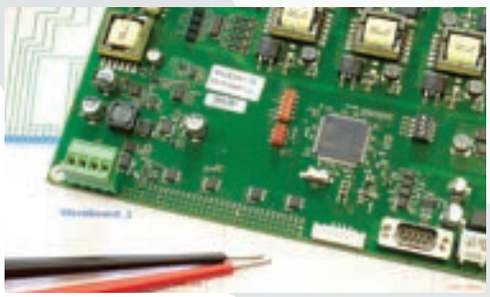


With adequate safety considerations outside of the charger/inverter, a non-isolated design can be implemented safely. The advantages of this approach are readily evident in cost and efficiency because a conversion stage is eliminated. Comprehensive control and monitoring circuitry in conjunction with the non-isolated charger/inverter can provide a highly effective solution at a competitive cost.

TDI Power
www.tdipower.com

ONLINE READER ENQUIRY NO. 536





Partner for innovation and development in the automotive industry

Flanders' DRIVE is a research institute for the automotive industry situated near the Lommel Proving Ground in Belgium. Together with leading companies and research institutions, Flanders' DRIVE works on high-tech, application-oriented research into the green and smart vehicle of the future.

Flanders' DRIVE supports the automotive industry through a wide range of activities, focusing on Clean Powertrains, Lightweight Materials, Active Safety and Manufacturing.

Vehicle electrification solutions:

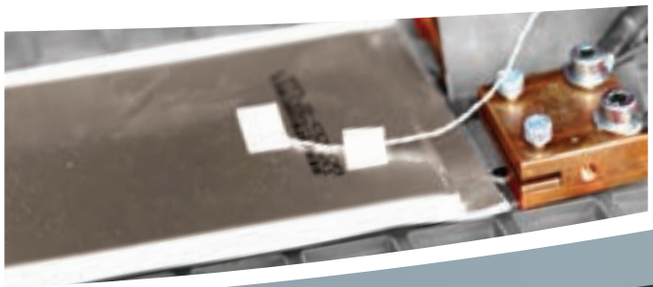
- Drivetrain architecture & design
- Drivetrain control systems
- Functional safety case development
- Lightweight system engineering
- Electrical, thermal & mechanical modeling
- Battery cell & pack characterization
- Lifecycle testing
- Vehicle evaluation & testing

Find out about our e-mobility projects:

- Inductive Charging
- Electric Powertrain
- Energy Storage

www.flandersdrive.be/clean-powertrains

To learn more about Flanders' DRIVE,
call us today at +32 (0)11 790 590
or send an e-mail to info@flandersdrive.be



Flanders' DRIVE is supported by the Flemish Government and offers its expertise to European projects

Sound design tools

Brüel & Kjær has developed a suite of software and hardware tools to create, evaluate, and deliver well-designed sounds for quiet vehicles in a quick and efficient manner.

Developed alongside the company's partner, NoViSim, these systems work together or individually to help sound engineers and designers create the right sounds at every stage of development, from initial design through validation processes, and sign-off to final production solutions.

Design and evaluation is taken care of by the Exterior Sound Simulator – an interactive audio-visual simulator that enables the evaluation of the sound experienced by the driver and pedestrians as a vehicle is driven around a user-defined scenario. It enables real-time modification of the sounds during the design phase, and controlled evaluation of many sound designs in a variety of scenarios.

When a final set of sound designs has been selected for real-world testing, they are downloaded directly onto QVSound – 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 signing off sound designs.

QVSound has an adaptive sound algorithm that enables the system to adjust the sound content and level according to the background noise environment around the vehicle. It can be used 'hands-on' by the development engineer or allowed to run automatically, and can be tailored for use as a production system.

Brüel & Kjær
www.bksv.com

ONLINE READER ENQUIRY NO. 537

Power distribution systems for HEV and EV applications

Rogers Corporation's Power Distribution System Division has an extended range of products for different application areas within HEVs and EVs.

The growing electrification in future cars will drive the need for reliable power distribution solutions. Rogers provides solutions for motor drives, DC-DC converters, battery packs, and fast chargers.

The RO-LINX PowerCircuit busbar was recently introduced and features high current capabilities (+100A), compactness, very low inductance, 3D design and compatibility with standard interconnection processes, such as soldering. PowerCircuit busbars are designed for motor drive and DC-DC converter applications.

Recently, Rogers Corporation and Himag announced a strategic alliance. Himag is a leading company in the design and manufacture of high-power planar transformers. Compared with wire-wound transformers, planar transformers are smaller, lighter, and have higher levels of efficiency. Combining planar transformer technology from Himag with Rogers' RO-LINX PowerCircuit busbars creates high value for DC-DC converters and fast charger applications.

Today's battery cells are connected with thick, high-current conductors and extensive wiring for monitoring each cell, thus increasing the total assembly time and risk for wiring errors. Rogers has developed creative solutions that combine power connection and signal lines, offering reliable and flexible all-in-one solutions.

Rogers has been developing and manufacturing laminated busbar solutions for more than 40 years and has been successful in leveraging that knowledge in different HEV and EV applications.

Rogers Corporation
www.rogerscorp.com

ONLINE READER ENQUIRY NO. 538

Accredited and experienced battery manufacturer

With new entries and a new ultimate battery solution for the HEV and EV market being unveiled on a regular basis, choosing the right combination of battery solution and supplier is an increasingly difficult task. With this daunting challenge, one must return to the basics. What is the supplier's experience? What accreditations do they have? And what are their capabilities?

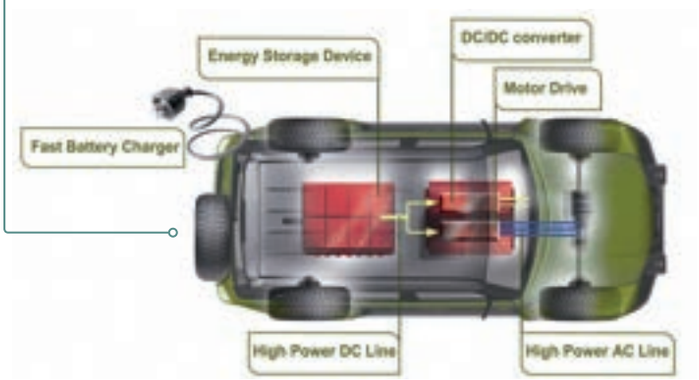
Specializing in lithium iron phosphate ($LiFePO_4$) and nickel-metal hydride (Ni-MH) chemistries, EVB Technology has 18 years' manufacturing expertise, from prototype to production, in large format batteries.

In a recent development, EVB updated its ISO/TS 16949:2002 certificate to ensure compliancy with today's strident automotive demands.

Moreover, as a fully owned subsidiary of the Gold Peak Group, EVB draws on the battery chemistry expertise from the group's extensive range of lithium chemistry offerings to support its capabilities in manufacturing stable and reliable $LiFePO_4$ systems. Ensuring the final output is a unique cell matching method developed over the years of manufacturing experience.

EVB Technology
www.evbtech.com

ONLINE READER ENQUIRY NO. 539



Maintaining quality in HEV designs

Existing sensor designs that have been optimized for, and in, traditional gasoline-powered vehicles may not perform adequately in hybrid and electric vehicles.

It has taken more than a decade for the semiconductor industry to fine-tune IC designs for the automotive market. Whether it is a simple door latch or a highly intelligent engine sensor, these ICs are designed for individual applications and their surrounding environment. The quality level of the average semiconductor IC in application today is less than 1ppm. Are hybrid and electric vehicles similar enough that the technology can be ported over to maintain the same level of quality?

The ICs used in traditional gasoline-powered vehicles today have evolved over time as system knowledge has gained, sometimes at the expense of costly recalls and/or loss of reputation within the automotive industry. The one common oversight was inadequate quantification of the in-system behavior that nominal assessments failed to convey. To prevent the same decade-long evolution from starting over, the hybrid and electric systems need to be fully characterized empirically to fully understand the impact of the differences. This calls for close working relationships between the automotive manufacturers and the IC suppliers. This is an approach foreign to most of the world today, where communication is commonly directed to the assembly manufacturers, who are rarely the IC designers.

Ever-increasing demands for quality and the introduction of hybrid and electric vehicles around the globe will create a demand for new IC designs for years to come in the automotive sector of the semiconductor industry.

Allegro MicroSystems
sales@allegromicro.com

ONLINE READER ENQUIRY NO. 540

Delivering world-class engineering

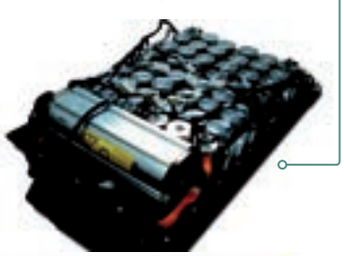
Formed in 2004, Hybrid Design Services (HDS) is a privately held and funded corporation, specializing in the commercialization of hybrid vehicle and electric vehicle technologies.

Operating from an advanced facility in Troy, Michigan, HDS offers complete product development assistance, from system specifications and failure mode analysis, to simulation and software development, as well as component design, manufacturing, and testing support, including global sourcing.

The HDS team has extensive automotive, heavy-truck, and alternative energy industry knowledge, as well as experience in designing and developing electric and hybrid vehicle 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 can help customers to select or invent the appropriate 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. It is currently using ISO 9001 – 2008 practices in engineering design and manufacturing.



Hybrid Design Services
www.hybriddesignservices.com

ONLINE READER ENQUIRY NO. 541

Alternative solution to rare earth metals

EV motor controls specialist Sevcon is heading a research group looking into the next generation of electric drivetrain systems. Sevcon is leading a collaborative project that includes Cummins Generator Technologies and Newcastle, working on the development of an innovative 'no rare earth metals' electric drive system for EVs using advanced switched reluctance motor technology.

Unlike current EV motors that rely on rare earth metals such as neodymium and dysprosium, the new motors will replace these rare earth metals with steel. Steel is not only cheaper and less damaging to the environment, but also more widely available – an important factor in meeting the expected increase in demand for hybrid and electric vehicles.

Sevcon is already a leading supplier of motor control technology to the international EV market.

Dr Peter Barrass, VP of engineering, says: "This is an exciting, cutting-edge project in a market sector that has great potential. We are already very active in the low-carbon vehicle sector and the performance capabilities of our advanced technology motor controllers are ideal for this sort of application. We are delighted to be bringing our automotive drivetrain engineering expertise to this project."

The advanced design being developed by the team will replace

traditional electronic control systems with new technology based on cutting-edge power electronics. As well as providing sufficient power, the new-generation system will also be designed to be cost-competitive and suitable for high-volume manufacture.

Sevcon Limited is a wholly owned subsidiary of Sevcon Inc and a specialist in the design and manufacture of microprocessor controls for zero-emission electric vehicles and hybrids. With offices around the world and 70 staff in the UK, global sales are more than US$30 million. Customers include manufacturers of on-road, off-road, and industrial vehicles, including cars, motorcycles, buses, forklift trucks, and aerial lifts.

Sevcon
www.sevcon.com

ONLINE READER ENQUIRY NO. 542

Sustainable transportation portal

EVtransPortal.org is a non-profit, tax-exempt organization helping sustainable transport to succeed by connecting people with the information and resources they need.

EVtransPortal's business-to-business and business-to-consumer portal provides market research, consulting, information, and referral services to companies within the EV, HEV, and fuel cell industries, as well as to individuals, organizations, and government groups. EVtransPortal provides EV companies with direct access to global customers, suppliers, and industry resources, including sources for cutting-edge battery technologies, EV and HEV product development, marketing, and venture capital. EVtransPortal is the information resource of choice for a growing number of automotive engineers, manufacturers, suppliers, and governmental groups developing electric drive vehicle technologies.

EVtransPortal
www.EVtransPortal.org

ONLINE READER ENQUIRY NO. 543

A winning stop/start system

With more than a year in the market and available throughout Europe, the PSA e-HDi micro hybrid system is a technology of the future. Other stop/start systems require a button to turn them off when they stop working, but the PSA e-HDi system requires no such button. PSA won an independent comparison test undertaken by the German publication *AutoBild* (No. 30, 2011), where PSA's system was rated highest in comfort within a field of competitors.

At the core of the PSA system are Maxwell Technologies' ultracapacitors. Continental Automotive integrated the cells into a powerful and agile package that works in conjunction with a Valeo-built belt-driven starter/alternator system. This not only works in the summer, when the *AutoBild* article was published, but in winter conditions too.

Maxwell Technologies
www.maxwell.com

ONLINE READER ENQUIRY NO. 544

Design and analysis of Li-ion battery cells

CD-adapco, in collaboration with Battery Design, has developed a new, unique and advantageous working methodology for the design and analysis of Li-ion battery cells, modules, and pack installations.

The toolbox, which consists of two pieces of software – Battery Design Studio (BDS) and STAR-CCM+ Battery Simulation Module (BSM) – allows the user to migrate from short-length scale simulations, such as studies of a detailed single cell, to complete vehicle/application analyses, while using the same battery performance model.

The workflow is as follows: the use of BDS to make fundamental battery cell design decisions works by offering its users an integrated simulation environment for the analysis and design of the electrochemical system and detailed geometry of a single battery cell. BDS provides the ideal platform to achieve a balanced cell design.

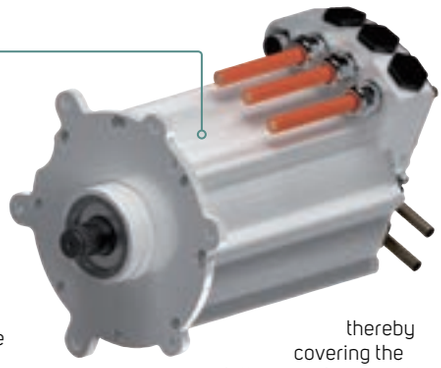
For single-cell analysis within STAR-CCM+, the technology combines the electrochemical solver of BDS with the flow and thermal solver of STAR-CCM+, allowing the STAR-CCM+ BSM to calculate the 3D thermal, fluid, and electrochemical properties of Li-ion battery cells on several length scales, starting from each finite volume/e-cell within a battery cell. This analysis focuses on the non-uniformity of parameters on the cell, such as state of charge and temperature imbalance, and the ways to adjust them.

Finally, for module level analysis within STAR-CCM+, once a satisfactory battery cell design is achieved, the single cell is duplicated as many times as needed to form a module or pack, and a coupled thermal/flow/electrochemical solution is computed for the entire installation. This includes thermally conducting parts such as metallic connectors at high discharge/charge rate, the surrounding structure, and the cooling system. This allows the user to predict how the assembly will perform under the expected electrical load, and to optimize the vehicle design accordingly.

CD-adapco
www.cd-adapco.com/industries/battery/index.html

ONLINE READER ENQUIRY NO. 545

Motor optimization



TM4, a supplier of electric powertrains, unveiled in 2011 a new version of its popular, high-speed motor from the TM4 MΦTIVE series of electric powertrain, targeting class A and B light-duty passenger vehicles.

While its success had already been confirmed by the fact that this motor has been chosen by more than 15 OEMs and integrators in 10 countries, TM4 was committed to improve on what was already one of the most power-dense electric motors on the market. With such a diverse customer base and with growing customer needs in new applications, it was clear that a versatile, highly configurable, and compact motor would further strengthen TM4's product line.

By changing many exterior features of the housing and keeping the same active components of its patented external-rotor PMSM motor technology, TM4 is able to supply its customers with a motor that is smaller and lighter than its predecessor, while achieving the same impressive performance. Ultimately, there is a 30% volume reduction and a 4kg weight reduction. Most importantly, the new design is flexible and customizable, therefore allowing easy mechanical and electrical interfacing with the gearbox and the wiring harness.

The TM4 MΦTIVE series comprises several scalable powertrain systems, with peak powers ranging from 55-400kW, thereby covering the full range of personal and commercial vehicle segments, and ready for volume production within TM4's 1,000m² manufacturing facilities.

TM4
+1 450 645 1444
transport@tm4.com
www.tm4.com
ONLINE READER ENQUIRY NO. 546

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, every 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 measurements 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. A daisy-chainable serial interface allows these 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. Furthermore, a ΔΣ ADC with 36dB of linear-phase filtering at 10kHz is incorporated. As a second-generation device, the robust features of the LTC6803 are enabling high-performance battery technology on the road today.

Linear Technology Corporation
www.linear.com
ONLINE READER ENQUIRY NO. 547

First electric car tire

At the IAA in Frankfurt, Germany, Continental unveiled a new tire designed specifically for electric vehicles – the Conti.e-Contact. Experts in the field had already anticipated the debut at the motor show, which focused on a large number of EVs. As Continental is also undertaking research into new types of powertrains and batteries for the upcoming EV generation, it was only a matter of time until a specially adapted tire appeared on the scene.

On view in an unusual size (195/55 R 20), the new tire claims to offer lower rolling resistance than today's standard tires, yet still performs safely on wet roads. To make this possible, engineers have adapted the tire to vehicle characteristics. Drivers will likely use EVs more in cities and not at high speeds, so the requirements for these vehicles differ from those of conventional cars in terms of handling and braking distances. This being the case, it has proven possible to reduce greatly the development conflicts standing in the way of low rolling resistance.

Continental Corporation
www.conti.de
ONLINE READER ENQUIRY NO. 548

Technical recruitment services

Consilium Group (UK) provides a 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 on a global scale. Consilium Group's database and network of vacancies and candidates enable the company to match technical roles with industry specialists.

Consilium Group 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 Group services cover the full range of technologies, from OEM to electric motors, as well as batteries and power electronics. This is supported with a long and successful record of building complete teams of engineers for major international clients, as well as securing one-off placements at small design consultancies.

Consilium Group
sdoyle@cgl.eu.com
www.cgl.eu.com

ONLINE READER ENQUIRY NO. 549

Coatings that offer reliable protection

Parylene conformal coatings are inert, pinhole-free coatings that are applied via a room temperature, vapor deposition process. While Parylene coatings have been used in the automotive industry for nearly 40 years due to their excellent chemical, moisture, and dielectric barrier protection, new applications continue to benefit from the ultra-thin, pinhole-free protection the coating offers. Parylene polymer coatings essentially grow a molecule at a time, resulting in coatings that are lightweight, incredibly thin, and penetrate even the smallest of crevices, resulting in complete encapsulation.

In addition to the excellent properties of traditional Parylene coatings, Parylene HT was specially designed to offer high levels of protection in high temperature environments (up to 350°C long term, 450°C short term), making it an ideal conformal coating to protect components such as MEMS, sensors, LEDs, and circuit assemblies used in leading-edge automotive technologies. Furthermore, Parylene HT provides excellent dielectric protection and superior UV stability levels.

Also recently introduced by SCS, AdPro Plus and AdPro Poly are high-tech adhesion technologies that improve adhesion of Parylene to historically difficult substrates, including metals, glass, plastics, and polyimides.

Whether today's miniaturized, multilayer packages are used in advanced electronic systems for powertrain and fuel systems or emissions, lighting, and fluid monitoring systems, all components must be able to survive hostile automotive environments, including high temperatures, corrosive fluids and vapors, and prolonged UV exposure. SCS Parylene coatings and technologies offer reliable protection that is unmatched by traditional conformal coatings.

Specialty Coating Systems
ahardy@scscoatings.com

ONLINE READER ENQUIRY NO. 550

Electric mobility trade fair

Elektro:mobilia, the trade exhibition for electric mobility and alternative drive technologies, is being transformed from a supporting congress exhibition into an international trade fair. The trade fair will continue to take place in parallel to, and be closely linked to, the ZVEI's (German Electrical and Electronic Manufacturers' Association) Expertise Meeting on Electric Mobility congress.

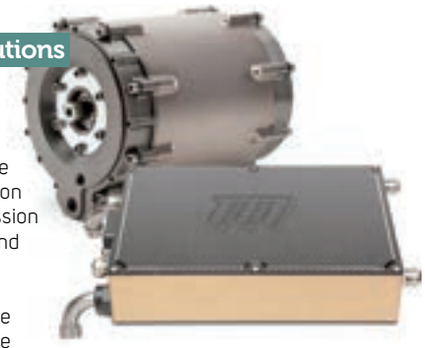
The most important objective in the conceptual restructuring of elektro:mobilia is to comprehensively present the entire electric mobility value chain on national and international levels. In addition to the manufacturers of electric, hybrid, and fuel cell vehicles, also represented at the trade fair will be products and services in segments, including drive systems, components, batteries, charging infrastructure, energy supply, traffic concepts, services, and organization.

In terms of visitors to the event, along with its previous focus group of customers from relevant industries and service sectors, the trade fair is increasingly addressing the needs of buyers including fleet managers from large companies and decision makers from public sector service providers such as public utilities and transport companies, which will play a pioneering role in the use of electric-powered vehicles. By appealing exclusively to visitors from the B2B sector, the trade fair serves all the players in the field of electric mobility as a platform for information, business, networking, and communication.

Elektro:mobilia
www.elektromobilia.de

ONLINE READER ENQUIRY NO. 551

Electric powertrain solutions



Mission Motors is a San Francisco-based company supplying advanced electric powertrain technology to vehicle manufacturers for next-generation hybrid and electric vehicles. Mission has developed technology around lithium-ion battery systems, power electronics, AC induction motors, and software that enable electric drive systems to be more compact, lightweight, efficient, and intelligent. The company's powertrain technology was originally demonstrated in the Mission R electric superbike, which broke the lap record for all-electric vehicles by seven seconds at the Mazda Raceway Laguna Seca in Monterey, California.

While better powertrain component technologies will lead to improved performance, there is also an opportunity for performance gains through the greater optimization of powertrain systems. Mission works with vehicle manufacturers from the earliest stage of vehicle development to understand the complete spectrum of needs from the hybrid or electric powertrain. The company then works with manufacturers to develop an optimized electric powertrain solution that leverages the performance benefits of Mission's technology in the most effective way.

Optimization driven by data collection and analysis is the third pillar of performance improvement. Mission's Skyline data acquisition system captures high-resolution powertrain performance data to constantly compare designed performance with actual performance in the real world.

Mission Motors
www.ridemission.com

ONLINE READER ENQUIRY NO. 552

Compact battery offers longer life

Next Alternative (NAI) has been working on a new lithium LIX battery, and the company has announced that this technology is six months ahead of schedule and is now ready for field trials and final packaging. The lithium LIX technology is lighter in weight, occupies less space, provides more power and energy, and has a longer life than the nickel-metal hydride batteries powering today's hybrid electric vehicles.

Tests show that even under a severe charge and discharge cycle at high temperature, capacity of the lithium LIX cell remains stable, with no loss in energy storage capability after 2,500 cycles.

This long lifecycle demonstrates the stability of the LIX system, providing a battery with a lifespan of 10 to 15 years. A cell will charge in 10 minutes and it takes four cell packs to make a 14.8V battery.

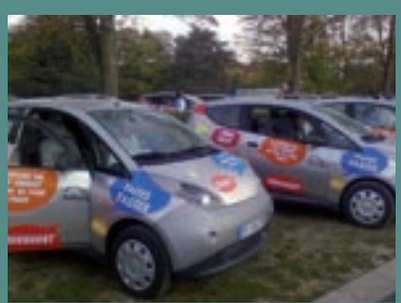
NAI's Carbon Nano Tube (CNT) batteries modify lead acid technology, applying a highly conductive carbon nano tube coating to the anode and cathode. The CNTs also increase the surface area of the anodes and cathodes in orders of magnitude, thereby increasing the batteries' energy storage capability.

The CNT batteries extend battery life to beyond 1,000 recharge cycles. The battery will charge in approximately 15 minutes. NAI is now moving into field trials. Live tests will allow NAI to monitor, in a real-world application, the effectiveness and reliability of the CNT batteries.

Next Alternative
info@next-alternaitve.com
www.next-alternative.com

ONLINE READER ENQUIRY NO. 554

Italy supports sustainable mobility



Turin, Italy's competence center for powertrain technologies, has boosted its e-mobility reputation by applying to take part in the European Smart City initiative, which aims to cut total emissions by 40% before 2020 through the improvement of efficiency in power generation and in sustainable mobility.

The following are some of the latest developments from companies within the From Concept to Car and Think Up groups, the automotive and ICT cluster projects devised by the Turin Chamber of Commerce and managed by Piemonte Agency for Investments, Export and Tourism.

Bylogix recently developed a software architecture for electric vehicle automotive instrument panel clusters based on a graphics TFT screen. An automotive microcontroller is able to run real-time communication protocol on the Standard CAN bus to connect with other onboard electronic units to display complex images to the driver. Information managed by this technology includes vehicle status (running and charging), vehicle total/partial odometer, vehicle speed, failures status, battery status, and vehicle lighting information, which covers such aspects as position, high/low beams, fog, direction, and alarm.

Despite the complexity and wide variety of color images that have to be handled in real time, this application is not based on any complex operating system, but instead on a proprietary scheduler that manages software tasks. As a result, the application also has a start-up time of less than one second.

Besides valuable EVs/HEVs components and service suppliers, the Turin region is also home to a full EV manufacturer that has two production sites close to the city.

Cecomp produces electric cars specifically for the city of Paris. Founded in 1978 by Giovanni Forneris, who trained at the Fiat Style Centre along with the most prestigious designers and body makers of Turin, including Michelotti and Giugiaro, Cecomp has 200 employees based in Turin and operates a joint venture in Shanghai, China.

Cecomp gives shape to ideas developed by designers, style centers, and research and development institutions of car manufacturers around the world, realizing all types of activities from prototype stage, pre-industrialization, and turnkey projects, through to the low production supply of complete vehicles. The company's main activity in the past year has been focusing on the full development and low-volume production of electric vehicles.

From Concept To Car
www.fromconcepttocar.com
www.thinkupict.com
www.bylogix.it
www.cecomp.it

ONLINE READER ENQUIRY NO. 553

Custom cables and harnesses for electromobility applications

BizLink is a global supplier of cables, wire harnesses, connectors, and other interconnect solutions in the motor vehicle and electronics markets. BizLink's background – working with leading and global OEM customers in both these industries – has made the company well suited to serve customers in the electromobility field, with everything from engine harnesses to specific active adaptors for in-vehicle entertainment.

BizLink supports electric vehicles, battery systems, and all related end products with innovative and robust solutions manufactured at the company's TS16949-certified facilities in Asia and North America.

BizLink takes pride in its ability to satisfy the needs of OEM customers with solid products manufactured under stringent processes and supported with local service and exceptional flexibility.

One of the company's newer products is the SAE 1772 AC charge coupler for EV charging stations.

BizLink has designed this product to be industry-leading in performance, as well as value by utilizing its vertical integration capabilities. The charge coupler is manufactured at one of BizLink's Asian facilities.

BizLink is a USA-based, vertically integrated global supplier.

BizLink
sales@bizlinktech.com
www.bizlinktech.com/ev.html
ONLINE READER ENQUIRY NO. 555

Next-generation hybrid drive

Heinzmann has presented 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, optimized use of active material, and features a robust design that is suited for heavy-duty applications.

Heinzmann develops and manufactures components and systems for modern hybrid drives for industrial and construction vehicles driven by diesel, gas, and petrol engines. With these modular 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

with a wide selection of electric motors for traction and to operate auxiliary units. These electric drives allow the partial (hybrid) and full electrification of mobile machinery to achieve substantial reduction of emissions (gaseous and noise emissions) and fuel consumption, as well as an increase in productivity.

Heinzmann
www.heinzmann.com
ONLINE READER ENQUIRY NO. 557

Orange cable protection to identify high-voltage cables

Partec has developed a range of orange cable protection products for electric and hybrid vehicles. According to the regulation ECE/TRANS/WP.29/GRSP/2009/16 from the World Forum for Harmonization of Vehicle Regulations, the outer covering of cables for high-voltage buses – not within enclosures – shall be identified by an orange color.

Partec, a specialist in cable protection products, has developed a special orange product range for the high voltage aftermarket. From slitted and close-corrugated polyamide conduits, to woven wraparound sleeving braids over shrinking braid to knitting hose

– all products are available in orange and can be ordered in any quantity.

Partec
jonny.billeter@par-tec.ch
www.orange-cable-protection.com
ONLINE READER ENQUIRY NO. 556

Low dew-point dry rooms for lithium battery production

The dry room is one of the most expensive investments that the high-volume lithium-ion battery manufacturer has to make. The demand for large, high-volume production facilities has created more complex design requirements in space configuration, personnel access, product flow, humidity/dew-point control, and cleanliness. As a result, dehumidification/mechanical systems have grown larger to address these needs.

Scientific Climate Systems is one of the largest global suppliers of dry rooms, integrating more energy-efficient designs and equipment to satisfy this new generation of dry rooms. The company can configure dry rooms up to 100,000ft^2 to meet any processing requirement, with personnel access air locks and product pass-through openings.

Vapor-tight insulated panel enclosures ensure uniform stable temperature and humidity conditions. Separate areas for coaters, slitters, and calender equipment can be integrated to provide easy access and product flow. Room humidity control at -5°C to -45°C dew point is common.

New dehumidification system designs offer greater drying capacity, with 25-40% less energy consumption compared with previous designs.

Scientific Climate Systems
www.dryrooms.com
ONLINE READER ENQUIRY NO. 558

Denmark's EV business portal

Denmark has a high e-mobility potential. The country has a well-developed decentralized electrical infrastructure, short traveling distances and is very flat! Furthermore, Denmark has previously shown the way in other clean tech areas such as wind power and heat pump technology. Numerous electric vehicle and smart grid projects – involving both public and private parties – are currently active in Denmark.

Insero E-Mobility is the Danish cluster organization working to build a bridge between the Danish and the international EV industry. The company does so by networking and matchmaking activities across the globe, whether in the form of hosting or visiting events and network meetings.

Insero E-Mobility's effort is also put into R&D projects testing new technologies and market potential, and some of this work is taking place within a unique living lab, where individuals and families drive EVs as part of their everyday life. This provides invaluable holistic user data based on real-life experiences that can enhance the technologies in question.

In the project pipeline of Insero E-Mobility is the very first demonstration of Vehicle-2-Grid (V2G) technology. Within a year, the company and its project partners will have 10 V2G-ready EVs driving around in Denmark, live testing the technology. Connecting the right people for this and similar projects will speed up the process of developing and testing new ideas for the market in order to realize the economic potential of e-mobility – which is the mission of Insero E-Mobility.

Insero E-Mobility
e-mobility@insero.dk
www.e-mobility.insero.dk
ONLINE READER ENQUIRY NO. 559

Technical and retractile cords and complete custom cables

Northwire Technical Cable, an innovative solutions provider, offers bulk technical and retractile cords and complete custom cable and assembly solutions for the charging of EVs, HEVs and equipment.

The company offers quotes in 24 hours or less; custom cables in five days or fewer; no minimum length or quantity; no-cost design and rapid prototyping; and standard, custom and composite configurations. Furthermore, the company has UL 62 approval and supplies technology that is compatible with SAE J1772 connectors and UL 2594 and the NEC 625 charging system.

Northwire's custom cable and assembly solutions also withstand severe temperature extremes, harsh environments, oils, chemicals, abrasion, crushing and more. The technology is 300V EVJT (TPE) and 300V EVJT (PVC) cables from 12-18AWG, and is 600V EVE (TPE) and 600V EVT (PVC) cables from 2-18AWG. The products are RoHS compliant for charging stations in wet locations.

Value-added services include stocking programs, custom colors, private labeling and lot traceability; assemblies, cutting and stripping; MIL-Spec packaging, barcoding and radio frequency identification; and UL, CSA, IEEE, MSHA approvals.

Northwire, a woman-owned small business, is ISO 9001:2008 certified and is engaged in company-wide professional certifications in Six Sigma, Lean, Project Management and American Society of Quality. The company's quality control laboratory is a certified testing facility for CSA under ISO 17025. This laboratory subjects the company's cable products to tests that surpass real-world conditions. ITAR registered, Northwire's CAGE Code is 7V821. Northwire maintains various UL, CSA, IEEE and MSHA approvals and works with suppliers to offer FDA, food-grade, RoHS and REACH-compliant materials.

Northwire
+1 800 468 1516
+1 715 294 2121
cableinfo@northwire.com
www.northwire.com
ONLINE READER ENQUIRY NO. 560

Electric vehicle developments showcased in Taiwan

Taiwan has accumulated a vast pool of experience and knowledge from its highly developed information communications technology sector, which the country is tapping into in order to realize state-of-the-art automotive green technologies. And now, followed by the success from launching its first EV show, in 2012 EV Taiwan will again join all the strengths of its domestic manufacturers showcasing their latest products and EV technologies for the emerging electric vehicle industry. EV Taiwan is co-located with Motorcycle Taiwan, a key event that aims to give buyers the best of Taiwan's vertical integrated motorcycle industry. EV Taiwan will showcase the very latest EVs, drive and motor systems, energy storage technology, energy and recharging infrastructure and test systems and services.

EV Taiwan
evtaiwan@taitra.org.tw
www.evtaiwan.com.tw
ONLINE READER ENQUIRY NO. 561

PLUG-IN 2012

July 23 – 26, 2012
San Antonio Convention Center
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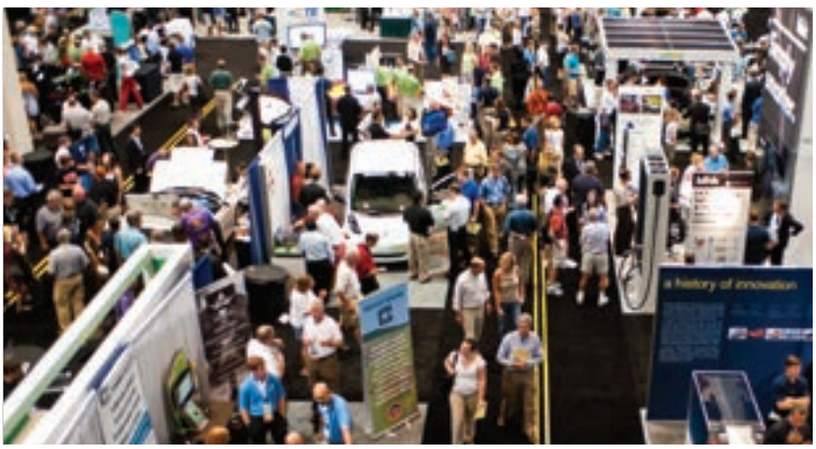


WE'RE PUTTING YOU IN THE DRIVER'S SEAT...

...and plugging you into the information needed to accelerate transportation electrification.

Nowhere else will you have a more complete, more open and more direct dialogue about plug-in hybrid and electric transportation than at the Plug-In 2012 Conference & Exposition – an international gathering of automakers, component suppliers, electric utilities, government agencies and other key industry stakeholders. Plug-In 2012 will feature:

- A content-rich agenda offering access to real-world data on vehicle and infrastructure deployment, user experiences and cutting-edge research on advanced plug-in technologies.
- A diverse exposition floor showcasing a range of vehicles, electricity infrastructure, batteries, components and other innovations associated with plug-in transportation.

Make plans today for Plug-In 2012!

Bookmark www.plugin2012.com for more details.

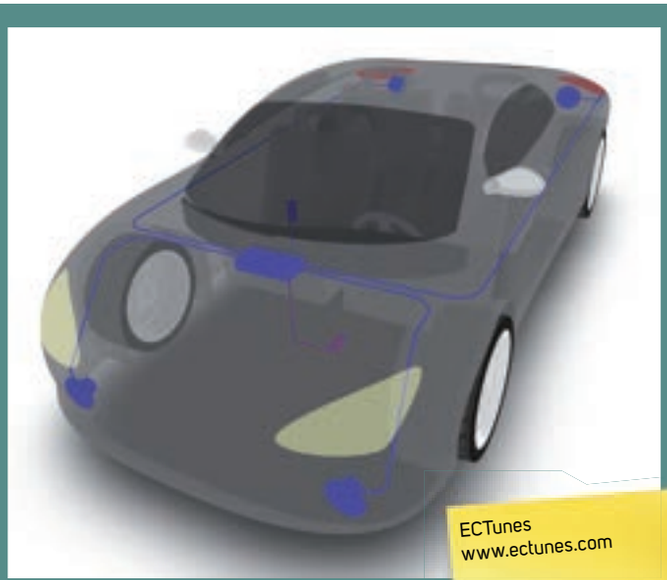
ORGANIZED BY: EPRI ELECTRIC POWER RESEARCH INSTITUTE

External warning sound systems

After launching its first warning sound system in 2010, ECTunes has introduced its next generation of robust, full-range outdoor automotive loudspeakers that deliver high-quality sound, reliability and performance in a very small and lightweight package. Combined with a new embedded electronics solution that will be available later this year, ECTunes has positioned itself to offer the market a complete off-the-shelf solution that is easy to integrate at low cost. All systems from the company meet requirements outlined by upcoming legislation, and to serve the market as best as possible.

The range of products and systems from ECTunes includes solutions for electric and hybrid cars, special solutions for electric industrial vehicles (such as forklifts) and the latest dedicated solution for electric motorcycles and scooters, which was showcased at ECarTech Munich in October 2011.

Together with the research institute Delta, ECTunes has released a new report on external sound for electric vehicles with recommendations to the legislation work – a study that OEMs and suppliers will find essential as they prepare to undertake EV development work. The report deals with how optimal warning sounds and intelligent sound systems will make it possible to obtain pedestrian safety with less noise pollution than from IC-engined cars. This report can be downloaded from the ECTunes website.



ECTunes
www.ectunes.com

ONLINE READER ENQUIRY NO. 562

Thermal management solutions

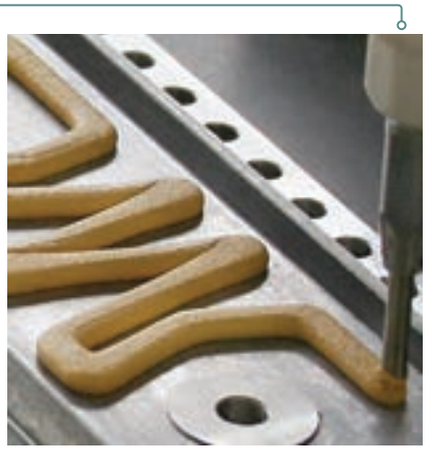
Effective thermal management is key to ensuring consistent performance and long-term reliability of many electronic devices. With a wide variety of applications requiring thermal management, the need for alternative thermal material solutions and innovative material placement methods continues to grow.

Two-part, cure-in-place materials are dispensed as a liquid onto the target surface. As components are assembled, the material will wet-out to the adjacent surfaces. Once cured, the material remains a flexible and soft elastomer, designed to assist in relieving coefficient of thermal expansion mismatch stresses during thermal cycling. Gap filler is ideally suited to replace grease or potting compounds.

Because gap filler is dispensed and wet-out in its liquid state, the material will create virtually zero stress on components during the assembly process.

Liquid gap filler materials are able to conform to intricate topographies, including multilevel surfaces. Due to its increased mobility prior to cure, gap filler can fill small air voids, therefore reducing overall thermal resistance to the heat generating device.

Unlike pre-cured gap filling materials, this liquid approach offers infinite thickness options and eliminates the need for specific pad thicknesses or die-cut shapes for individual applications.



Manual or semi-automatic dispensing tools can be used to apply material directly to the target surface, resulting in effective use of material with minimal waste.

Although gap fillers are designed to flow easily under minimal pressure, they are thixotropic in nature, which helps the material to remain in place after dispensing and prior to cure.

Bergquist Company
www.bergquistcompany.com

ONLINE READER ENQUIRY NO. 563

A new producer of battery grade lithium carbonate

Rincon Lithium is developing battery grade lithium carbonate from its resource at the Salar del Rincon in Salta Province of Argentina. The future demand from the EV industry will need considerable expansion in lithium production capacity. That, in turn, will demand large-scale capital investment in new plant and resource development. Rincon has developed the resource in an orderly and thorough way to ensure that it will be a long term, stable and large capacity producer, as well as delivering value to its shareholders and its customers.

Operations are in transition from a development project into a commercial business and Rincon is one of the most advanced of new producers. Rincon Lithium will produce >99.5% Li2CO3 as a raw material for lithium-ion battery cathode materials with first commercial shipments to customers in early 2012.

Plant commissioning has been conducted and is in early phase production in which attention to quality, consistency and reliability has priority to address the automotive industry needs of consistent quality and supply security, particularly through securing ownership of critical reagents.

Lithium brine sourced production of battery raw materials, such as that at Rincon, has lower energy and carbon footprints associated with solar evaporation, lower carbon fuel consumption and the absence of conventional mining activities.

Rincon Lithium
www.rinconlithium.com

ONLINE READER ENQUIRY NO. 564

Announcing the 3rd European

advanced automotive battery conference

aabc europe

The third European AABC will examine the rapidly expanding advanced automotive battery market with a focus on the activities and needs of European automakers.

June 18 - 22, 2012

Rheingoldhalle Congress Centrum, Mainz, Germany

Symposia **Posters** **Exhibits** **Networking**

Technology-focused Symposia in parallel June 19 - 20, 2012

LLIBTA
Large Lithium Ion Battery Technology and Application

Where leading developers and prospective users explore the status and prospects of large lithium-ion batteries to power applications ranging from advanced automotive to stationary installations.

ECCAP
Large EC Capacitor Technology and Application

Where key developers and prospective users of large electrochemical capacitors explore the recent advances and future prospects of this technology, including advances in materials and cell design, pack engineering and performance in key applications.

Automotive-application-focused Symposium June 20 - 22, 2012

AABTAM
Advanced Automotive Battery Technology, Application and Market

Where European automakers and their international energy-storage suppliers discuss the latest technological progress and market direction for advanced vehicles and the batteries that will power them.

Register now to join the largest European energy-storage conference of 2012, with over 700 attendees expected.

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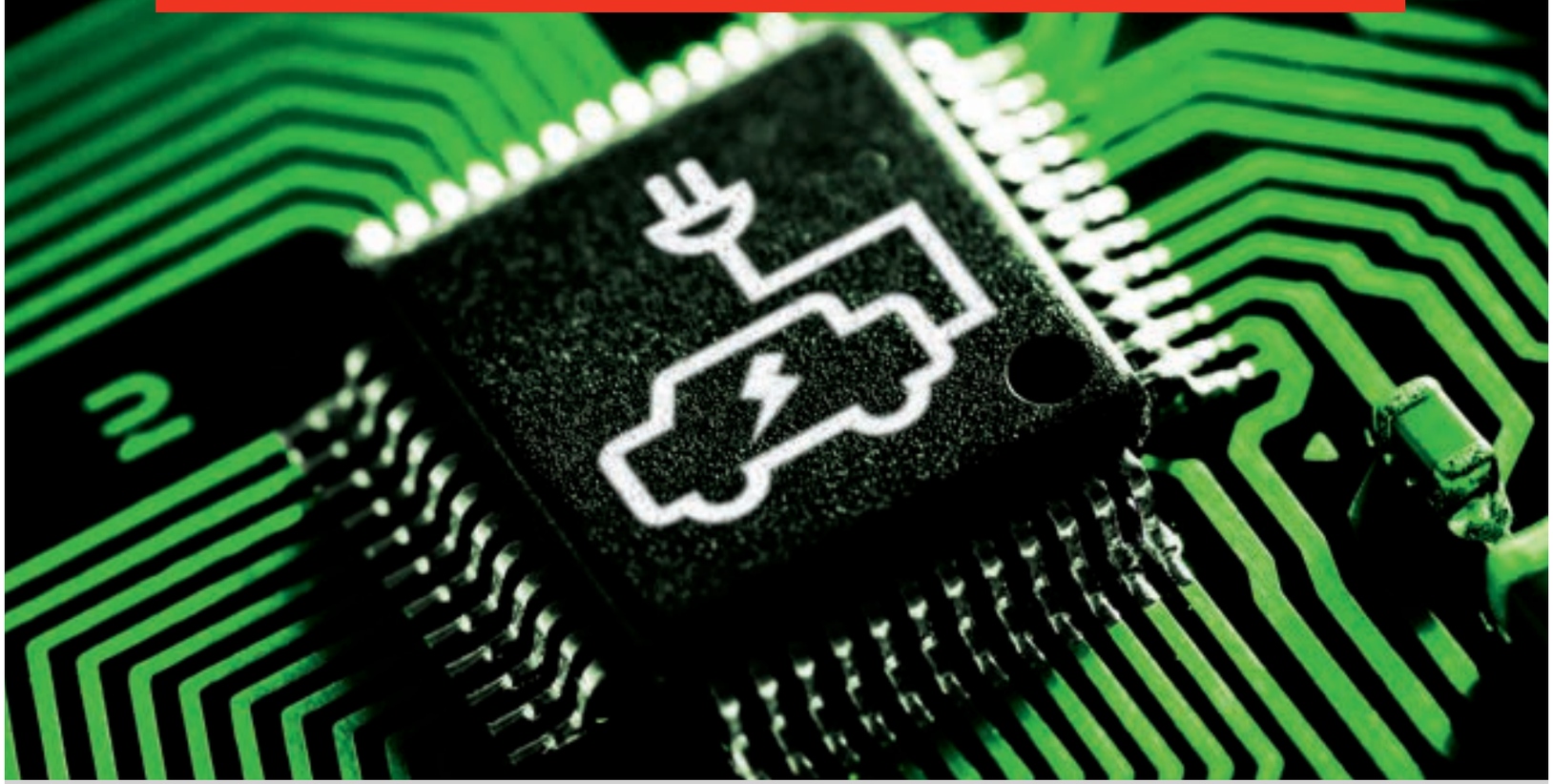

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Reaping rewards

REAPsystems designs, manufactures and integrates BMS for large, high-voltage lithium-ion batteries that are used in electric vehicles and other market applications.

Dr Dennis Doerffel founded the company in 2003 following his research that involved testing and characterizing large lithium-ion batteries. Since its establishment, REAPsystems has provided BMS products, services and solutions to more than 120 different customers globally. This expertise and experience has led to a continued expansion of the organization and the services offered.

The continued success of REAPsystems has led to an increase at the company's production facility based in Southampton, UK. Products offered include an off-the-shelf BMS, a customized BMS, battery modules and complete battery solutions.

REAPsystems also offers an experienced support team consisting of multilingual engineers with vast practical experience of layout design, EMC testing, validation, battery module and pack design/assembly, system integration, commissioning and tuning.

Looking into the future, the next 12 months will see REAPsystems move into its ninth year of business with the company continuing to grow its worldwide customer base across many different applications.

REAPsystems
info@reapsystems.co.uk
www.reapsystems.co.uk

ONLINE READER ENQUIRY NO. 565

Battery management control

Provector, which is based near Cambridge, UK, has built a range of battery management, control and power electronics products to meet the demands of leading-edge vehicle projects. For example, a 30kW 610V PM generator controller was required for a military AFV. The ideal location was next to the generator, but this was mounted on the main engine. There was little

space, 100°C ambient temperature, high levels of shock and vibration and strict EMC limits. Provector's solution met all these requirements, delivering a high level of system performance and functionality.

Provector's projects often involve the installation of a different battery in a hybrid or stop/start vehicle. The company's contribution is normally based around one of its BMS products, which are designed to form an excellent basis for complete pack management. They incorporate features that are valuable to a battery pack builder in addition to a strong platform of SOC, SOH and SOF estimation, and thermal control. These include IO to monitor and control contactors, cooling systems and other hardware and even a GPS port to time stamp test data.

A particular benefit of the Provector approach is that all string current and cell voltage measurements are taken simultaneously, rather than using a multiplexer. This gives a much more accurate picture of the state of individual cells under dynamic conditions.

Provector believes that support tools are a crucial element and offers remote configuration and a rich set of data collection and logging tools, including remote logging.

Provector
www.provector.com

ONLINE READER ENQUIRY NO. 566

Energy management systems

Efficiency in an electric drive vehicle is everything. Improved energy efficiency in a powertrain will lead directly to improvement in driving range. There are three ways of improving energy efficiency: don't use energy you don't have to; recover energy that would otherwise be lost; and when you need to use energy, do so with the minimum of losses.

The modern electrically propelled vehicle has many interconnected systems, most of which consume or convert energy, such as BMS, DC/DC converters, controllers and motors. A systems-level approach to design is vital. Only by considering all the sources of energy generation, conversion and consumption in a vehicle can the three means of improving efficiency be effectively applied to produce an optimized energy management system (EMS).

Frazer-Nash Energy Systems has developed a number of optimized components for electric drive

vehicles. By communicating with and controlling the way these individually optimized subsystems work together as a system, the EMS ensures energy is either saved or recovered or only used efficiently. Frazer-Nash Energy Systems can therefore deliver a system engineering and integration package that results in increased range – the key factor in electric drive vehicles.

Frazer-Nash Energy Systems
www.fn-energy.com

ONLINE READER ENQUIRY NO. 567

Getting the infrastructure blocks in place

As momentum continues in the development of alternatively fueled and advanced technology vehicles, it is becoming increasingly apparent that the key driver for change and acceptance in the eyes of the public will be a cost-effective, safe and reliable energy infrastructure. Organizations such as leading test and development facility Millbrook are working closely with government and industry to ensure that the vehicles of tomorrow have the infrastructure needed today – whether that is rapid electric charging points or mobile hydrogen refuelling stations.

While these vehicles – like all new models – need to go through rigorous testing procedures before being introduced on a large scale, the refuelling infrastructure will also need to undergo a stringent testing schedule. For example, local authorities and landowners need to understand the consequences of an electric charging point being damaged or vandalized. Likewise, builders and planners must be aware of any changing electricity demands and locations for power supply points in houses and offices.

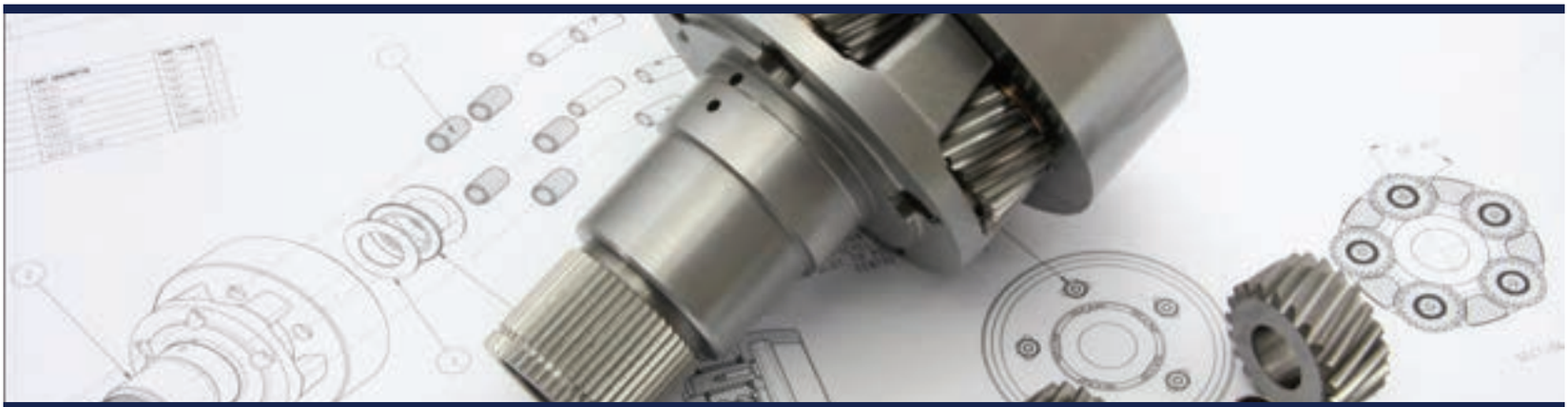
The next stage in the development of a future technology vehicle park in the UK will be instilling confidence in the consumer. While 'range anxiety' – the fear that a driver will not reach their destination – and financial concerns still permeate consumer decision-making, alternatively fuelled vehicles are unlikely to be the first choice for drivers. However, more and more clever technologies are being adopted in both the personal and commercial vehicle industries that will assuage such fears. Millbrook, with other advanced engineering partners, is playing host today to the conversations that will ultimately see a safe and practical transport future.

Millbrook
info@millbrook.co.uk
www.millbrook.co.uk

ONLINE READER ENQUIRY NO. 568

innovative automotive transmission products and services

antonov plc



www.antonovplc.com

Antonov has experience in the design, analysis and development of transmissions for the automotive, commercial vehicle, military and industrial markets. As well as a wealth of technical capability brought to the company by the transmission industry's leading engineers, Antonov has well developed business and project management processes to ensure that projects are delivered to the highest quality, within budget and on time.

Complementing Antonov's technical excellence, these processes and capabilities enable us to be a complete service supplier within the transmission sector.

Antonov 3-Speed Electric Vehicle Transmission

TX-6 Transverse 175Nm 6-Speed Automotive Automatic Transmission

Antonov provide expert consultancy and commercial engineering services in all aspects of transmission design and development:

- Concept to production design of all types of transmissions for conventional ICE and electric vehicle applications.
- Virtual product development using state of the art analysis software for transmission durability and NVH optimisation.
- Transmission control software design and calibration.

For more information contact: **Antonov Plc**
Simon Roberts – Chief Commercial Officer
Tel: +44 (01926) 455 800, Email: sroberts@antonovplc.com
Antonov Plc, 2 Hawkes Drive, Heathcote Industrial Estate, Warwick, Warwickshire, CV34 6LX, UK

Eco-friendly exhibition and conference

Ever Monaco is an international event recognized as the meeting for ecological vehicle manufacturers and the parties involved in the renewable energies sector. Ever Monaco is organized under the patronage of HSH Prince Albert II. For the seventh year, Ever Monaco 2012 will be held in the prestigious Congress Centre of the Grimaldi Forum from March 22-25.

The exhibition will take place in the Espace Ravel, a 4,000m² area at the heart of the Congress Centre, looking out onto the Mediterranean Sea.

As part of the event, one exhibition will welcome the ecologic vehicle manufacturers (electric, hybrid, fuel cell, gas, biofuel and any mode of propulsion presenting a real ecological interest), as well as battery manufacturers and equipment suppliers from around the world.

There will also be two ride and drive circuits: one for licensed vehicles and one for two-wheeler vehicles. This parade will proceed past the most famous landmarks of Monaco.

The two-wheel electric performance program, which is also part of the event, is a challenge that is open to series vehicles (salon exhibitors only). There are two tests here: an autonomy test and an acceleration test. At the end of the challenge, the winners will be presented with an award.

Meanwhile, the Rallye Monte Carlo for New Energies and Electric Vehicles, which is registered in the FIA Alternative Energies Cup, will be open to all types of ecological vehicles and will run from March 22-25.

Another exhibition on renewable energies will welcome services, equipment and products associated directly or indirectly, in whole or in part with renewable energies, the environment and energy saving.

The conferences will have a scientific orientation and will bring together specialists from universities and industry in the ecological vehicles and renewable energies sectors. These speakers will have the opportunity to share their know-how and techniques with participants from all over the world.

MITI
www.ever-monaco.com

ONLINE READER ENQUIRY NO. 569

Battery testbeds – the long term

Battery validation methods are currently being defined, and it will take some time to stabilize. However, manufacturers are equipping themselves with costly, heavy testbeds now. How do engineers choose the right one? D2T Powertrain Engineering has an aptly named solution: ZEUS. It takes into account the need for benches to develop from durability tests into research tests. Its opening can be adapted to all bench equipment, present and future, including power drives, climatic chambers and cooling systems. Its flexibility and performance allow for it to change with future methodologies: more complex testing procedures, robust databases and integration of models in real time on the bench. ZEUS is offered in three different packages: ZEUS Easy for durability tests done on an autonomous test bench, 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 bench in real time.

D2T Powertrain Engineering
regis.de-bonnaventure@d2t.fr
www.d2t.fr

ONLINE READER ENQUIRY NO. 570

In-hub motor to revolutionize hybrid drive

For the past 30 years, L-3 Magnet-Motor has been developing innovative hybrid electric drive systems and has become a leading supplier of compact electric motors for the automotive industry.

L-3 MM's M70 electric integrated wheel motor is the company's latest advancement in hybrid electric vehicle propulsion, offering unmatched performance in both power and torque. The M70 motor is a completely maintenance-free permanent magnet, inner rotor machine, featuring a highly efficient water-cooling system. It provides precise mechanical control via electronic inverters aided by a high accuracy resolver system.

Designed for propulsion systems requiring high torque and high power, the M70 supports endless possibilities in new vehicle design. With a large central bore, the M70's in-hub wheel motor provides enough room for a conventional disk brake or a planetary gear set to support extra high torque applications. It can also be installed as an add-on hybridization of an existing mechanical drivetrain. Two M70 motors in a vehicle will deliver full traction, and four will ensure optimal performance for the most extreme environmental or terrain conditions.

L-3 Magnet-Motor
+49 8151 262 0
www.L-3com.com/mm

ONLINE READER ENQUIRY NO. 571

Safe and reliable lithium batteries

Sinopoly Battery engages in production, sales, research and development of safe and reliable lithium-ion power battery technology. With a main product range of 40-1,000Ah, 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 this is one of the most important factors in choosing batteries for HEVs and EVs. The high-energy-density Sinopoly batteries enable vehicles to have a longer runtime 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 PONY.

Sinopoly's lithium-ion battery is applicable in different types of electric vehicles, such as pure electric cars, electric minibuses, electric buses and electric tour buses. 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 in Liaoyuan, Jilin Province, China, in November 2011 after a satisfactory trial that lasted for two months. The formulation of anode and cathode materials inside the battery delivers high power, excellent lifecycles and a short recharging time.

With applications in many different fields, the batteries are sold to different customers all over the world.

Sinopoly Battery International
sales@sinopolybattery.com
www.sinopolybattery.com

ONLINE READER ENQUIRY NO. 572

Transportation revolution

The industry is accustomed to companies and politicians making grossly exaggerated claims about their technological or political ideas for transforming society. Have we become cynical in evaluating their respective claims? It is with this phenomenon in mind that we evaluate claims with trepidation – but we must do so.

In 1860, lead acid batteries came into existence. Some 130 years later, Sony released its first lithium-ion battery systems that are used extensively today. The problem with these batteries is that they lack sufficient energy to power vehicles over long distances safely. In addition, they are toxic, cacogenic, heavy and expensive. They are pollutants, in an age where society is demanding clean energy forms.

The failure with Li-ion batteries is their very bad record with safety. In September 2010, a cargo aircraft was brought down carrying a consignment of Li-ion batteries. In the past six months alone, there have been grave failures in the use of these batteries in vehicles. Consequently, the poor energy density and its safety failures make the family of Li-ion batteries unsuitable to replace the petrol engine.

So, what is different about Oxis Energy and its scientific team? The Oxis team has executed a breakthrough in battery technology. Its use of chemical compounds is profoundly different from anything that has gone before. Its energy density is five to six times the performance of any Li-ion battery, and it is inherently safe. It is also biodegradable.

The Oxis chemistry and technology is revolutionary. Its technology makes it capable of replacing the petrol engine. Within the next two years, vehicles will appear in Europe making use of this revolutionary power – allowing society to reduce its dependency on oil.

OXiS Energy
www.oxisenergy.com

ONLINE READER ENQUIRY NO. 574

New versatile plug-in HEV powertrain

After various historic attempts to launch electric mobility, the latest global wave of automobile electrification is touching fixed grounds.

Within this context, DTI concentrates on compact and cost-effective solutions for PHEV powertrains. The solutions convey a multipower mode structure where innovative transmission and IC engine technology play a crucial role. DTI's PHEV realizes a much smaller battery pack while reducing range anxiety and offering long charging intervals.

Furthermore, the company's aim is minimizing complexity, and number and size of expensive parts such as electric motors, inverters and batteries. In effect, DTI regards PHEV as an enabler for widespread affordable electric mobility while battery technology can mature further at a healthy pace.

One of DTI's PHEV configurations realizes various operational modes, including powershiftable speed ratios in pure EV mode (for efficiency maximization); fixed gear ratios in pure IC engine mode (for highway mode and range performance); parallel hybrid modes (for power reserve in rural/highway mode); and powersplit hybrid mode (for hybrid vehicle launch and CVT driving).

With these modes at hand, the powertrain's energy management system conveys an electric city driving range of between 30-50km, and fuel consumption of at least 94mpg during longer drive missions. The first prototypes will be tested in mid-2012.

DTI
www.dtinnovations.nl

ONLINE READER ENQUIRY NO. 573

Innovative RACS high-voltage connectivity system

Huber+Suhner has drawn on its many years of experience in the connectivity of high-voltage systems to develop the innovative RADOX Automotive Connection System (RACS). The system is used in conjunction with High-Voltage Distribution Units (HVDUs) in EVs.

Its innovative direct connectivity allows the system to ensure a safe and more efficient connection between high-voltage distribution systems and high-voltage units, as well as saving a great deal of space. The design means that the system can be manufactured using fewer individual parts, reducing both sealing work requirements and fault probability. The high-voltage connectivity system is a customer-specific assembly that comes in a single, two- or three-pin design. It is supplied with Huber+Suhner RADOX cables and a connection plate that's developed in-house. Customers can specify the type of connections and cable length/cross-section themselves.

RACS has a shielded high-voltage connection and is protected to IP69K. With a low electrical resistance of <10mOhm between the connector and the HVDU, and with a high current capability, the system proves its worth. Together with the Huber+Suhner high-voltage distribution systems, the product has made a name for itself with a number of well-known customers.

Huber+Suhner
www.hubersuhner.com/automotive

ONLINE READER ENQUIRY NO. 575

Silicone hosing developments

Silicone hosing is quickly becoming the go-to solution for hybrid and electric vehicle manufacturers. Silicone boasts excellent compatibility with hybrid and electric vehicle cooling, ventilation, induction breather, fuel and fluid transfer systems, and offers savings on component costs and assembly time, improved performance, significantly lower tooling costs, small batch runs and rapid prototype development.

For assemblies, silicone is often misconceived as being a high-cost material. However, in many instances, custom-designed silicone hoses reduce cost compared with standard rubber hoses (removing the need for cumbersome and costly T-pieces and adaptors), while providing the benefits of zero points of failure and reduced weight.

UK-based Silflex is one of the world's foremost manufacturers of silicone hose, with more than 20 years' experience of silicone hose engineering, R&D and development of silicone elastomer technologies operating to ISO 9001:2000, and is a proven Tier 1 and 2 supplier. Silflex's silicone hose products can operate at significantly higher and lower temperature levels than conventional rubbers, and offer far superior resistance to degradation, in particular being immune to ECD.

The company's range of products is enhanced with the addition of specialist lining materials such as Silflex's Pro-Fuel for fuel and chemical transfer, and Silflex's market-leading low leaching Silgiene liner – the optimal choice for use in fuel cell power applications.

With a UK head office and design and engineering division, Silflex offers UK and overseas manufacturing facilities fast design, quote, prototype and small and large batch services.

Silflex
www.silflex.com

ONLINE READER ENQUIRY NO. 576

Ready to power the future

The Remy Electric Motors story started more than 100 years ago in automotive rotating electrics. More than 20 years ago, Remy Electric Motors brought its first hybrid motor design into production. Today, Remy has more than 90,000 electric motors in the field with 2,000,000,000km on the road – which the company says separates it from the rest of the sector. Remy has moved beyond the test track and onto the roads of five continents. Remy's applications are vast, ranging from space-sensitive applications of electric motorcycles to large metropolitan hybrid buses. Remy Electric Motors applications include heavy- and medium-duty trucks, utility trucks, SUVs, passenger cars, electric vehicle conversions, agricultural equipment and construction equipment. It currently has two families of motors ready for delivery, the HVH250 and HVH410. The Remy Electric Motors HVH product line offers unrivaled durability and value while ensuring industry-leading power and torque densities. Remy's HVH250 has won races two years in a row at the Isle of Man and recently set a land speed record at the Bonneville Salt Flats.

Remy Electric Motors
www.remyinc.com

ONLINE READER ENQUIRY NO. 578

Range extender acts as a bridge for EVs

Range anxiety is a major barrier to consumer acceptance of electric vehicles. To alleviate this concern, OEMs have developed the range extender concept, usually a small supplemental IC engine designed specifically for the vehicle in which they are installed, requiring extensive design, packaging and engineering. Using a completely innovative approach, FEV, a leading developer of advanced powertrain and vehicle technologies based in Aachen, Germany, has supported the global automotive supplier KSPG in the development of a compact range extender that can be universally mounted in electric vehicles – allowing for possible installation in a space underneath the rear of the vehicle.

The clear advantage is that the range extender can be added as an optional piece of equipment, providing a bridge between fully electric vehicles and those with a supplemental source of power – should battery energy be depleted before recharge – thus alleviating range anxiety.

The KSPG range extender offers several additional advantages. Car manufacturers can, for instance, design a propulsion system using smaller batteries, reducing the cost and overall weight of the vehicle.

The system includes FEV's Full Engine Vibration Compensator, which has been designed into the range extender to maintain valued EV properties such as reduced NVH when the range extender is in operation.

Universally mounted, with reduction in the engine vibration of more than 95%, optimized NVH properties, smaller package size and a significantly extended driving range, the KSPG concept may be a catalyst that generates significant additional market demand for electric vehicles.

FEV
www.fev.com

ONLINE READER ENQUIRY NO. 577

Innovative EV QBEAK set for market launch

Danish company ECOmove is set to launch what it describes as a unique and innovative electric vehicle: QBEAK – a car that fully meets future customer needs for an energy-saving, easily driven and flexible EV with a minimum of environmental impact.

Flexible energy modules, based on lightweight technology and operated by a smartphone, are just some of the innovative features in the new QBEAK EV that ECOmove is launching in early 2012.

In many ways, QBEAK will be a novelty in the EV market. First, QBEAK is made of alternative materials such as EPP in order to obtain weight reduction and thereby energy savings. Together with a flexible modular structure, this makes the car able to run up to 300km on one charge.

The car is equipped with one to six energy modules, and batteries can be added or swapped. In addition, QBEAK is prepared for range extenders, and a smartphone manages all communication.

Several unique features are said by the company to characterize

QBEAK, such as in-wheel motor units and a platform that is variable in size, length and width. Finally, the car can be customized to meet the exact needs of the customer. For example, it can be produced with one to six seats and in all types of colors.

ECOmove plans to enter the markets of both professional and private customers.

ECOmove
mogens@ecomove.dk

ONLINE READER ENQUIRY NO. 579

First UL approval for charging cable in the USA

Leoni was the first European cable manufacturer to receive UL FFSO approval (category code). This category covers cables for charging electric vehicles according to the National Electrical Code (NEC). The cables are designed for AC and DC applications and are compatible with the SAE J1772 plug concepts. The USA has a single-phase energy supply network, which means that the power cores, unlike the European and Chinese versions using three-phase systems, are usually only equipped with two poles plus a protective ground and the corresponding signal and/or pilot cores. The cross-sections are dimensioned in the AWG segment and are usually greater than comparable European types.

The range of services provided by Leoni according to UL FFSO comprises the following standard types: EVJE and EVJT for voltages up to 300V; and EVE and EVT, larger, more robust cables, for voltages up to 600V.

The cable cross-section is also limited by the voltage and the processability of the cable. The maximum current projected at present is around 200A in the DC charging segment. The cables transmit current and control signals during the charging process, with heat resistance up to +105°C and resistance to media of up to +60°C (oil and water). The cores themselves are built with flexible copper strands from cross-section AWG18 upwards.

Leoni
www.leoni-electromobility.com

ONLINE READER ENQUIRY NO. 580

Vehicle integration and rapid prototyping with high efficiency levels

Founded in December 2009, Rational Motion is a specialist company offering turnkey development solutions and system integration in the field of alternative fully electric and hybrid powertrain systems. Services provided by the Cologne-based designers and engineers range from conception to prototype and near-series development through to design reviews, with in-house implementation of all parts and processes, on both the hardware and software level. With its roots in the F1 development environment and having accumulated years of expertise and experience, the team at Rational Motion has a proven record of bringing forth excellence in even the most competitive – and at the same time most advanced – areas of application for automotive vehicle integration.

Rational Motion stands for visionary engineering and highly efficient integrated solutions in the e-mobility sector. Today, Rational Motion is already much in demand as a collaborator with a striking range of automotive and component manufacturers, as well as other innovators in the e-mobility sector. In fact, since April 2011, Rational Motion has been TM4's official exclusive partner for distribution and technical support operations in Germany to ensure that customers can successfully integrate TM4 components.

Rational Motion
info@rationalmotion.de
www.rationalmotion.de

ONLINE READER ENQUIRY NO. 581

Lifecycle management, high-voltage style

Now that EVs and HEVs are gaining mainstream status, lifecycle management of their high-voltage battery packs will demand new levels of vigilance and responsibility.

What happens when something in the battery pack malfunctions, such as a cell cluster or a wiring harness? While dealers can replace modules, few are capable of attending to the technical complexities of these new high-voltage packs.

ATC New Technologies (ATC NT), a division of ATC Drivetrain, offers a broad range of the hottest repo services in town for the hottest batteries in the business. Headed by ATC NT director Dirk Spiers, the company can repair any high-voltage powertrain part for (P)EV battery packs, as well as address such advanced battery pack needs as cell balancing, storage and cell grading to meet specific OEM requirements. Using the in-house lab's high-volume cell grading equipment, technicians can monitor cells by a wide variety of parameters though any specific test pattern.

The state-of-the-art pack and cell testing equipment can all be controlled externally by the OEM. "Because this is a new market, we need to work in close partnership with the OEM's battery engineers and after-sales staff," explains Spiers. "To ensure consistency and confidence, we use the same high-quality equipment they do. For example, customers can remotely view and even control work being done in such equipment as Bitrode's cell cyclers through high-resolution cameras."

ATC NT's lab has also begun to offer second life services, repurposing end-of-vehicle life hybrid nickel metal hybrid batteries, and soon high voltage lithium-ion packs, to new uses.

Bitrode and ATC New Technologies
www.bitrode.com
www.atcnewtechnologies.com

ONLINE READER ENQUIRY NO. 582

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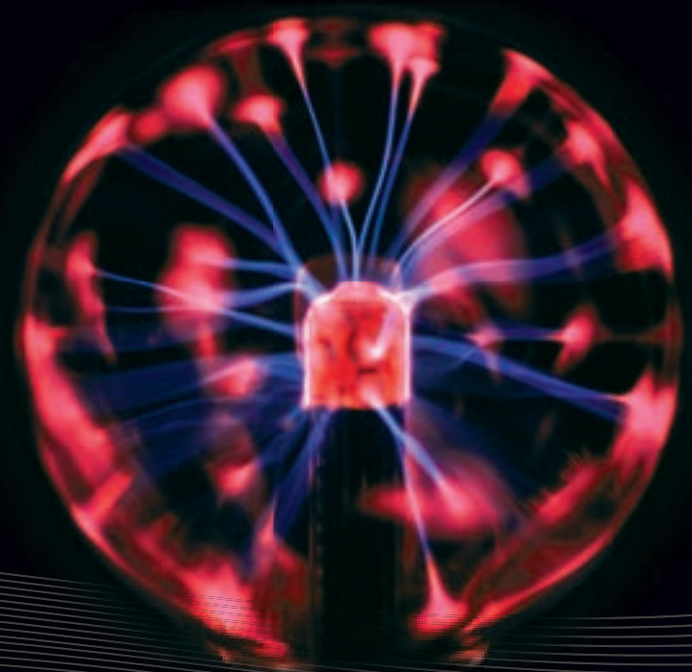

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LAST **WORD**

Jet engine electric vehicles are very appealing to those that can afford it, but what about true, emissions-free transportation for the masses?

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

GREG **OFFER**

"We need to design and make cars that are affordable for the masses, right now"

The blossoming zero emissions sector seems to be dominated by the development of exclusive luxury models or high-end performance prototypes. The Jaguar C-X75 is my favorite, with independent four-wheel drive, 0-60mph in 3.5 seconds, a 68-mile EV range, and (the best bit) the inclusion of two jet engine range extenders. A jet engine electric car – I want one! Except I can't, because Jaguar isn't making them (yet), and when it does, the C-X75's price tag will put it out of my reach. I understand the point of these EVs is to prove the technology, and get people excited about zero emissions transportation, but what's the point of a normal everyday person getting excited about EVs when they can't afford even a basic model?

Putting aside the Jaguar for one moment, I point to the Mitsubishi i-MiEV, Nissan Leaf, Peugeot i0n and GM Volt/Ampera, all of which are at the high end for most consumers, with the vast majority of people in developed countries not being able to afford one, let alone the rest of the world's population in developing nations. Yet these cars do make financial sense for those who will use them every day to drive an appreciable distance, enabling them to potentially recoup their investment within three years. That's a better rate of return than almost any other investment out there, but only if you already drive a lot.

We need to do it differently. We need to design and make cars that are affordable for the masses, right now. We need zero emissions people's car projects; we need to revive the spirit that drove the founding of companies such as VW, which got the masses moving. Tata Motors is a great example of an OEM trying to do this in modern times, with the Nano, but its EV, the Tata Indica Vista EVX, is going to be a similar price to the Leaf. That's not good enough. Why can't we have an electric Nano? Imagine the impact such a vehicle would have both on the market and for Tata personally.

Some smaller companies are taking the right approach, such as French developer MEGA with its Mega City electric, a four-seater with a 65km range that's less than half the price of the Volt. In my book, that makes the Mega City affordable to most, right now, and a regular user could get payback within three years. I am pretty sure that Tata, or even VW – if it really wanted to – could today build an affordable mass-produced electric city car with a modest range and price it for less than US$7,500 by using existing technology. And in a few years as technology improves, perhaps the end cost to the user would decrease further. This could change everything, and would help deliver the dream of cheap sustainable mobility to the world's masses.

For those who disagree, and want to quote Henry Ford II saying "small cars, small profits", I'd counter by saying "big cars, small market" and if the luxury segment is saturated with profitable companies who can afford to invest in new technology, I would advise those trying to break into new markets to develop small affordable cars for the masses. Eventually, the companies that succeed will become the new Toyotas, and can develop their own luxury brands like Lexus. If the incumbents don't see this coming, and fail to create affordable cars for the masses once again, then they are only sowing the seeds of their own decline by abandoning the very markets where their history began.

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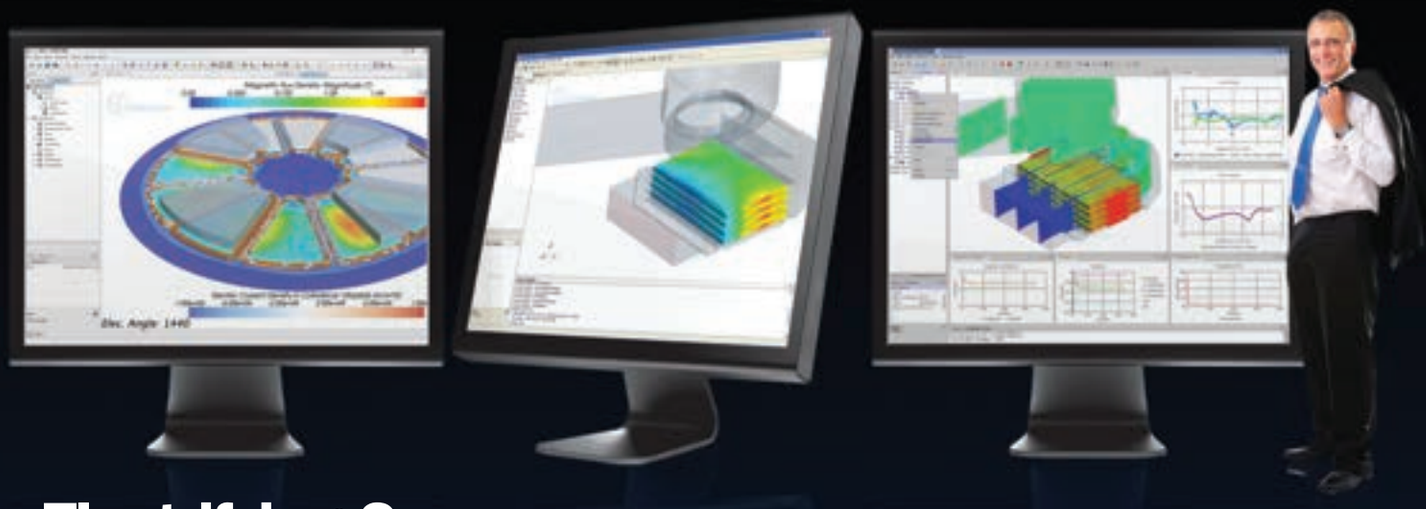

Electrifying Success

CD-adapco has embarked on a journey of collaboration to create a simulation system which is relevant and focused on today's trends within the automotive marketplace. The journey so far has taken in energy storage technology, electric machines analysis, electro-thermal behaviour and continues apace to deliver engineering success to all our users.

The system is built around the class-leading CAE tool STAR-CCM+, a tool which deals with complex, heavy weight 3D resolved physical phenomena. These could include a tightly coupled thermal-electromagnetic problem or an electrochemical-thermal process, all solved within one code, STAR-CCM+. Aligned to this complex 'heart' of the solution are specific design level tools which are focused on the problems design engineers face in the early part of a project. Such tools allow a subsystem to be developed which 'parachutes' the user into the correct design space before deploying STAR-CCM+ to gain those final few percent that make the difference.

The value of such a simulation ecosystem is that there is no duplication. Information entered at the component level is directly interpreted into the complex 3D simulation, allowing a range of engineering groups to use the same models in differing circumstances. This is evident in electric machines design where the upfront analytic tool is used to create a machine which delivers the required torque/speed characteristics. The model is then passed to a thermal group who seamlessly transfer it into a detailed 3 dimensional analysis, adding surrounding cooling systems and componentry, which is used to understand local maximum temperatures within the proposed machine under previously defined operating loads.

Such a tight integration between 'design' tools and 'analysis' tools provides the most value from a group's investment in analysis while avoiding redundant calculations.

CD-adapco

For more information on this growing simulation system designed by world-renowned leaders in analysis with the simple aim to solve your engineering problems and ensure you achieve engineering success, please visit: www.cd-adapco.com.

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